Watershed Management Challenges

Improving Productivity, Resources and Livelihoods

Edited by

Bharat R. Sharma, J.S. Samra, C.A. Scott and Suhas P. Wani

IWMI International Water Management Institute

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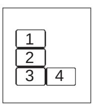

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Foreword

Productivity gains in agriculture, considering both water and land resources, have witnessed impressive increases over the past decades. Countries like India have emerged from food insecurity to a position of food self-sufficiency. Yet with growth in population and changes in dietary habits (both through increased purchasing power and also a perceptible shift towards fewer cereal grains), the national and regional agricultural production challenges remain formidable. The Green Revolution provided a significant boost to total output through sustained yield increases in primarily irrigated cereal crops of rice and wheat. Yield increases among the coarse grains (specifically millet and sorghum) have been less impressive, in part due to unfavorable production environments, lack of investment capacity of marginal farmers, forward and backward market linkages, and very importantly, food procurement and distribution policy centered on rice and wheat. Yet, productivity increases have been shown to be possible through appropriate land and water management, and critically, soil fertility and erosion control as well as marketing channels.

Additionally, inter-regional disparities in agricultural investment—whether by government or by farmers—have led to certain economic growth inequities. The Government of India has targeted 150 of the country's most backward districts for priority investment, including particularly land and water management under the watershed development and management model that has emerged and been refined over the decades since Independence. Watershed programs and schemes sponsored by Central and State Governments are complemented by activities taken up by farmers groups, *Panchayati Raj* institutions, and non-governmental organizations. Yet to date, the results of these investments and efforts have not generated the desired or expected results. Further strengthening of watershed programs will be required, not simply through technological and biophysical interventions, but increasingly through integration of institutional, social and economic considerations. Several countries in Sub-Saharan Africa and southeast Asia and China, facing similar problems of resource degradation, have evinced keen interest in learning from people-centric watershed development programs of India.

The three institutions we head as Directors General of the International Water Management Institute (IWMI), the Indian Council for Agricultural Research (ICAR), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), are committed to improving the outcomes of water and land management, particularly under the guise of watershed management and development in fragile, drought-prone, and resource-poor regions of the country, and indeed, the world.

The present volume addresses these issues head-on by shedding light on watershed development and management in developing countries, with a particular focus on India. Through a series of introduction and overview chapters and case studies that aim to better understand watershed management for improved agricultural and livestock productivity, natural resource management, and livelihood improvement, the editors and contributing authors provide detailed documentation of what works and what does not. The book is part of ongoing collaboration between the Indian Council for Agricultural Research and two centers of the Consultative Group for International Agricultural Research. While each institution may approach the subject of watershed management from a diverse perspective, we unanimously concur that watersheds as resource use units coupled with the management decisions of human users offer immense potential to transform rural livelihoods in marginal and resource-poor regions of the developing world. To this end, our three institutions jointly collaborated on an international workshop "Watershed Management Challenges: Improving Productivity, Resources and Livelihoods" held 3-4 November 2004 in New Delhi. This volume; sponsored by Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India; brings together the best of the papers presented and deliberated during the workshop, and peer-reviewed and revised through the efforts of the editorial team and subject matter experts.

The editors and contributing authors represent a wide spectrum of experience and perspectives on watershed management, and collectively form a growing 'community of practice' that will generate, exchange and broker knowledge. The volume should serve to change thinking on the part of decision makers in such international bodies as the Food and Agriculture Organization, the Global Environment Facility, national and state governments, researchers and practitioners. IWMI, ICAR, and ICRISAT see this as an important boost to promoting sustainable use of watersheds for improving livelihoods using water management as an entry point.

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Watershed Management Challenges: Introduction and Overview

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Introduction

In Asia and Africa, hundreds of millions of poor and marginal farmers rely on degraded land and water resources and struggle to cope with a diverse array of agro-climatic, production and market risks. It is estimated that the rate of land degradation in rainfed areas in India in the 1990s is likely to have proceeded at more than twice the rate observed in 1980s, basically on account of soil erosion from run-off (Reddy, 2000). At the same time, these regions in particular and the world in general does not have enough utilizable water needed to grow the food to adequately feed the future generations. The world is rapidly converting forest, wetlands and other critical habitats into agricultural land to meet growing demands and diverting major rivers to produce food (Anonymous, 2005). How to produce more and better food and maintain or improve critical ecosystem services without further undermining our environment is a major challenge.

Under such a scenario, the challenge is to manage land and water sustainably to achieve higher productivity levels, husband resources for future generations, and derive livelihoods in the most equitable manner possible. These are laudable goals; yet, specific management options must focus at the level of what is practical. Small holder farmers, livestock keepers, forest users, and others who derive livelihoods from land and water find that their interactions affect others in a watershed context. As a unit of land and water management, the watershed offers immense scope to improve crop productivity—whether of rainfed crops or under small-scale irrigation—and biomass for livestock. The concept of integrated and participatory watershed development and management has emerged as the cornerstone of rural development in the dry and semi-arid regions and other rainfed regions of the world, and is a paradigm shift from earlier plot-based approaches to soil and water conservation.

Over the past three decades, India has addressed these challenges head-on and made major investments in the area of watershed management through an appropriate mix of technical innovations, participatory approaches, and an enabling policy environment. There is certainly evidence of positive impacts in terms of improved soil and water conservation and agricultural productivity in normal rainfall years in regions that have been ignored in the conventional green-revolution-based rural development (Samra, 1999). Countries in Sub-Saharan Africa, South-East Asia and even China look towards India to learn from these experiences and adopt this unique natural resource based rural development model. However, overall gains from watershed development have not been equitably shared, either within the farming community or between different geographical settings. Even with massive public investments (approx. USD 700 million/annum) and a government- non-governmental organization consortium approach for programme implementation, less than 10 percent of the rainfed area in India needing immediate land and water treatment has been covered. Acute shortages of drinking water are experienced in several regions of the country and impacts of drought have become increasingly severe and recurrent. This calls for an assessment of watershed development and management approaches with a view to addressing biophysical, socio-economic, and institutional and policy issues. Several reviews on the performance of watershed development projects (Hanumantha Rao, 2000; Joshi *et. al.*, 2000, 2004; Kerr *et al.*, 2000, 2004; Palanisami *et al.*, 2002; Joy *et al.*, 2005) in India have diagnosed various limitations of watershed programmes, including the following:

- Productivity gains are often limited and temporary.
- Landless and marginal farmers often benefit only marginally or not at all, increasing inequities at the village level.
- Common lands do not get adequately treated and revegetation does not take place as expected.
- Gains from recharge of groundwater are rapidly dissipated through increased withdrawal.
- Domestic, livestock and ecosystem water needs often do not get adequately addressed and may even suffer as a result of increased withdrawal.
- Downstream impacts of intensive upstream water conservation are not being considered.
- Costs at which the gains are achieved are considered to be high.
- People's participation is limited to the watershed project implementation stage.
- No/little building of institutions for long-term collective management of resources.

Problems arise because the interaction between the biophysical and the socio-economic processes in watershed development is not properly understood and is not addressed in an integrated manner. Results from a meta-analysis comprising 310 watersheds revealed that the mean benefit-cost ratio of watershed programmes was quite modest at 2.14 (Joshi *et al.*, 2000). Some of the important challenges confronting successful implementation of the watershed management programmes in India and other regions are discussed below.

The Watershed Concept

The watershed approach enables planners to harmonize the use of soil, water and vegetation in a way that conserves these resources and maximize their productivity. The watershed is the appropriate hydrological unit for technical efforts to manage water and soil resources for production and conservation. But watershed management is complicated by the fact that watersheds rarely correspond to human-defined boundaries. The fundamental social problem of watershed development is that it often distributes benefits and costs unevenly, making it a likely source of disagreement and conflict. Mostly, watershed projects distribute costs and benefits unevenly, with costs incurred disproportionately upstream, typically among the poorer farmers, and benefits realized disproportionately downstream, where water use is concentrated and richer farmers own most of the land. The challenge is to internalize the costs and the benefits in such a way that all the stakeholders are part of a win-win scenario.

Equity

Equitable sharing of the benefits among all the intended population of the watershed remains a major challenge. By their nature, area development programs offer benefits primarily to landowners, with landless people benefitting indirectly, either through peripheral programme activities or trickle-down effects. In fact, watershed projects can actually make women and landless people worse off by restricting their access to resources that contribute to their livelihoods. Even some of the more participatory projects have found it difficult to ensure that benefits reach all the intended population. The very best projects help the poorest and socially backward community members negotiate with other members to ensure that everyone benefits, but this remains an area where all projects need to pay special attention. The role of livestock as a watershed-based livelihood strategy of landless, poor women and men needs further articulation as well as research and policy support.

Participation

Experience has shown that sustainability of watershed management projects is closely linked to effective participation of the communities who derive their living from natural resources. This requires sustained effort to inform and educate the rural community, demonstrate to them the benefits of watershed development and that the project should be planned and implemented locally by the rural community with external expert help (from government and non-governmental agencies) as required. Since the rural societies in the poor and developing countries are plural and stratified, divisions are based on gender, caste and religious groups, and socio-economic status including land tenure; ensuring participation of all sections becomes a major exercise in patience and social maneuvering. These conditions call for a flexible approach and responsiveness to diverse, often unexpected situations. The better performance of the projects with higher-levels of participation seems to be related to the complex, often site-specific locally prevalent livelihood systems. It is important to understand the conditions when people participate in watershed management programmes. These are: (i) making people aware of potential benefits of collective action in conserving and managing natural resources; (ii) including demand driven activities in the watershed program; (iii) empowering people in planning, implementing and managing watershed programs; and (iv) expecting high private economic benefits (Joshi *et al.*, 2000). The major challenge is to benefit the landless, the socially disadvantaged and resource-poor participants who have low ability to pay for the different programmes.

Government- Non-government Organization Collaboration

In general, government projects focus largely on technical improvements; the non-governmental organizations focus more on social organization and the collaborative projects try to draw on the strength of both the approaches. Fixed guidebook and physical target-driven approaches pursued by technocratic, hierarchical organizations are poorly suited to sustainable watershed management programmes. Organizations with better social skills (read NGOs) devote time and resources to organize communities to establish locally acceptable social arrangements and community-based leadership for watershed interventions. As such but with some exceptions, the performance of government-managed watersheds has been more modest while those managed by research institutions and reputed NGOs have been rather successful. The technocratic project officials who oversaw top-down approaches for many years are increasingly being called on to increase the level of local participation in the new government projects. Expecting them to rapidly transform their mindset from supervisor to facilitator is unrealistic; it will take time, orientation, training where required, and encouragement. This calls for a consortium approach of watershed development, which capitalizes on the synergies of the government machinery and the capabilities and advantages of research institutes and non-governmental organizations. Given the limited number of such organizations in poor and developing countries on the one hand, and the massive need and ambitious plans for watershed development on the other, implementation capacity poses a serious challenge.

Issues of Scale

Most of the successful watershed programmes in India have been implemented on a small scale in a few villages and through the collaborative and concerted efforts of research institutes, non-governmental organizations and government departments. These projects were successful as the participant organizations devoted time and resources to social organization, built each group's interests in the project, worked with the farmers to design interventions and select technologies; chose the village not the watershed as the unit of implementation; screened villages for enabling conditions, and ensured effective coordination in their work. Project staff generally worked very hard, and development funds for all kinds of activities were allocated on a priority basis. This facilitated the development of successful model watersheds like Sukhomajri, Ralegaon Sidhi, Chitradurga, Fakot, Kothapally, Tejpura, Alwar (all in India), Tad Fa and Wang Chai in Thailand and Xinoxincun and Luchebe in China and several others. Such special treatment will not be possible as watershed projects are replicated. Additionally, depending on NGOs to implement projects may work well on a small scale, but there are not enough capable NGOs to do so on the vast scale required to cover millions of hectares in remote and difficult terrain. Certain states in India have been more successful than the others by implementing these projects in "mission mode", viz., Karnataka Watershed Mission and Rajiv Gandhi Watershed Mission (Madhya Pradesh). Leveraging of international support from large donors like the World Bank, DFID, DANIDA, SIDA etc. have also been quite helpful in developing proper protocols, implementation strategies and internalizing international experience. Gujarat (India) has been successful in leveraging the participation of private entrepreneurs in implementation of a large number of successful village-level water harvesting structures. However, appropriate models for translating 'points of success' to 'regions of success' are still elusive and remain a formidable challenge for researchers and development agencies.

Water Rights

Property rights and collective action institutions fundamentally shape the outcomes of resource governance (Knox and Meinzen-Dick, 2001). Most successful watershed development projects create either a surface water body and/ or augment the underground water reservoir. Sharing of the created resource and ensuring its sustainability, especially the groundwater resource, is a complex problem. The famous Sukhomajri watershed is unique where the benefits were distributed equitably to all the villagers including the landless labourers and marginal farmers (Arya and Samra, 2001) and thus everyone had the incentive to save water. While surface water resource can be managed to some extent through conveyance, with groundwater the issue is particularly difficult. First, it is not always the case in small watersheds that water recharged through efforts in a particular village remains available to the same population. Second, water laws in most countries (including India) state explicitly that any landowner is entitled to water pumped from beneath his land, as long as it does not interfere with drinking water supplies (Sharma, 2001). As a result, project organizations can try negotiating arrangements to share groundwater, but they cannot force landowners who dissent. There have been several instances where benefits of enhanced groundwater supplies made possible through investment and a few influential/ rich farmers for their personal use or even sale to the neighbouring farmers pocketed efforts of whole of the community. Legislative reforms in this area would be extremely unpopular among those who own irrigation wells, but it could provide an important means of making watershed development more sustainable.

Conflict Resolution

Watershed programmes are often viewed as a shortcut to rural development; different ministries, organizations and institutions with divergent interests working at different levels have been implementing watershed programmes, giving rise to inherent contradictions and conflicts. Such conflicts may be at the federal level between different ministries (agriculture, rural development, forestry, environment, water resources etc.), each following its own guidelines, interests, approaches and resource allocation protocols. Whereas the agriculture ministry places greater emphasis on food production, the rural development ministry may design programmes for poverty reduction and employment generation, or the forest ministry declares all forest areas within the watershed 'out of bounds' for all other ministries. At the state and district level the conflicts are observed between government bureaucracy and elected representatives. Both these centres of power struggle to exercise control over the development funds from state or federal sources. It is important to internalize the comparative strengths of these different organizations in order to complement the overall development process by minimizing conflicts. Similarly, watershed committees and village level elected institutions at the local level, government departments and non-government organizations as the project implementing agencies, and upstream and downstream inhabitants within the village/ watershed have different perceptions and expectations from the project that can become potential source of conflict. The challenge is to ensure universal but flexible guidelines at higher levels of governance and the necessary flexibility and adaptability at the grassroots level to manage inherent contradictions and conflicts through adequately designed resolution mechanisms.

Assessing the Impacts

Inadequate monitoring and impact assessment of watershed programmes is a major concern. To date there are few comprehensive evaluation studies of integrated watershed management (Kerr, 1996). Watershed development projects affect social, economic and environmental activities. Traditionally, completion of activities and physical and financial targets are monitored rather than the process mapping, results achieved or their biophysical, socio-economic, and environmental impacts (Sikka, 2002). Given the vast budgets for watershed projects, a proper performance assessment would go a long way toward more cost-effective government investment. Currently, too many funds are allocated on the basis of too little information and the potential for waste is great.

Researchers and other agencies find it hard to conduct meaningful impact assessment studies mainly for want of baseline data against which to compare current conditions, and for lack of monitoring data for easy assessment of current conditions. In both government and non-government implemented projects, typically there is no systematic mechanism for storing baseline data and making it available at a later date. Moreover, these data collected for the purpose of planning (and not evaluation) are often discarded once the project work comes to a close. All publicly funded projects keep detailed records of funds spent, structures built, and other physical targets, but such information does not reveal much about the impacts. Kerr (2002) identified three main constraints for conducting meaningful impact assessments: (i) it is difficult to obtain the data that have been collected for monitoring, (ii) the available data are not organized in a common format across different types of projects, so that are not necessarily useful for comparison between project types; and (iii) the monitoring procedures, even if available in some projects, fail to address socio-economic issues or the implementation process.

There is a strong need to develop common guidelines for collecting baseline and monitoring data, which would not only help in analyzing the impacts of current and future activities but also plan corrective measures after mid-term evaluation. Kerr (1996) and Palanisami (2002) suggested that even a tiny sum (say

1 percent) of programme outlay spent on meaningful monitoring and evaluation would have very high pay-off in terms of achieving the programme objectives. The challenge, therefore, is to put in place an institutional mechanism for research and monitoring in the field of watershed development by involving reputed national institutions and international organizations for upgrading the quality of monitoring and impact assessment.

Knowledge Generation, Sharing and Brokerage

Different participants and stakeholders in a watershed development programme have different perceptions, expectations, and roles and responsibilities in project planning and implementation and there is a need to bring all of them to a common understanding. Adequate knowledge may be imparted to strengthen those processes and skills that help in the delivery of programmes and activities, convey technical subject matter in a demystified manner, develop communication skills and enhance community participation. Knowledge generation for successful design and implementation of large watershed development projects still is mainly entrenched in classical soil and water conservation techniques and makes little use of modern tools and techniques, viz., remote sensing, geographical information systems, decision support tools, computer based planning tools, institutional analysis, poverty and socio-economic analysis etc. There are only a few centres of advanced learning that are engaged in the development and effective dissemination of such knowledge. The capacity building needs must be redesigned according to the roles and responsibilities of the various actors in the programme. Government and non-government partners in a programme or implementing different projects in the programme should be encouraged to share their knowledge and experiences so as to draw valuable lessons and better appreciate each other's strengths and concerns.

A definite gender bias exists in the kind of capacity building and awareness programmes planned for men and women, as women are typically isolated from the scientific and technical aspects of watershed development. Issues of sustainability, equity, gender and community organization, project management and information system, and monitoring and impact assessment have received little attention in knowledge generation and sharing exercises. Whereas countries like India have more than three decades experience in watershed management and programmes have successfully evolved in the past; the efforts are of more recent origin in southeast Asia and Africa. International agencies (the Consultative Group on International Agricultural Research system, the Food and Agriculture Organization, and other UN agencies) with adequate experiences, exposure and presence in many developing countries can play an effective knowledge brokerage role by building knowledge bridges between the relevant countries. The ongoing experience of the International Water Management Institute, in collaboration with the Indian Council of Agricultural Research and the International Crops Research Institute for the Semi-Arid Tropics, to broker knowledge between the Indian National Agricultural Research System and their counterparts in eastern and central African countries has been quite encouraging. ICRISAT is also helping several countries in Southeast Asia and China for developing successful linkages with Indian counterparts on watershed development programmes. For reaching remote areas and a wide variety of knowledge users, setting up of virtual knowledge academies, distance learning programmes and other interactive modes of learning can be very quick, far-reaching and cost effective.

Overview

The International Workshop on "Watershed Management Challenges: Improving Productivity, Resources and Livelihoods" held during November 3-4, 2004 in New Delhi conducted its deliberations under the four major themes of resource management and conservation, livelihood impacts and equity outcomes, institutions and policies and knowledge and experience sharing through presentation of 25 well articulated, commissioned and reviewed papers. An overview of the important issues deliberated during the workshop is given below. Thanks and acknowledgements are extended to the authors and session rapporteurs, from whose reports we borrowed heavily in drafting the sections below.

Reversing Land and Water Degradation through 'Bright Spots'

Negative trends in resource degradation are a challenge that must be tackled to meet poverty alleviation goals and ensure ecosystem resilience. Throughout the world, poor farmers tend to be associated with marginal lands and low yields (Rockstrom *et al.,* 2003). Land degradation and water scarcity are generally agreed to be key factors limiting food production and wealth generation for poor people, and further degradation and scarcity are projected. Opportunities to begin to slow or reverse land and water degradation do exist. Intensification of agricultural systems in a way that is sustainable and compatible with the dual needs of nature and society, including food production, clean water, bio-diversity, and carbon sequestration is possible and demonstrated in numerous successful 'bright spots'. A recent assessment of bright spots that studied 286 recent cases from 57 countries covering 36.9 M ha showed increased average productivity of 83.4% across 12.6 M farms. The bright spots also sequestered 11.38 Mt C yr^{-1}, with an average gain of 0.35 t C ha^{-1} yr^{-1} (Pretty and Hine, 2004). Water productivity was improved by approximately 16 and 30% in irrigated rice and cotton systems respectively and 70 to 110% in rainfed systems growing cereals and legumes. Similar results were also obtained from 204 bright spots in southern India and Punjab. Local bright spots can play an important role in regional development by resonating laterally to increase adoption of promising farming systems, and vertically to improve policy making to support sustainable development. An in-depth analysis of the key drivers for the success of these bright spots included individual (leadership, aspiration for change), social (social capital, participatory approach), technical (quick and tangible benefits, low risk of failure, innovation) and external (markets, property rights, supportive policies) drivers. The importance of linking local 'bright spots' to larger scale biophysical, social and policy opportunities to reverse land and water degradation and preserve landscapes cannot be overestimated. The research was able to establish that significant opportunities exist for integrated land and water management in small holder system to improve water productivity and provision of ecosystem services including food supply, and larger scale biophysical, social, and policy approaches for preserving landscapes can enhance positive impacts of intensification on local bright spots and go beyond 'up scaling'.

Managing Rainwater for Improved Livelihoods

About 80 percent of the world's agricultural land is rainfed, contributing about 60 percent of global food production. Uncertainty of rainfall and poor socio-economic conditions of the farmers living in these regions, prevent them from making heavy investments in rainfed agriculture. Increased productivity through improved rainwater–use efficiency in rainfed regions through the adoption of a holistic and participatory consortium approach is possible (Wani *et al.,* 2003). Convergence of watershed activities such as agriculture, horticulture, livestock, fisheries, poultry and micro-enterprises to bring value addition to rural production provides a roadmap for improved livelihoods. *In-situ* and *ex-situ* conservation of rainwater through a range of innovative techniques and enhancing rainwater-use efficiency through supplemental irrigation has lead to the creation of a number of bright spots under different agro-ecologies. The success of interventions is further enhanced through integrated nutrient management (use of legumes and green manures, micro and secondary nutrients), integrated pest management, micro-enterprises, village-based seed banks and rehabilitation of common property resources. The impact of such watershed based interventions is visible through increased productivity in benchmark watersheds, a shift in cropping pattern and diversification, improved groundwater levels, reduced run-off and soil loss, and increased incomes. This convergence model implemented with participatory approach has the potential of scaling-up (experimental models to regional coverage) and scaling out (India to Africa, China, Vietnam, Thailand etc.). For the sustainability of such models, empowerment of all the stakeholders (farmers, partners, NGOs, government departments and policy makers) through capacity development is very critical. Further, there is a need to investigate and explore a range of opportunities to promote village level micro-enterprises and pathways for market links for rural produce.

Watershed Management in Upper Catchments

Upper catchments are important source of water, energy, ecological diversity, basic raw materials, and flora and fauna. Although significant opportunities exist in upper catchments for improved water, land and biomass management, the complexity and diversity of resource users for a variety of uses within upper catchments often limit potential improvements in water management (Cook *et al.,* 2001). Upper catchments in the Himalayan region are characterized by exploitative land use leading to high rates of soil erosion, low crop productivity, high population of low yielding livestock, loss of biodiversity, shrinking forest cover and pasture lands, and excessive human population. There is an increasing frequency of disasters such as landslides, floods, droughts, hailstorms, sedimentation of reservoirs and deterioration of water bodies due to accelerated deforestation, conversion of marginal/ forest land into agriculture and unplanned developmental activities like road construction, mining etc. Over the years, the flow in natural springs and streams has sharply declined. The average annual run-off ratio (volume of run-off/

volume of rainfall) in the Himalayan watersheds is estimated to vary from 15 to 20% in the valleys to as high as 50% in high hills. The average annual soil loss in the Himalayas has been estimated as 20 t/ha/ annum. It is estimated that sediments from the Himalayan rivers contribute a quarter of the total ocean sediment (Valdiya, 1997).

The participatory integrated watershed management approach currently being adopted has shown encouraging results over the previously adopted commodity based or sectoral approaches. The strategies in integrated watershed management programmes include land configuration systems, agronomic measures, alternate land use systems, run-off harvesting and recycling methods and measures for control of mass erosion problems. Some of the successful technologies for watershed management in the upper catchments included organic mulching, conservation bench terrace system, horticulture development in valley and other suitable lands, low density polyethylene film lined tanks for supplemental irrigation, construction of check dams and planting of grasses in the lower foothills, agri-silvi-horticultural systems for degraded lands, and mushroom and off-season vegetable cultivation in low cost poly-houses. Mass erosion control in mine spoil and other vulnerable areas through integration of protective, mechanical and vegetative measures. A paradigm shift from externally driven, centrally controlled, target oriented and top-down approaches to people-centered, bottom-up and demand driven approaches has paid rich dividends but needs further evaluation for different agro-ecologies and implementation strategies. Priority areas of research for better understanding of upper catchments include hydro-ecology of upper catchments, issues of scale in watershed assessments, participatory change processes in watershed management and watershed research, upstream-downstream conflicts and complementarities, trade-offs and environmental externalities of catchments management; property rights, land tenure and collective actions, and water, poverty and livelihood in upper catchments.

Forest-watershed-irrigation linkages: Forests and water for irrigation are two central resources for livelihood enhancement, especially for the rural poor in upper catchments. Restricted access to often-degraded water, land and forest resources combined with low productivity of open-access resources invariably result in seasonal or permanent out-migration and the loss of traditional knowledge, labour for management and community solidarity to address resource degradation. There are a number of successful community based natural resource management innovations (Community Forestry Policy in Nepal and Joint Forest Management Programme in India) that have led to significant improvements in food security and livelihood sustainability. The major shortcomings of these resource specific institutions, however, have been their ineffectiveness in resolving inter-sectoral conflicts. Successful examples of multiple resource management (say forest and water) by communities are less common. Integration of activities of forest user groups and water user groups at the watershed level would improve the management of natural resources and have beneficial impacts on the livelihoods dependent on both the resources. The development of watershed level institution is expected to overcome problems associated with land, forest and water management by integrating the activities of various local level institutions like Water User Groups, Forest User Groups, local elected institutions and other interest groups while at the same time providing crucial external institutional linkages. Such integration would also help to empower local communities in a broader context of decentralization while providing an improved incentive structure for collective action.

Managing Common Pool Resources

Common pool resources (CPRs) of land, water, forest, fisheries, wildlife and agriculture constitute an important component of community assets in India and several other developing countries and significantly contribute towards the people's livelihoods despite the decline in their area and physical productivity. The poor households and small farmers secure a substantive portion of their fuel, fodder, income generation, and risk minimization through CPRs (Jodha, 2002). However, despite this CPRs are generally neglected and declining in different areas. The decline is visible in their shrinking area, biophysical degradation, and loss of management systems. Not only has the availability of products from CPRs declined drastically but also the overall biodiversity and carrying capacity of pastures have seriously declined. Increased population pressure, regressive land distribution policies, insensitive land reforms, introduction of more formal village institutions (disregard to 'social capital'), integration and penetration of market forces to remote villages and negative impacts of other development programmes are cited as some of the reasons for rapid degradation of CPRs (Marothia, 1993; Jodha, 1996).

Local land and water management and rainwater harvesting in a watershed context provide the key to the transformation of the ecological and economic base of villages economically dependent on CPRs (Agarwal and Narain, 2002). In order to develop a good village-level natural resource management programme, it is essential to develop a conceptual framework that addresses both the private and common property resources of the village, its diverse biomass needs, and the interests and needs of different socio-economic groups within the village community. Such eco-regeneration of CPRs will have a significant impact on the village economy by increasing local carrying capacity, increasing incomes and local employment, and reducing distress migration. To replicate the scattered successful experiences of Sukhomajri, Ralegaon Sidhi, Tarun Bharat Sangh (Alwar), Nartora watershed (Chattisgarh) and several others, it is essential to emulate the system of governance that enabled local communities to improve and care for their resource base. The Rajiv Gandhi Watershed Development Mission of the Madhya Pradesh Government and similar efforts in Karnataka have shown that the state can replicate community based efforts if there is adequate political will and pressure on technical and administrative bureaucracy to deliver results. Institutional arrangements (both external and internal) are important factors in CPRs management under different property rights regimes. The basic requirement for effective management of community-based resources is an authority system that can guarantee the security of expectations to the resource users. Distributed and decentralized governance seems to be most appropriate for designing CPRs management programme in the initial phase of watershed development before withdrawal of technical, financial and organizational support.

Livestock-Watershed Interactions

Under semi-arid rainfed conditions, the pre-dominant farming system in almost all watershed areas is the mixed crop-livestock farming. Livestock constitute an important asset base on which village communities depend for supplementary incomes, especially in times of stress. With diminishing land-holding size, diversification of agriculture became an unavoidable compulsion and for vast majority of households in water scarce areas, livestock invariably was the first option. Small and marginal farmers hold bulk of the milch animals in India (67%), small ruminants (86.6%) and pig and *desi* poultry (over 90%) (Kurup, 2003). Water and fodder are the most critical constraints for livestock development in semi-arid areas. Though livestock is generally considered to have high importance particularly for resource poor farmers, there is lack of an explicitly spelled out policy or priorities for livestock management in watershed programmes. Watershed programmes are often not recognized to have substantial benefits for livestock-based livelihood dependence; however, the enhanced productivity of biomass that should be accessible to landless or marginal farmers from watershed programme implementation is crucial to livestock-dependent livelihoods.

There is no great increase in total livestock population as a result of the watershed development programmes, but there is a change in composition of the population. Dairy appears to make an increasing contribution to the income from livestock. In a typical Shiwalik foothill village, which experienced integrated watershed management, the village derived 54% of its total income from animal husbandry (Arya *et al.*, 1994). A gradual shift from local stock to crossbred animals was observed in cases where markets were accessible. However, due to reduction in grazing space and ban on grazing imposed under watershed development programmes, the population of small ruminants has declined. The positive environmental and livestock impact of the grazing ban is visible, but it is not clear how the landless and other poor livestock owners, which were dependent on public and private grazing resources, were rehabilitated (Kerr, 2002). Local agreements for community pasture management need to be established in which all stakeholders have a say. Similarly, the relationship between villagers and the forest department is generally strained with the forest departments hesitantly permitting villagers to co-manage and develop forestland for use. Even where communities invest in plantations and biomass development, the user rights of these newly created assets are not secure. Several examples exist of villagers investing in plantations and the forest department later forbidding the biomass to be used. To enhance and stimulate local resource management, clearer agreements between government departments, *panchayats* (village councils) and villagers are needed that clearly define roles, responsibilities and sharing of benefits.

The importance of common property resources and pasturelands for sustainable livestock activity in watersheds needs to be emphasized. There is also a need for assessment and inclusion of livestock fodder needs in forestry projects. Livestock owners may be organized into user, self-help or beneficiary groups to have a strong voice in local decision-making. Effective use of watershed development institutions needs to be made to build necessary linkages to develop and exploit markets for livestock and their products.

Upstream-Downstream Conflicts in Water Scarce Watersheds

The most important lesson learned from the Indian experience is that greater water availability made possible by watershed development is rapidly captured as private benefits through increased use, often as groundwater using conventional inefficient irrigation methods. The implication is that watershed management as practised now cannot alone satisfy increasing demands and that allocation and demand management of water must be dealt with as well. Generally, landholders in the valley bottom capture most of the improved water resources created by investments in good land management practices by other stakeholders. In the post-development phase of watershed programmes, attention has to be shifted to efficient use of natural resources and increasing production potential by: (a) proper estimation of natural resources availability and augmentation of sustainable use, (b) improving agronomic practices through farming system approaches, and (c) demand management of water. Scales of watershed management may vary from household, community, watershed, meso-watershed (group of watersheds) and river basin. Presently, the whole exercise of watershed development is being undertaken without really estimating how much water is received in, how much is stored where, and how much can be used under different availability scenarios (drought, normal, surplus years). Alteration of flow paths in a particular watershed will not only affect the neighboring downstream watersheds but it will also have impact on the whole basin. Besides the complexity inherent in the hydrology of watersheds, a basic problem encountered in watershed management is the complexity of the institutional arrangements needed to manage large watersheds or basins that consist of large number of small micro-watersheds. Several case studies analyzed in water scarce regions of Gujarat and Madhya Pradesh states of India revealed that over-development of water harvesting structures upstream substantially reduced the inflows to the downstream reservoirs. As the area covered by watershed interventions increases, wider issues such as upstream-downstream equity, allocation of water among and within watersheds, flood protection, drought preparedness, pollution of water courses, biodiversity and protection of rare habitats will increasingly become important during the planning process and formulation of development proposals.

Enhancing Tribal Livelihoods in Watersheds

Most watershed projects are implemented with the twin objectives of soil and water conservation and enhancing the livelihoods of the rural poor. The importance of these programmes is particularly high in regions where agriculture is dominantly rainfed. Roughly one hundred rainfed districts in India across the belly of the country (between 18° and 25° latitudes) are home to more than 70 percent of India's tribal population. These districts have fair to high annual rainfall, undulating, hilly and mountainous terrain and a relatively good forest cover. Tribals derive a portion of their livelihoods from rainfed monsoon (*kharif)* farming and the balance from forest produce gathering and/or wages earned by seasonal migration. Despite high rainfall, the tribals generally lack facilities to harvest and access water for stabilizing their *kharif* yields and much less taking a second crop. Reduction in sustained opportunities from the forests, deterioration in the quality of land resources, lack of public policy on tribal agriculture, and increasing population pressure have created an all-too-common pattern of tribal misery in India. Watershed programmes can make significant impacts on tribal livelihood; however, tribal people have not been able to benefit from watershed interventions (Pangare, 1998). Investments in soil–water conservation alone do not seem to have exerted any significant impact on poverty reduction except through direct employment generation during implementation of the watershed programme (Fan *et al.*, 2000). Reduction in migration is achieved only for families who benefit in terms of substantial increase in irrigation provision. Enhancing access to improved water control is, therefore, critical to improved productivity and migration-reducing impact of watershed interventions.

Several studies (Mardikar, 2003; Khorasi, 2004) have shown that whereas watershed projects were popular for their wage work opportunities during the implementation phase, such biophysical activities had little impact on tribal livelihoods post-implementation. On the other hand, good income generating interventions like BAIF's *Wadi* Model (0.5-1.0 acre agri-horti-forestry plot) have been successfully implemented in several locations in tribal Gujarat, Maharashtra and Rajasthan. Similarly, low-cost on-farm and close-to-farm water harvesting structures (5% Model, *Hapas*, seepage tanks) developed by NGOs have shown encouraging results in tribal areas.

When access to common property resources such as forests and pastures is controlled with the aim of regenerating them naturally (social fencing), the highest costs are paid by tribal people and other marginalized communities who depended significantly on these resources. Shah (2004) suggests that specific allocation of water for pasture irrigation should be made in each watershed to hasten the process of regeneration. For enhancing tribal livelihoods in the watersheds, a shift from focusing on the 'degree of resource use' to the 'productivity of resource use'; and from ridge-to-valley to a farms-to-commons approach would have visibly beneficial impacts on the livelihoods of the neglected and marginalized tribal communities.

Mitigating the Migration

Poor people from rural and less endowed areas resort to seasonal, circular and other forms of short-term migration to eke out a better livelihood. While it is true that people migrate out because there is not enough work locally, many poor people perceive migration as an opportunity to escape highly exploitative patron-client relationship in the village and earn far more than they would ever be able to in their own villages (Deshingkar and Start, 2003; Deshingkar, 2004). An interesting dimension is the relationship between agriculture, natural resources and migration. A common assumption is that deteriorating agriculture leads to out migration and improving the natural resource base and generating employment in rural areas can mitigate migration. Watershed development implementation can affect migration through an increase in short-term employment as well as long-term productivity gains. The evidence indicates that many watershed development programmes do succeed in reducing migration rates at least during the implementation phase. Sastry *et al.* (2003) showed that migration rates reduced in all the 37 watersheds studied and the reduction ranged from 22% in government agency implemented watersheds to 42% in NGO implemented watersheds. This was attributed to the improvement in several physical and biological factors. However, only in a handful of cases has a near complete halt or reversal of migration been achieved. Recent review of several watershed programmes in Karnataka and Maharashtra states of India concluded that impact of watershed development on livelihoods and migration and employment patterns has not been as significant as the impact on soil and water conservation.

Declining opportunities in agriculture, natural disasters like droughts and floods, poor mountain and forest economies and the fall in agricultural commodity prices (due to macro-economic reforms) act as 'push factors' for migration. Growing urbanization, spread of manufacturing and the gap in rural and urban wages act as the main 'pull factors'. An important implication of livelihood diversification (through out migration) is that natural resource-based activities may become part-time and this could have negative consequences particularly for participatory resource management such as watershed and community forestry programmes. It is very likely that the increase in productivity as brought about by watershed development alone may not be sufficient to stem the tide of migration and sustain rural livelihoods (Reddy *et al.*, 2004). There is, therefore, an urgent need to understand how watershed development can become a part of efforts to support more diverse livelihoods where a win-win situation can be created say, through improving the resource base which creates a more conducive environment for investing remittances leading to an overall increase in growth, employment and poverty reduction.

Policy and Institutions for Participatory Management

India has experience of more than three decades in the area of publicly financed soil and water conservation and natural resources based rural development. As the impact of such interventions was slow, inequitable and short-lived, serious thought was given by academicians, policy planners and civil society to streamline the policy and implementation guidelines. The severe drought year of 1987 demonstrated the potentialities of watershed management as a mitigating strategy, and as a result, the programme was scaled up at the national level with larger public investments. In these programmes several innovative ideas were introduced and the programme is still evolving. Some of the significant policy changes introduced were: (i) The past monopoly of central and state governments in the implementation of publicly funded watershed programmes was diffused by recognizing reputed NGOs/ registered institutions as equal partners. Watershed level institutions were empowered through decentralization of decision-making processes, (ii) The sectoral approach was replaced by the formation of multi-disciplinary watershed development teams. Formation of Self-Help Groups and User Groups was also encouraged in order to ensure wider participation, (iii) Financial systems were made more transparent through the inclusion of watershed association members as co-signatories to all financial transactions, (iv) To ensure better initial acceptance of the programmes by the local communities, about 3% of the budget was earmarked to take up the most pressing entry-level activity (approach road, drinking well, religious structure etc.), (v) Beneficiary communities were also required to make reasonable contributions in cash or kind (labour, local materials etc.) to ensure personal and community commitment to the project structures and interventions, (vi) Suitable exit protocols were developed for use after the active implementation phase for maintenance of the structures and upkeep of the institutions, (vii) Training, exposure visits and skill enhancing activities of the local communities and service providers were an important and integral part of watershed programmes for better internalization of the potential of new technologies and indigenous technical knowledge, (viii) Landless and other socially or economically disadvantaged members of the community (including women) were specifically prioritized through micro-credit and micro-enterprise activities to minimize inequalities and social conflicts, (ix) Persons involved in similar activities were encouraged to form user group for realizing economies of higher scale and minimizing transaction costs, and (x) Suitable regulations were imposed to restrict the expenses on the salary of project functionaries (max. 10%) so as to realize maximum allocations for actual project activities.

Since this was a new development paradigm, it went through institutional conflicts at various levels involving federal ministries, federal vs. state level policies, district level conflicts between the bureaucracy and elected representatives, watershed and village level conflicts, government and non-government organization conflicts, and upstream and downstream conflicts within a watershed and across watersheds. However, most of these conflicts could be resolved through persistent dialogue, application of a flexible approach, and improvement in the guidelines. Policy, institutions, empowerment and equity-based reforms are still in a dynamic, formative stage, and will require continued assessment and modification.

Sustainability of Participatory Approach

Taking the watershed as the basic unit for planning and implementation internalizes the externalities of soil and water conservation in village decision-making, thus allowing for optimization of conservation results (Knox *et al.*, 2001; Swallow *et al.*, 2001). A common assumption is that participatory approaches to watershed development have been more successful than technical approaches because they better succeed in addressing the disincentives for household investments in soil and water conservation, they subsidize costs and pay attention to wider constraints to farm household production (micro-credit, capacity building, market linkages etc.; Farrington *et al.*, 1999). However, external interventions cannot change the socio-economic and agro-ecological context in which rainfed agriculture is practised. Users will not cooperate to invest in heavily degraded resources, as expected benefits are low, but may decide to cooperate if the resource base is rehabilitated and the expected benefits of cooperation increase. Studies conducted in four meso-scale watersheds in India to assess the importance of contextual variables in explaining project results and longer-term impact of project interventions on soil and water conservation revealed that 'intensity of treatment' seemed to play an important role- more intense (costly) interventions have a greater probability of being sustained in the long run. Another contextual factor was the degree of market development, which positively affected the incentive to invest in soil and water conservation because of a low benefit-cost ratio. But once investments are made, households do choose to maintain the structures because of significant effects. Village level inequality should also be recognized; involving all stakeholders and ensuring access to conservation benefits in the long run are crucial determinants for sustainability of participatory watershed development.

Integrating Watershed Management Institutions

Though watersheds are physical units in nature, institutions evolved over time that are essential for their management do not strictly follow their physical boundaries. These institutions interact in diverse action arenas to facilitate or constrain actors involved in managing watersheds. Again a number of factors (physical, social and cultural) influence the arena, but institutions constitute a crosscutting factor and a particular driving force in the decision making process (Young, 1999). Agents interact among each other to take decisions within and among diverse arenas. In each, institutions integrate in diverse and complex ways to facilitate and constrain decisions. Understanding the institutions involved will improve understanding of the complexity and interactions among institutions in various arenas. Three principal types of institutions interact in watershed development arena and enable agents to take decisions: (i) policy, (ii) legal, and (iii) administrative institutions.

Diverse forces influence resource management in watersheds, but the institutional options available invariably do not match with ground reality. External agencies (state governments, donors, NGOs) impose different concepts and conditions (carried through funding) by creating new institutions. Rarely do these funding agencies attempt to examine and modify the institutional failures of existing distributive governance. The poor who are caught between the macro (formal) and micro (informal) are being increasingly marginalized in the process. Addressing them requires an effective role of various institutions in addressing education, lack of income generating opportunities, overcoming the constraints imposed by natural factors, and importantly, social forces that have often led them to poverty.

Watershed Management Efforts in Thailand and China

The concept of people-centric integrated watershed management is rather new in China and other southeast Asian countries. Accelerated and continued deforestation in several parts of Thailand has lead to widespread land degradation and very low agricultural income for a large number of small holding farmers. Many regions of Thailand (46 out of 76 provinces) are facing water shortage and as a result vicious cycle of soil degradation, low yields, poverty and low investment has gripped the rainfed agriculture. Most of the earlier initiatives by various government departments focussed either on increasing the availability of water for agriculture or reducing soil erosion. A multitude of agencies related to agriculture, land development, land reforms, irrigation, energy, mines and minerals and public health were engaged independently in different activities related to land and water resources development in different regions. In spite of large (but uncoordinated) investments and efforts, the impacts were small and short-lived. However, it was realized that development of small-scale water resources in the rainfed areas (80% of total) played important role for improving productivity of rainy season paddy and obtaining higher income from dry season crop cultivation. More recently, the multi-disciplinary consortium approach is focussing more on increasing the productivity and improving livelihoods of farmers through better management of natural resources.

People-centric integrated watershed management programme implemented during the last five years in Tad-Fa and Wang Chai watersheds in Khon Kaen province of northeast Thailand was quite successful. The experience validated the consortium approach, resulted in tangible economic benefits to individual farmers and participatory planning helped in proper location of the water ponds and other structures. Innovative interventions like cultivation of fruit trees were highly successful. It was found that most of the farmers cooperate when offered immediate private gains rather than long-term social gains. Self-help groups helped the farmers to share the knowledge on improved technologies and find solutions to common problems. Capacity building was important for internalization of new knowledge and sustainability of the new institutions. However, success of the programme needs to be considered in the absence of large subsidies being provided by the government.

Mountainous topography, multi-ethnic residents and poor eco-environmental conditions characterize southwest China. The major constraints in this region are severe soil erosion, water scarcity for crop production and land degradation. Earlier research by the local institutes laid emphasis on vegetable production in hot-arid valley regions, rainwater harvesting and its utilization in adjacent areas, crafting land development institutions and selection of drought resistant crops/ varieties. Integrated watershed management was introduced in the region with major emphasis on rainwater harvesting and its efficient utilization, control of soil erosion and other interventions to improve income of farmers. This approach was evaluated in Xinoxincun and Luchebe watersheds, which were highly degraded (up to 43.3 t/ha/ annum soil loss) with huge expanding gullies, having small land holdings and poor income condition. Some of the successful interventions in the watersheds included formation of community groups, rainwater harvesting through tanks and cisterns, crop diversification through inclusion of horticultural crops, integrated plant protection management, evaluation and introduction of forage crops to check overgrazing on steep slopes, drip irrigation of horticultural crops and improving market information and access. Capacity building of farmers for better adoption of new technologies was an important component of the project and helped in better results. Integrated watershed management, though in its nascent stage in China, was poised to achieve the twin objectives of economic development and improvement of eco-environmental conditions in western China.

Potential for India-Africa Knowledge Exchange

The Human Development Report (UNDP, 2003) indicates that 60% of the combined population (285 million) of the ten countries of Eastern and Central Africa (ECA) currently live below the 1 USD/day poverty line. The region spends about USD 18 billion to import food annually, receives 3 million tonnes in food aid even in normal years, and still leaves 200 million of its people chronically hungry. The regional and country level strategies recognize that the high level of poverty and chronic dependence on food aid, despite ample availability of gross land and water resources, is largely a result of failure to effectively manage the natural resource base for agriculture and other productive purposes. Land degradation is a major problem in the areas of concentration of rural and urban population such as highlands of Ethiopia as well as the Lake Victoria Basin (500-1000 people per km^2). More than 95% of crop and livestock production is by small holder subsistence farmers and pastoralists, mostly using low inputs. But, estimates made at continental level show that the rate of loss of nutrient from small holder fields are in the range of 660 kg N, 75 kg P and 450 kg K per hectare (Buresh *et al.,* 1997). Temporal and spatial variability of rainfall is a major constraint to productivity. Droughts followed by floods have been a major cause of famines affecting millions of people during the last 50 years. In spite of abundant water resources, most of the countries in ECA face an economic water scarcity due to inadequate investment in water control structures and systems for effective management of water resources. Most of the past watershed management projects focussed on erosion control and afforestation without due attention to improving livelihoods, microeconomic conditions, or equity; they did very little to improve productivity within the croplands. Recent reviews showed that technical innovations and technologies by themselves are not adequate to bring about increased productivity of land, water and labour. There is a need for equal emphasis on innovations in policy, marketing, institutions, and infrastructure and financing.

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) identified three main thrusts for collaboration with South Asia (India) for enhanced access to: (i) NRM knowledge, information and technologies; (ii) policy and institutional arrangements; and (iii) capacity building and knowledge management strategies to ensure access and utilization of knowledge from global, regional and national resources. Several technical solutions are available in the region but are scarcely being implemented for want of inadequate expertise/ experience on the economics of different approaches to NRM, components and optimum levels of integration, role of markets and strategies for their strengthening, and justification of public investment in improved management of agro-ecosystems. Specific knowledge exchange is required to understand the role of subsidies, crafting and management of local institutions, regulatory frameworks and enabling policies and enhancing capacity of human resources at all levels to ensure innovations and adaptation. Technologically, countries in ECA have attempted virtually similar interventions as those implemented in India, but with negligible impact. Explaining these differences will be a good entry point for strategic policy planning in the region. Collaboration and partnership between ECA, India and international organizations with respect to strategies for integrated management of watersheds is a strategic necessity of paramount importance.

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Linking Land, Soil and Water Management

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Abstract

Land and water degradation threaten food security for many of the poorest and most food insecure living in South Asia, Africa and Latin America. It also contributes to persistent poverty, and results in decreasing ecosystem resilience and provision of environmental services. Negative trends in resource degradation are a challenge that must be tackled to meet poverty alleviation goals. The Comprehensive Assessment (CA) of Water Management in Agriculture is a global research and consultative project that evaluates current water management challenges and solutions, and identifies the best options for the future. The 'Bright spots' project of the CA addresses linkages between land and water degradation and agricultural productivity, livelihoods and environment.

This paper briefly reviews the current state of knowledge related to the condition of global land and water resources, and highlights the importance of linking land and water management at local and landscape scales in order to address pressing issues. Evidence, primarily from the 'Bright spots' project, but also from the wider on-going CA consultation process, is presented to support the key messages: (1) significant opportunities exist for integrated land and water management in small holder systems to improve water productivity and provision of ecosystem services including food supply; (2) larger scale biophysical, social, and policy approaches for preserving landscapes can enhance positive impacts of intensification on local 'Bright' spots and go beyond 'upscaling'; and (3) productive use of low quality waters is possible and provides opportunities to close large gaps in nutrient cycles to slow or reverse trends in land degradation and water pollution. These strategies could help reverse land and water degradation, and intensify agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services including food production, clean water, biodiversity, carbon sequestration, and resilience to climate change.

Introduction

The Comprehensive Assessment (CA) of Water Management in Agriculture is a research and consultation project that evaluates current water management challenges and solutions, and identifies the best options for the future. Governments, donors and rural communities have invested billions of dollars in water development and management to boost food production, improve livelihoods and foster economic growth. Yet we still don't have a comprehensive view of the impacts of that investment or a clear consensus on questions such as: "How much water will be needed to produce enough food for our growing population?" "How can we grow more food with less water?" "How can we best manage land and water in rainfed agriculture to increase food production, improve rural livelihoods and maintain biodiversity?" (Molden and de Fraiture, 2004). One important research question under the CA is, "What are the consequences of land and water degradation on water productivity and the multiple uses of water in catchments?" The 'Bright spots' project of the CA addresses this question, exploring linkages between land and water degradation and agricultural productivity, livelihoods and environment, to identify key challenges and opportunities for the future.

Land and water degradation threaten food security for many of the poorest and most food insecure living in Asia, Africa and Latin America (Kaiser, 2004). It also contributes to persistent poverty, and results in decreasing ecosystem resilience and provision of environmental services (Costanza *et al.*, 1997). Poor farmers tend to be associated with marginal lands (Table 1), and low yields (Rockstrom *et al.*, 2003). Increased expansion of agriculture into new areas is contrary to conservation goals in many countries, and if expansion is onto even more marginal lands, has little hope of improving livelihoods for poor rural farmers. Meeting poverty alleviation goals therefore requires that downward spiraling trends in resource degradation be arrested and reversed.

This paper briefly reviews the current state of knowledge related to the condition of global land and water resources, and highlights the importance of linking land and water management at local and landscape scales in order to address pressing issues. Evidence, primarily from the 'Bright spots' project, as also from the wider on-going CA consultation process, is presented to support the key messages: (1) significant opportunities exist for integrated land and water management in small holder systems to improve water productivity and provision of ecosystem services including food supply; (2) large scale biophysical, social, and policy approaches for preserving landscapes can enhance positive impacts of intensification on local 'Bright' spots and go beyond 'upscaling'; and (3) productive use of low quality waters is possible and provides opportunities to close large gaps in nutrient cycles to slow or reverse trends in land degradation and water pollution. These strategies could help reverse land and water degradation, and intensify agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services including food production, clean water, biodiversity, carbon sequestration, and resilience to climate change.

Table 1. Relationship between rural poor and marginal land

Region	Rural poor on favored lands (millions)	Rural poor on marginal lands (millions)	Rural poor on marginal lands (%)
Sub-Saharan Africa	65	175	73
Asia	219	374	63
Central & South America	24	47	66
West Asia & North Africa	11	35	76
Total	319	613	66

Scherr (1999), based on Nelson *et al.* (1997).

Land and Water Degradation

Current Trends

Land degradation has been estimated to affect 50 percent of agricultural lands over the last 50 years with up to 70 percent of cultivated land in Sub-Saharan Africa now affected by some degree of degradation. Effects including salinization, erosion, nutrient depletion, carbon loss, and loss of water holding and buffering capacity have resulted in reduced productive potential and abandonment of lands (Wood *et al.*, 2000). Degrading and abandoning land is strip mining our agricultural land resources (Penning de Vries, 2001). While we may not run out of soil before oil, as was predicted by Lester Brown of the Worldwatch Institute in the mid-1980's, the process is similar. It can be estimated for example (Fig. 1) that lands abandoned in Latin and Central America account for approximately 15 percent of historically available arable lands in that region, that an additional 20 percent are currently cultivated, leaving 'reserves' of approximately 65 percent. In South Asia, however, land is 'over-cultivated', i.e. in aggregate for the region there are no reserves, marginal lands are already exploited, and 40 percent of historically available arable land has already been lost. This proportion will increase to 50 percent by 2020 (Penning de Vries, 2001).

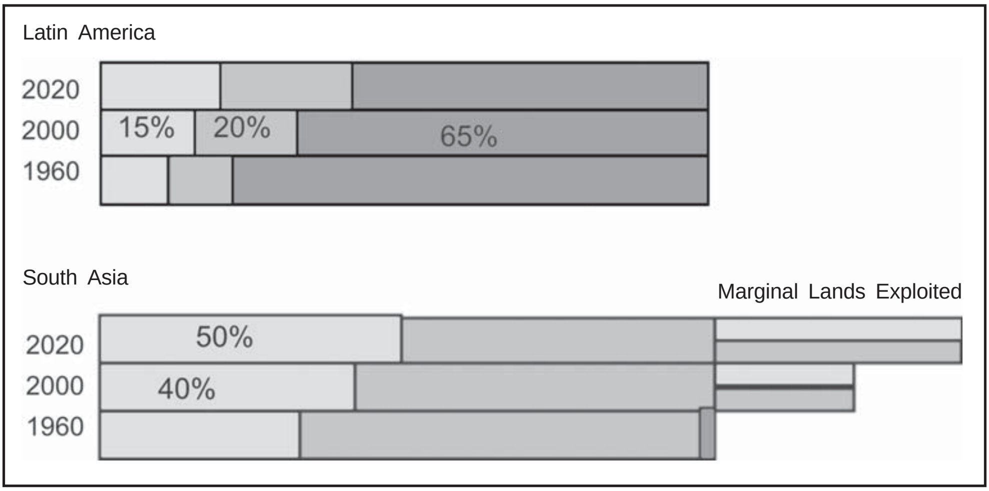

Figure 1. "Strip mining" of soil resources. For each region the full length of the bar represents historically available arable lands, which is split into fully degraded (▢); currently in use for agriculture (▢) and still available (▢). Where the bar is split (▢) / (▢), it indicates when more land is "used" than is "available" for sustainable agriculture (Penning de Vries, 2001)

Water resources are also over-exploited in many basins. Surface water in important river basins such as the Colorado, Huang-He (Yellow), Indus, Nile, SyrDarya, and Amu Darya is 100 percent exploited to the detriment of aquatic ecosystems and human well being (WRI, 2000). Equally important are trends in unsustainable groundwater exploitation particularly in South Asia (Morris *et al*, 2003). Water scarcity is generally agreed to be a key factor limiting food production and wealth generation for poor people, and increasing scarcity is projected (Fig. 2). Water pollution is also an increasing concern (WRI, 2000), and there is now about 12,000 km^3 of polluted water on the planet, equal to more than the contents of the world's ten biggest river basins, and equivalent to six years worth of worldwide irrigation needs. Water quality degradation limits the range of productive uses of that water, and in particular degrades the value of that water for environmental services. The conflict between irrigation and wildlife conservation is already considered to be at a critical point (Lemly *et al.,* 2001) due to the impacts of irrigated agriculture on wetlands and wildlife.

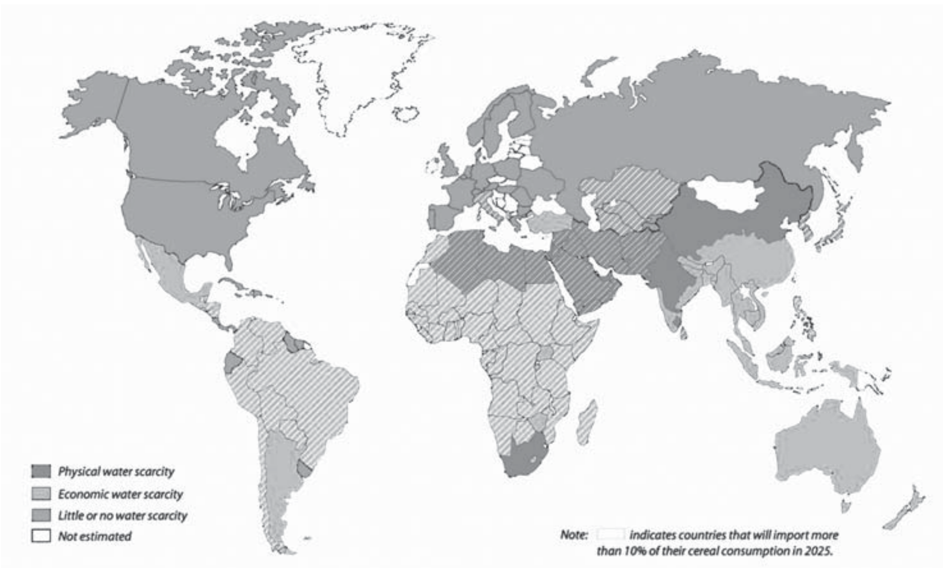

Figure 2. Projected water scarcity in 2025 (IWMI, 2000)

Processes Linking Land and Water Degradation

Parallel Trajectories of Land and Water Degradation On-site

Land and water degradation occur in parallel and are interlinked. The relationships are obvious, but often these resources are still considered independently. In particular land management options can be understood and acted upon in relation to the 'water crisis.' Mismanagement of land degrades water quality and reduces water productivity (Molden *et al.,* 2003; Zwart and Bastiaanssen, 2004). At the extreme, complete crop failure in rainfed systems reduces water use efficiency to zero. While this is often due to temporary or seasonal drought, is also caused by soil nutrient and carbon depletion that reduce productivity and increase drought sensitivity. More commonly chemical and biological degradation of land result in incremental reductions in water productivity. Examples from northeast Thailand demonstrate that on tropical sandy soils, chemical and physical degradation strongly limit water productivity in both rainfed and irrigated systems (Noble *et al.,* 2004a). Water productivity can be increased 250 and over 500 percent in irrigated and rainfed systems respectively, when soil amendments that alleviate chemical degradation are applied. Even in the relatively dry Sahel region it is often the supply of nutrients, not water as commonly assumed, that limits farm productivity (Penning de Vries and Djiteye, 1982; Breman, 1998).

Mismanagement of water similarly contributes to degradation of land, such as increasing erosion, salinization and water logging. Salinization of soil and water affect productive potentials, reduce water use efficiency, result in loss of high quality water to saline sinks, and abandonment of previously arable lands. Although data is poor, estimates indicate that worldwide 20 percent of irrigated land suffers from salinization and waterlogging (Wood *et al.,* 2000). As an example, in the Bhakra irrigation system in Haryana a major threat to sustainable production is significantly declining wheat yields due to shallow and rapidly rising water tables (Bastiaanssen *et al.,* 1999). Water tables in the Sirsa irrigation circle are rising at a rate of 82 cm $year^{-1}$ with salt accumulation at 1.8 t ha^{-1} yr^{-1}. Over half the land area is now affected (Sakthivadivel *et al.,* 1999).

Landscape Cycles and Off-site Impacts

The costs of degradation in terms of lost ecosystem services are not all realized or appreciated by the local landowners and resource users. Similarly, the benefits of local investments in resource conservation are not all appreciated or realized locally. This limits the ability of the users to invest in resource conservation, and at the same time limits the will for investments to be made from higher levels, either regionally or nationally. Consideration of landscape scale cycles and flows of water, sediment and nutrients is necessary to understand and address land and water degradation. The causes and consequences of degradation are better understood at landscape scales, and it is at these larger scales that policy instruments can effectively either drive degradation or enable resource conservation. Two important large scale cycles are upstream and downstream transfers in watersheds, and rural–urban nutrient flows.

Downstream effects of upstream catchment land degradation cascade throughout watersheds. It is well recognized that intensified land use in upper catchments, largely by poor farmers increasingly forced onto marginal lands, results in increased sediment discharge and elevated nutrient loads reducing water quality and availability downstream. It is estimated that more than 25 percent of the world's water storage capacity will be lost in the next 25 to 50 years in the absence of measures to control sedimentation in both large and small reservoirs (Palmieri *et al.,* 2001). Striking examples are found in southeast Asia where upper catchments are extensively exploited. Rapid deforestation of the steep hillsides above Hoa Binh reservoir, Vietnam, increased soil erosion and accelerated siltation of the reservoir reducing the projected life of the Hoa Binh dam from 100 to about 50 years (UNDP, 2002). This dam generates 80 percent of the electricity for Hanoi and Northern Vietnam. Sedimentation not only reduces the useful life of reservoirs (Maglinao and Valentin, 2004) but also results in increased labour demand to de-silt irrigation canals. Sedimentation and eutrophication of aquatic ecosystems leads to declining fish catches that in turn threatens the nutrition and health of downstream communities. Marginalized communities can be hardest hit, because local fisheries form a high proportion of the protein in their diets. Reduced quality and quantity of surface waters directly affects community health, and requires people to find alternative sources of drinking water (Fengtong *et al.,* 2003). Women are burdened with having to devote a greater proportion of their time transporting water or caring for ill children as a result of drinking poor quality water. In Vietnam, shifting from surface to groundwater resources for drinking water has resulted in the potential exposure of 14 million people to elevated levels of arsenic (Tanh, 2003).

Nutrient disjunction flows occur ubiquitously from forest to farm, from terrestrial ecosystems to the ocean, and increasingly from rural to urban areas, including across continents. The result is nutrient depletion at the source and pollution at the sinks. Nutrient depletion in agricultural soils during 1996-1999 is so high in many countries in Asia, Africa and Latin America that current land use is not sustainable (Craswell *et al.,* 2004). Worldwide natural regeneration of soil fertility plus fertilizer applied compensates for only half of what is taken from the soil on cultivated fields (Sheldrick *et al.,* 2002). Nutrient balance analysis demonstrates nutrient depletion in many Asian countries of the order of 50 kg NPK per hectare per year (Sheldrick *et al.,* 2002). Trends are more negative in Africa, where nutrient depletion in some east and south African countries is estimated to average 47 kg N, 6 kg P, and 37 kg K per hectare per year (Smaling, 1993; Stoorvogel *et al.,* 1993). Country averages hide important site-specific variation. Where farmers are poor, and cannot afford inputs, nutrient mining is much higher. Nutrient depletion is now considered the chief biophysical factor limiting small-scale farm production in Africa (Sanchez *et al.,* 1997; Drechsel *et al.,* 2004). While nutrient depletion is the rule in rural and poorer countries, nutrient accumulation occurs in urbanized countries where much food and feed is imported (Penning de Vries, 2004), and in densely populated urban areas of Asia and Africa. Increasingly large volumes of domestic and industrial wastewater are produced in rapidly growing cities around the world. Each day over 2 million tonne of waste is dumped into rivers and lakes (WWAP, 2003). Globally, a very small percentage of these wastewaters receive even primary treatment. In India less than 35 percent of wastewater receives primary treatment, and there is little, if any treatment in smaller cities and rural areas. This untreated wastewater, clearly a pollution problem, is also a resource valued by small farmers in peri-urban areas because of its year round supply and high level of nutrients.

Reversing Degradation: "Bright Spot" Opportunities

Opportunities to begin to slow or reverse negative trends in land and water degradation while meeting poverty alleviation goals do exist. Promising opportunities include: (1) integrated land and water management for small holder farmers to provide on- and off-site ecosystem services including sustainable livelihoods; (2) larger scale biophysical, social, and policy approaches for preserving landscapes; and (3) sustainable utilization of low quality waters to reduce pressure on high quality waters and preserve land.

Bright Spots

Intensification of agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services including food production, clean water, biodiversity, carbon sequestration, and resilience to climate change, is possible and is demonstrated in numerous examples. Successful cases involving small-holder farmers and communities have received considerable attention in recent years[1]. One key feature of indigenous success stories is that land and water management are always integrated (Critchley, 2004). To explore the potential and driving forces behind these successes, the CA 'Bright spots' study compiled a dataset from a collation of new survey information and published case studies, including the previously compiled SAFE World database of the University of Essex (Pretty *et al.,* 2000; Pretty and Hine, 2004) and other public domain and grey literature sources. The 'Bright spots' database currently contains 286 recent cases from 57 countries covering 36.9 M ha that show increased productivity across 12.6 M farms (Table 2). While degradation trends globally are still strongly negative, these cases provide compelling evidence that improvement is possible. The gains in productivity were accompanied by improvement in the supply of other environmental services (Pretty *et al.,* 2004). These 'Bright spots' sequester 11.38 Mt C yr^{-1}, with an average gain of 0.35 t C ha^{-1} yr^{-1}. When Integrated Pest Management (IPM) was implemented, yield increases were accompanied by reduction in pesticide use from 50 to 90 percent. Water productivity improved approximately 16 and 30 percent in irrigated rice and cotton systems, respectively and 70 to 100 percent in rainfed systems growing cereals and legumes.

Table 2. Summary of adoption and impact of agricultural sustainability technologies and practices on 286 projects in 57 countries (Pretty *et al.,* 2004)

FAO farm system category	Number of farmers	Number of hectares under sustainable agriculture	Average % increase in crop yields
1. Small holder irrigated	179,287	365,740	184.6 (±45.7)
2. Wetland rice	8,711,236	7,007,564	22.3 (±2.8)
3. Small holder rainfed humid	1,704,958	1,081,071	102.2 (±9.0)
4. Small holder rainfed highland	401,699	725,535	107.3 (±14.7)
5. Small holder rainfed dry/cold	604,804	737,896	99.2 (±12.5)
6. Dualistic mixed*	537,311	26,846,750	76.5 (±12.6)
7. Coastal artisanal	220,000	160,000	62.0 (±20.0)
8. Urban-based and kitchen garden	207,479	36,147	146.0 (±32.9)
All projects	12,566,774	36,960,703	83.4 (±5.4)

Notes: Yield data from 405 crop project combinations; reported as% increase (thus a 100% increase is a doubling of yields).
Standard errors in brackets.
* Dualistic refers to mixed large commercial and small holder farming systems, mainly from southern Latin America.

[1]Groups with projects cataloguing and detailing success stories: Centre for Development and Environment (CDE), Berne; Centre for Environment and Society, University of Essex; Ecoagriculture Partners; FAO Land and Water Development Division; FAO/AGL Gateway Project; Ingenious farmers; Centre for International Cooperation, University of Amsterdam; IRCD; Sustainability Institute, Stockholm Environment Institute (SEI); UNEP success stories; WOCAT, World Overview of Conservation Approaches and Technologies, Berne (not a comprehensive list).

A key area for impact, as demonstrated in the 'Bright spots' study, is where productivity is much below potential due to lack of inputs, land degradation or climatic uncertainty in rainfed agriculture (Fig. 3). In the latter case, development of independently managed supplemental irrigation systems can reduce risk and greatly increase productivity of both land and water (Rockstrom, *et al.,* 2003). Key priming factors in these successful cases include investment, secure land tenure, appropriate integrated land and water technologies, and aspirations for change amongst the local population. And while participatory approaches alone could not reverse degradation processes, they were one key driver of change.

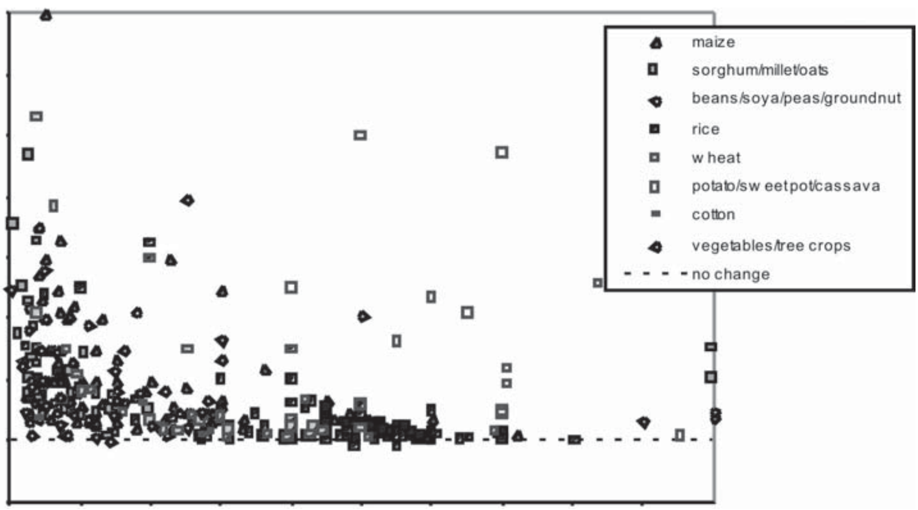

Figure 3. Changes in crop yields with agricultural sustainability technologies and practices (360 crop yield changes in 198 projects) (Pretty *et al.,* 2004)

"Bright Spots" in South Asia

In South Asia, a total of 204 "Bright spots" questionnaires were collected, from individual farmers in southern India (94) and Punjab (110). These cases had a focus on introducing new technologies associated with improved rice production, integrated nutrient management, promotion of organic farming systems (composts, bio-fertilizers), use of new planting material and crop husbandry techniques (Noble *et al.,* 2004b). The mean annual rainfall for the cases from south India and Punjab were 1027 mm (range: 685-1250 mm) and 869 mm (range: 400-1500 mm) respectively. Both regions exhibited a wide range in annual precipitation regimes. Clearly in several of the cases associated with rice production water is a critical component and hence its effective management. Several of the projects promoted SRI (System of Rice Intensification) as a means of improving water use efficiency and enhancing productively through better crop management (*see* Box 2). The dominant crops grown were rice and wheat in Punjab with field peas and cotton being of minor importance. Increases in yields of these commodities were relatively modest with mean percentage increases for rice and wheat being approximately 17 percent (Table 3). In some cases there was a decline in productivity with the implementation of change. Rice production systems and a range of improved technologies to enhance productivity dominated the south India dataset. The mean percentage increase (24%) was higher than in Punjab cases (Table 3). Plotting responses for wheat and rice from both India (Fig. 4), it is evident that similar to the larger dataset, the greatest opportunities for increasing productivity were associated with the farms that had the lowest initial yields.

Table 3. Mean yields and range for before and after the development of the 'Bright' spot.94 respondents in South India and 110 from the Punjab, South Asia. Values in parentheses are the standard errors of the mean (SE) (Noble *et al.*, 2004b)

Crop	Number of observations	Average yield before (t/ha)	Average yield after (t/ha)	Average% increase in crop yield
Punjab				
Cotton	3	2.80 (0.10)	3.7 (0.1)	32.2 (1.1)
Field peas	4	0.29 (0.00)	0.37 (0.00)	25.7 (1.8)
Rice	88	5.07 (0.04)	5.93 (0.05)	17.23 (1.09)
Wheat	86	4.07 (0.06)	4.73 (0.06)	16.7 (1.2)
South India				
Rice	86	5.06 (1.0)	6.19 (0.11)	24.3 (2.3)

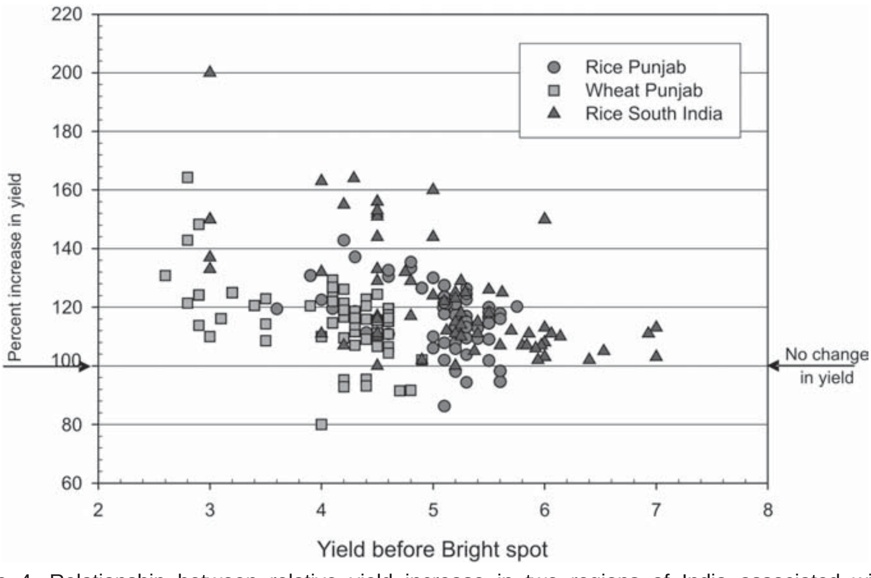

Figure 4. Relationship between relative yield increase in two regions of India associated with the implementation of improved on farm management systems and the adoption of new technologies by individual farmers (Noble *et al.*, 2004b)

"Bright Spots" Drivers

This set of 'Bright Spots' was compiled from well-documented cases, where evidence suggested they were able to sustain themselves beyond implementation, although continued sustainability cannot be guaranteed. It should be noted that the dataset primarily describes development projects where impacts were achieved through external investment therefore they under-represent individual, or spontaneous 'Bright Spots,' and do not represent examples of development project failure. Nevertheless, their numbers and impact provide grounds for cautious optimism.

Although data is scant, the issue of investment deserves some discussion in this context. Almost all 'Bright spots' in the database were based on development projects, and therefore represented a certain amount of investment from international, bilateral, national government, community, NGO or other sources. Few published cases or survey respondents included a breakdown of investment, but data from 10 cases in Latin America and 15 from Africa was compiled and can be summarized as follows: Funds to individual projects ranged from US$ 3,000 to US$ 10.5 million and from US$ 45,000 to US$ 8.9 million in Latin America and Africa, respectively. The mean investment per hectare directly impacted by the projects could be estimated at US$ 714 per hectare in Latin America, and approximately half of that, US$ 366 per hectare, in Africa (Noble *et al.,* 2004). Although these cases are few, it is informative to compare to the rates of expenditure for conventional irrigation projects, which are often 10 times as high. For 233 Worldbank and ADB irrigation projects in Asia and Africa, unit costs ranged from US$3,000 per hectare in south Asia to US$28,000 per hectare in Africa for new construction, and from US$1,000 per hectare in south Asia to US$5,000 per hectare in Africa for irrigation infrastructure rehabilitation projects (Inocencio *et al.,* 2004).

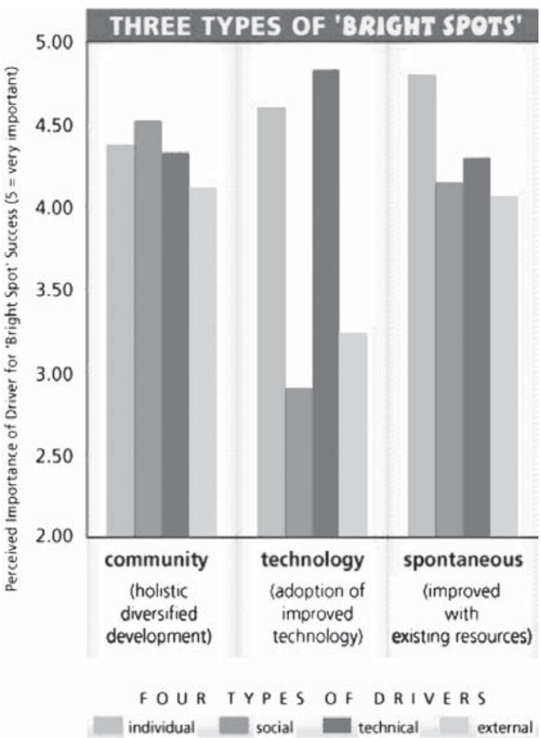

Figure 5. Preliminary drivers analysis for three types of 'Bright' spots: community (n=15), technology (n = 95), and spontaneous (n=3)

Local 'Bright' spots can play an important role in regional development by resonating laterally to increase adoption of promising farming systems, and vertically to improve policy making to support sustainable development. To facilitate understanding of the success of these 'Bright Spots', a preliminary 'drivers' analysis was undertaken in which the relative importance of a range of individual, social, technical and external drivers (Box 1) was determined. Case studies were classified into three primary groups (Box 2): Community Bright Spots that is integrated watershed development, in which investment in social capital such as community organizations was as important as technical inputs for success and sustainability; Technology Bright Spots which were successful in large part through strong individual initiative and because the new technology or knowledge was particularly appropriate and effective; and Spontaneous Bright Spots where significant improvement was made in resource condition and profitability without external investment, driven by strong leadership and the availability of appropriate technology (Fig. 5). It is hoped that this type of analysis of drivers will help inform efforts aimed at replicating success.

Box 1. Key drivers for success of 'Bright' spots

Individual

1. *Aspiration for change*. This reflects an internal demand by an individual or community for change that may be driven by faith or a wish to try something different.
2. *Leadership*. In order for a 'Bright' spot to develop and continue there is a need for strong leadership. This may include a single individual or group that champion change.

Social

3. *Social capital*. 'Bright' spots develop where there are community organizations, networks, and partnerships (private as well as public). This social capital also includes intangible aspects of social organizations such as norms and rules of behavior that can play an important role in promoting sustaining change.
4. *Participatory approach*. 'Bright' spots require deliberative processes that actively involve the community in the decision making process. This includes a strong element of learning and teaching.

Technical

5. *Quick and tangible benefits*. Immediate tangible benefits to the community or individual are an important requirement for the development of a 'Bright' spot. For example, this may include increased yields within the first year of implementing changes; a reduction in the costs of labour, etc.
6. *Low risk of failure*. Resource poor farmers by their very nature are risk-averse hence any changes that are made to create a 'Bright' spot need to have an element of low risk.
7. *Innovation and appropriate technologies*. Innovations, new technologies and information are important key components in the development and continuance of a 'Bright' spot. This includes new skills and knowledge that contributed to the development of a 'Bright' spot.

External

8. *Market opportunities*. In order for a 'Bright' spot to develop, markets need to be present and assured to effect change.
9. *Property rights*. For the development and continuance of a 'Bright' spot secure (individual or communal) property rights are important to facilitate change.
10. *Supportive policies*. Favourable changes in supportive policies at the local, regional and national levels are key drivers for the development and continuance of 'Bright' spots.

Box 2. Case studies representing three 'Bright spot' typologies.

Community Bright Spot
Small holder farmer managed irrigation in Zimbabwe

Dryland farmers in Murara, in Mutoko district, Zimbabwe, faced significant resource problems including poor soil fertility and irregular and insufficient rainfall, resulting in food insecurity. A group of about 36 farmers now manage a small irrigation scheme covering 18 ha of land. They have increased cropping intensity 200 percent and maize yields from 1.5 t/ha under dryland farming to 6 t/ha in the irrigation scheme. There has been a significant increase in food security, drought tolerance, and farm incomes. They have been able to invest in, and diversify their farming enterprises, including growing vegetables for market, purchasing livestock and planting trees and woodlots. Farmers have been able to acquire new entrepreneurial skills, and become more self-reliant. Significant ecosystem benefits resulted because farmers have given up destructive gold panning activities that used to be undertaken to supplement their incomes. Small holder, primarily farmer managed, irrigation systems now cover 13,000 ha of land in Zimbabwe, serving farms with plot size ranging from 0.5 to 2 ha.

Technology Bright Spot
System of rice intensification (SRI), India

The System of Rice Intensification (SRI) is a suite of practices including water-saving irrigation management, organic matter inputs, reduced chemical inputs, and a range of agronomic techniques. Benefits can include higher yields, drought resistance, water-savings, and improved health of aquatic habitat. Adaptations of SRI concepts are on-going in India where plant spacing, weeding technologies, and incorporation of cover crops has been optimized. Adoption numbers are not well known, but implementation of SRI practices and ideas has taken place in Madagascar, China, Indonesia, Philippines, Cambodia, Bangladesh, Sri Lanka, Myanmar, Laos, Nepal, Sierra Leone, The Gambia, Benin, Guinea, Cuba, Peru as well as India. Because individual farmers undertake SRI methods, and benefits can be realized immediately, the relative importance of external enabling elements such as land tenure, new markets, or policy support is low. Likewise, social drivers are somewhat less important than for watershed development projects, for example. Thus individual initiative along with a particularly appropriate technology is seen as key drivers for adoption.

Individual Bright Spot
Uzbekistan, Central Asia

Newly privatized farms of the former Soviet Union have experienced declining yields, declining incomes, and increased soil degradation from rising salinity levels and wind erosion. A few farms have achieved higher yields (40 and 64% higher cotton and wheat yields respectively), reduced salinity, increased profits between 3 and 7 folds, and increased farm workers income by 125 percent. The stimulus for change in all cases appears to be internally driven by resourceful individuals who have a vision. These individuals exhibit strong leadership skills, have innovative approaches to addressing biophysical and economic problems and have a strong social commitment to their labor force and the community as a whole.

Beyond "Up-scaling"

The importance of linking local 'Bright spots' to large scale biophysical, social and policy opportunities to reverse land and water degradation and preserve landscapes, particularly relevant to watershed development, cannot be overestimated. Landscape management can provide opportunities beyond 'upscaling' of local solutions. Landscape approaches take into account the ecology and function of landscape components and makes strategic use of their potential (Ryszkowski and Jankowiak, 2002). Forests, woodlots and riparian buffer zones are important in this respect as trees provide large scale opportunities to influence the water cycle and maintain water quality. In the Eastern Himalaya, Sikkim, Assam and Nepal, steep slopes, low fertility, intense precipitation resulting in erosion and slumping, and increasing population pressures complicate land management. Strategic planting of the Alder-cardamom agroforestry system in riparian zones (Fig. 6) satisfies a diversity of farmers' needs while also providing watershed protection (Zomer and Menke, 1993). Riparian buffers trap sediments and reduce bank erosion, providing significant water quality benefits. Purposeful use of this type of production system provides opportunities to increase the provision of ecosystem goods and services at the landscape scale, which cannot always be achieved when management targets only those lands under annual cropping systems, without regard to landscape features. Another landscape approach aims to restore natural bio-drainage processes that have been disrupted through deforestation, to alleviate high water tables. Studies are underway to assess the potential of this approach in Eastern India, Central Asia, and northeast Thailand. Policy and institutional mechanisms (Rosegrant, 2004) and basin level water management (Karar, 2004) are required to support these opportunities for reversing trends in land and water degradation. Likewise, investment in social capital, recognizing and building upon gendered and social organization of small holder farming communities creates new opportunities that enhance both productivity and equity (Pretty, 2003).

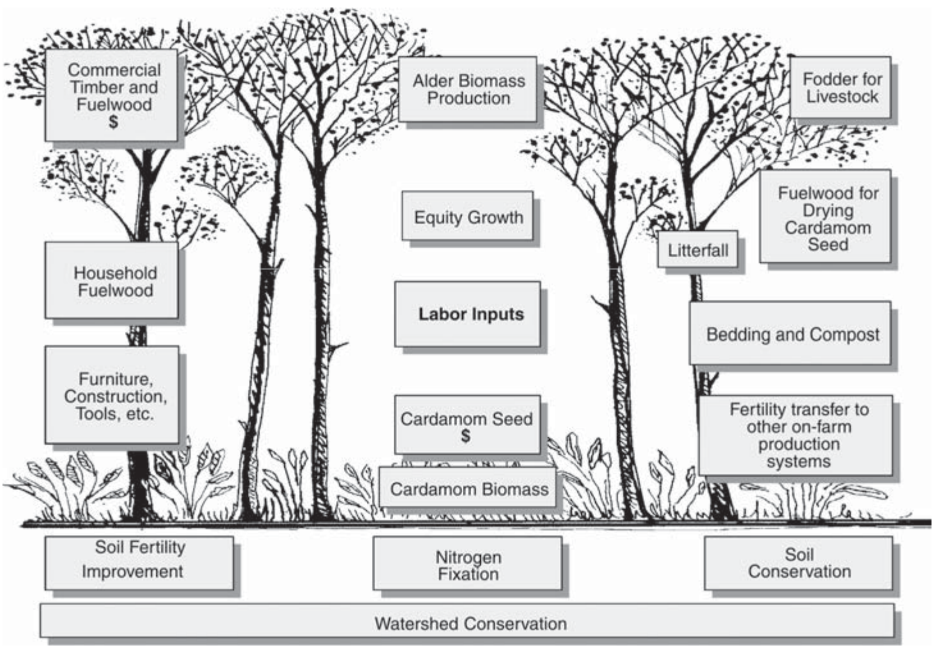

Figure 6. Alder-cardamom agroforestry system provides for a diversity of farmer's needs simultaneously without the need for external inputs or heavy labor, and also stabilizing riparian zones and providing watershed protection (*Source:* Zomer and Menke, 1993)

Productive Use of Waste Waters

Using low quality waters productively to address nutrient disjunction flows and salinization of land and water is an area with increasing opportunity due to increasing volumes of these waters. Appropriate utilization has the potential to help close rural-urban nutrient cycles, limit continued water logging and salinization of soils, and reduce the impact of agriculture on the environment (Sanio *et al.*, 1998). State-of-the-art, environment friendly systems for productive use of low-quality waters are being tested and employed primarily in developed countries. Sequential biological concentration to eliminate off-site drainage of saline waters and agroforestry systems for productive land-based sustainable wastewater disposal (Myers *et al.*, 1999) are two examples. One challenge is to adapt these technologies for application in developing countries by ensuring economic opportunities for local communities that depend on these low quality waters. For example, peri-urban agriculture has the advantage of proximity of markets and low transportation costs for urban wastes. However, current economic incentives favour using wastewaters to produce high value vegetable crops with potentially large negative health consequences. Local policies tend to ignore this agricultural sector completely despite its importance (wastewater produce supplies 95 percent of the fresh vegetable market for cities like Kumasi in Ghana) (Drechsel, 2004). Productive use of wastewater that is environmentally sound and without health risks is a biophysical, social, economic, institutional and policy challenge.

Conclusion

Through a consultative process including workshops and joint research on the ‘Bright’ spots project preliminary consensus was reached on three key messages: (1) significant opportunities exist for integrated land and water management in small holder systems to improve water productivity and provision of ecosystem services including food supply; (2) larger scale biophysical, social, and policy approaches for preserving landscapes can enhance positive impacts of intensification on local ‘Bright’ spots and go beyond ‘upscaling’; and (3) productive use of low quality waters is possible and provides opportunities to close large gaps in nutrient cycles to slow or reverse trends in land degradation and water pollution. These strategies could help reverse land and water degradation, and intensify agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services.

The value of the ‘Bright spots’ analysis is that it was based on existing cases where arresting or reversing resource degradation trends were achieved. Thus results provide the basis for asserting that small holder systems, even on marginal and degraded lands, are not always hopeless cases, where the only option is for off-farm employment and urbanization to rescue the rural poor. Several external factors are necessary. Land rights were a precondition of these successes. Institutions that bolster small holder farmers within a wider context of preserving landscapes can help balance food production with other ecosystem services. The pivotal role of leadership was also clearly evident in the ‘Bright spots’ analysis, thus emphasizing the need to increase the capacity of farmers themselves, and not just researchers and extension agents. Policies that address large scale underlying causes of degradation, and support rather than ignore the growing sector of urban and peri-urban wastewater agriculture are needed. And there is need for substantial investment. Past investments aimed at addressing degradation have been too modest. Investments in land and water conservation have generally represented less than 5 percent of agricultural spending (Penning de Vries *et al.*, 2003). Another clear message is that contrary to the assumption that all required knowledge already exists, there is a large potential for innovation in small holder farming systems linking land, soil and water management.

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Sustainable Management of Rainwater through Integrated Watershed Approach for Improved Rural Livelihoods

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Abstract

Rainwater, an essential resource for growing food also plays an important role in providing livelihood support for rural people in the rain-fed regions. Eighty percent of the world's agricultural land is rain-fed and contributes to about 60 percent of the global food production. An insight into the rain-fed regions shows a grim picture of water-scarcity, fragile ecosystems and land degradation due to soil erosion by wind and water, low rainwater use efficiency, high population pressure, poverty, low investments in water use efficiency measures, poor infrastructure and inappropriate policies. The current rainwater use efficiency for crop production is low ranging between 30 and 45 %; thus annually about 300-800 mm of seasonal rainfall goes unproductive, lost either as surface run-off or deep drainage. The challenge, therefore, is to improve rural livelihoods through efficient and sustainable rainwater management technologies for increasing rain-fed productivity and thereby contribute to food and livelihood security. Watershed as an entry point acts as a beginning to address the issues of sustainable rainwater management for improving livelihoods. An innovative integrated farmer participatory consortium watershed management model developed by ICRISAT along with NARS partners is a holistic model unlike the earlier watershed approaches which were sectoral with emphasis only on the soil and water conservation measures. The integrated watershed approach uses new science tools, links on-station research to on-farm watersheds, provides technical backstopping through consortium of institutions with convergence of livelihood-based activities. The core theme of the model is sustainable natural resource management for increasing the farm productivity and improving the rural livelihoods. The approach covers issues starting with conservation of natural resources and ensures increased productivity and incomes through convergence of all necessary activities to achieve the good. In order to ensure equity for women and landless people, emphasis is put on development of common property resources as well as establishing micro-enterprises. This integrated watershed approach enables to have 'win-win' situations for sustaining productivity and improving livelihoods as it includes convergence of activities at various levels thus enhancing community participation and creating income-generating options. Successful results from on-farm integrated watersheds are discussed. However, the challenge is to scale up the approach to larger areas on sustainable basis. Lessons learnt from past watershed experiences are that we need to focus

on issues such as keeping the community interest for participation; institutions to continue activity for maintenance after the project activity ceases; maintaining the link between the watershed and supporting institutions for technical backstopping, appropriate policies for groundwater use and common property resources and innovative ways to merge common wastelands. Thus the lessons learnt from the integrated watershed management can help re-engineer suitable roadmaps for maximizing returns to investment on watershed programs. With ever changing policies and economies, improved institutional and policy support mechanisms in partnership with stakeholders especially the farmers, market links for products, value addition products for rural areas, infrastructure and suitable ways to meet the challenges for the target areas need to be addressed.

Introduction

Rainwater, a scarce and critical resource for growing food and providing livelihood support for rural populations, is under threat particularly in the arid and semi-arid regions of the world. Rainfed agriculture that constitutes the livelihood base for the vast majority of rural inhabitants (about 75 percent of the poor in south Asia, and about 80 percent of the population in east Africa) in the developing countries is a source of food security, and livelihoods. It is estimated that about 80 percent of the world's agricultural land is rainfed, contributing to about 60 per cent of the global food production. Rainfall in the semi-arid tropics (SAT) generally occurs in short torrential downpours. Most of this water is lost as run-off, eroding significant quantities of precious top soil. The current rainwater-use efficiency for crop production is low ranging from 30 to 45 percent; thus annually about 300-800 mm of seasonal rainfall goes unproductive, lost either as surface run-off or deep drainage. An insight into the rain-fed regions shows a grim picture of water-scarcity, fragile ecosystems, drought and land degradation due to soil erosion by wind and water, low rainwater-use efficiency, high population pressure, poverty, low investments in water use efficiency measures, poor infrastructure and inappropriate policies.

The ever-growing problems as burgeoning population, poverty, lack of improved varieties, poor knowledge base on improved farm technology, resource poor farmers, low farm productivity and income levels constitute major threat for progress towards sustainable development more so in the SAT. The SAT regions of the world, covering parts of 55 developing countries has over 1.4 billion population of whom 350 million are classified as rural poor (Ryan and Spencer, 2001). It is estimated that over the next 15 years most of the projected 1.1 billion increase in global population (from 6.1 billion in 2000 to 7.2 billion in 2015) will be in the developing countries (United Nations, 2001). A recent report published by the United Nations Population Fund projects a grim picture of constraints to sustainable development in the future for the countries experiencing rapid population growths (UNFPA, 2003). One billion of the world's poorest people living in SAT regions will be affected by water scarcity (Seckler *et al*. 1998; Ryan and Spencer, 2001). Uncertainty in rainfall and poor socio-economic condition of the farmers prevent them from making heavy investments in agriculture. To save the crops from drought during rainy season and to meet the water needs of the post-rainy season crop, farmers resort to groundwater exploitation resulting in recession of groundwater levels due to inadequate groundwater recharging facilities.

The poverty of Asia's poor is both a cause and a consequence of accelerating soil degradation and declining agricultural productivity. The challenge, therefore, is to develop sustainable and environment-friendly options to manage natural resources in this fragile ecosystem to increase the farm productivity and incomes of millions of poor farmers who are dependent on the natural resources for their survival. The way forward to address this gigantic task is by sustainable management of rainwater and other natural resources in a manageable land unit, which is a watershed.

Large Yield Gaps for Rain-fed Crops Between Potential and Current Productivity

Current productivity of rainfed crops in the SAT hovers around 1.0 t/ha. However, number of studies have shown that productivity of rainfed farming systems could be doubled or in some situations like in west Africa could even be quadrupled through adoption of improved soil, water, crop and nutrient management options (Rockstorm, 2004; Wani, 2004).

Crop growth simulation models in an integrated watershed management approach provide an opportunity to simulate the crop yields in a given climate and soil environment that can be used for yield gap and constraint identification. ICRISAT researchers have adopted DSSAT v 3.0 a soybean crop growth model to simulate the potential yields of soybean crop in Vertisols grown at different benchmark locations. Mean simulated yield obtained for a location was compared with the mean observed yield for a period of five years to calculate the yield gap. The results (Table 1) showed that there is a considerable potential to bridge the yield gap between the actual and potential yield through adoption of improved resource management technologies (Singh *et al.*, 2001).

Table 1. Simulated soybean yields and yield gap for the selected locations in India

Location	Mean simulated yields (kg ha^{-1})	Mean observed yield[1] (kg ha^{-1})	Yield gap (kg ha^{-1})
Primary zone			
Raisen	3050	-	-
Betul	2370	860	1510
Guna	1695	840	855
Bhopal	2310	1000	1310
Indore	2305	1120	1180
Kota	1250	1010	240
Wardha	3000	1040	1960
Secondary zone			
Jabalpur	2240	900	1350
Amaravathi	1620	940	680
Belgaum	1990	570	1420

[1] Mean of reported yields for five years.

Using the CROPGRO models of soybean and chickpea sequential system the potential yields, yield gap and water balance of the soybean-chickpea sequential system for selected benchmark sites showed that the average potential productivity of the soybean-chickpea system under rain-fed system ranged from 1390 to 4590 kg/ha across sites and yield gap of 200 to 3300 kg/ha for the system indicating the potential to increase productivity with improved management. Water balance analysis showed that on an average 35 to 70 percent of rainfall was used by the crop as evapotranspiration, whereas 25 to 40 percent was lost as surface run-off indicating the need for water harvesting for supplemental irrigation or recharging of groundwater (Singh *et al*., 2002).

Watersheds for Grey to Green Revolution

A watershed, a land unit to manage water resources is also a logical planning unit for sustainable resource management. Sustainable watershed management is the rational utilization of all the natural resources for optimum production to fulfil the present need without compromising the needs of future generations with minimal degradation of natural resources such as land, water and environment.

Innovative Participatory-Consortium-Approach-Watershed Model

Conventional watershed approaches in the past focussed only on soil and water conservation measures hence did not bring in much productivity gains or contributed to improve the rural livelihoods. A new model for efficient and sustainable management of natural resources in the SAT has emerged from the lessons learnt from long watershed-based research conducted by ICRISAT in partnership with National Agricultural Research Systems (NARSs) (Wani *et al*., 2003a, d). The important components of the farmer participatory integrated watershed management model are:

- Farmer participatory approach through cooperation and not through contractual mode.
- Use of new scientific tools for management and monitoring of watersheds through linking of on-station and on-farm watersheds.
- A holistic system's approach to improve livelihoods of people and not merely conservation of soil and water compartmental approach.
- A consortium of institutions for technical backstopping of the on-farm watersheds.
- A micro-watershed within the watershed where farmers conduct strategic research with technical guidance from the scientists. Planned gradual shift from contractual mode of participation to consultative and collective mode of participation.
- Low-cost soil and water conservation measures and structures throughout the toposequence to achieve equity.
- Amalgamation of traditional knowledge and new knowledge for efficient management of natural resources
- Emphasis on individual farmer-based conservation measures for increasing productivity of individual farms and private economic gains alongwith community-based soil and water conservation measures for ecosystem services.

- Minimize free supply of inputs for undertaking evaluation of technologies. Farmers are encouraged to evaluate new technologies themselves with empowerment.
- Continuous monitoring, evaluation and refinement of options by the stakeholders.
- Empowerment of community individuals and strengthening of village institutions for managing natural resources.

A Holistic System's Approach

In order to address the farm productivity and dependent rural livelihood issues, the strategy of participatory consortium model is to take the on-station research results to real-world on-farm watersheds for fine-tuning the technologies. The integrated genetic and natural resource management (IGNRM) strategy is a new paradigm to sustain and increase productivity and improve the rural livelihoods. The strategy encompasses integrated water and soil management alongwith integrated crop management. The process begins with the management of soil and water, which eventually leads to the development of other resources for enhancing productivity and incomes. Further scaling-up and scaling-out of the potential technologies are done for greater impact, which aims to create a self-supporting system essential for sustainability and development in the dry regions. As people's participation is critical for sustainable development and management of watersheds, a holistic approach converging the activities, which could improve livelihoods of rural people including landless dependent on natural resources, is adopted (Wani *et al.,* 2003d; Ramakrishna and Osman, 2004).

Increased Productivity through Improved Rainwater-use Efficiency in Rain-fed Regions: Improved *vs* Conventional Systems – Vertisol Watershed

In an improved system with improved soil, water and nutrient management options, the average productivity of maize/pigeonpea or sorghum/pigeonpea systems over 27 years was 4.7 t/ha, which indicates a carrying capacity of 18 persons/ha/yr, whereas the traditional system (post-rainy sorghum) with farmer adopted practices could yield only about 0.95 t/ha and have a carrying capacity of only 4 persons/ha/yr (Fig. 1). Alongwith this higher productivity, the improved system could also sequester more carbon (0.3 t/ha/yr) and improve soil quality (Wani *et al.,* 2003b). Most importantly, in the improved system 67 percent of the rainfall was used as green water (evapotranspiration) by the crops, 14 percent of the rainfall was lost as run-off and 19 percent as evaporation and deep percolation. In the traditional system only 30 percent of the total rainfall was used by the crops, 25 percent was lost as run-off and 45 percent as soil evaporation and deep percolation. The soil loss in improved system was only 1.5 t/ha compared to traditional system where the soil loss was 6.4 t/ha. Moreover, the improved system was gaining 78 kg/ha/yr in productivity indicating the sustainability towards attaining new state of equilibrium.

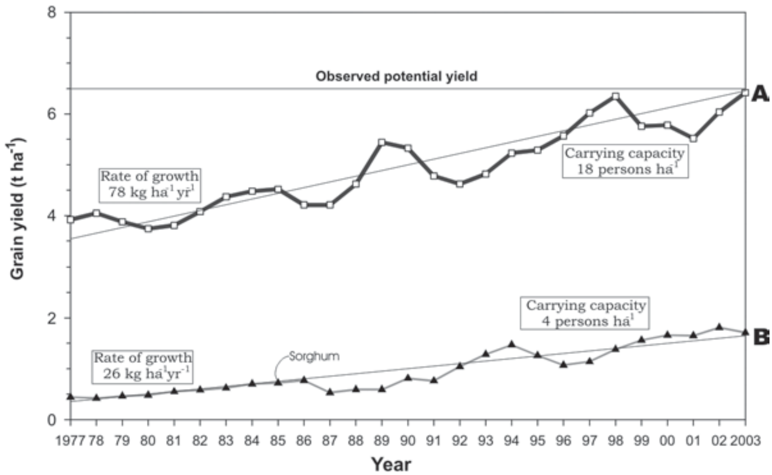

Figure 1. Average grain yields under improved (A) and traditional (B) technologies on a Vertisol watershed at ICRISAT (1977-2003)

Increased Productivity-Vertic Inceptisols Watershed

At ICRISAT, Patancheru, crop productivity and resource use were studied by adopting integrated watershed approach for a soybean-chickpea sequential and soybean+pigeonpea intercrop systems on two landforms [broad bed and furrow (BBF) and flat sowing on contour] and with two soil depths (shallow and medium-deep) at watershed scale on a Vertic Inceptisol. The results show that during 1995-2003 the improved BBF system recorded on an average 0.1 t/ha more grain yield than the flat landform. Increased crop yield of 2.9 t/ha of soybean intercropped with pigeonpea on BBF was recorded compared with 2.63 t/ha in flat landform treatment. The total run-off was higher in the flat land system (23% of the seasonal rainfall) than on the improved system (15% of the seasonal rainfall). The BBF landform treatment stored 15 mm more rainfall in the soil profile than the flat landform treatment enhancing the green water flow and reducing the run-off. The BBF had more deep drainage than the flat land system, especially for the shallow soil. The run-off figure in the flat land system (190 mm), with a peak run-off rate (0.096 m^3/s/ha) compared unfavourably with the BBF system, which had lower run-off (150 mm) and a lower peak run-off rate (0.086 m^3/s/ha). Hence, the BBF system was useful in decreasing run-off and increasing rainfall infiltration and green water use for crop production. The soil loss in flat land system was 2.2 t/ha *versus* 1.2 t/ha in the BBF system (Wani *et al.*, 2003b).

Improved Livelihoods through Convergence

To achieve the goal of improving rural livelihoods and sustainable utilization of existing resources, the roadmap chosen was through convergence of activities in the watersheds, such as agriculture, horticulture, livestock, fisheries, poultry and small enterprises that bring value addition to rural produce. The overall objective of the whole approach being poverty reduction, the new integrated watershed management model fits into the framework as a tool to assist in sustainable rural livelihoods. The convergence approach is to make watershed development to be explicitly linked with rural livelihoods and effective poverty reduction and in the process identify policy interventions at micro, meso and macro levels.

In the new model, emphasis is on to encourage the convergence of people-centric rural development programs at the watershed level. Any project design should encourage a more holistic understanding of the needs and priorities of the poor people in integration with policy and institution structures.

An example of convergence for agriculture related activities in the watershed and its link with other micro-enterprises is shown in Fig. 2 (Wani *et al*., 2003a).

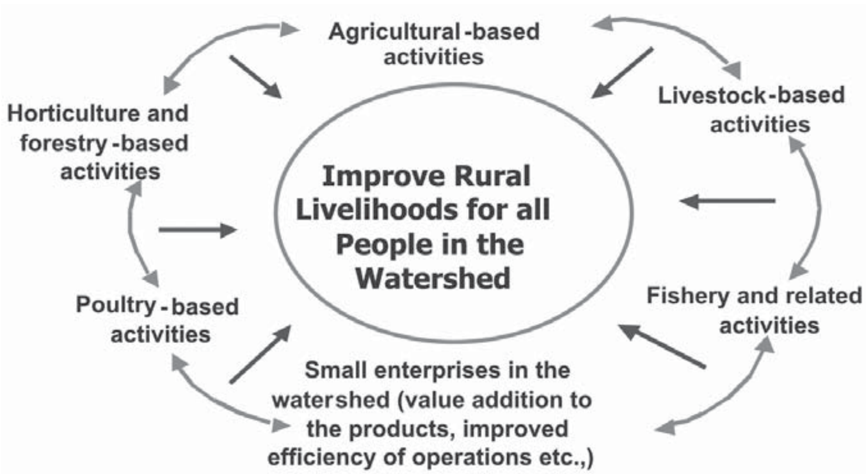

Figure 2. An example of convergence of various activities based on use of natural resources

Convergence can take place at different levels. Convergence at the village level requires facilitation of processes that bring about synergy in all the watershed related activities. An approach is needed to address the equity issues while addressing livelihood options through integrated watershed management. Scope for issues related to suitable processes for change in micro-practices, macro-policies, convergence and knowledge management systems also form part of the program. Socio-economic institution and policy needs to increase adoption of improved options by the rural people are adapted in the convergence approach.

Integrated Water Management

In-situ conservation of rainwater includes landforms (e.g., BBF, ridges and furrows, planting on contours, raised beds and sunken furrows, etc.), tillage, bunding and vegetative barriers, continuous contour trenches and staggered trenches, increased soil organic matter through green manuring, plastic and organic residue mulching, crop residue incorporation and wasteland development. All these activities result in increased water in soil profile and soil conservation.

Ex-situ conservation includes grassed waterways, gully plugging, silt traps, excess water from fields drained out safely, recharging pits, diversion drains, recharging of dead open wells and storage tanks that results in increased water availability for life-saving irrigations to crop plants and enhance groundwater recharge.

Rainwater harvesting results in storing water in above ground tanks, dugout farm ponds, which could be used for life-saving irrigation or increasing recharge of groundwater (Singh and Sharma, 2002). In rainfed agriculture, conjunctive use through supplemental irrigation results in significant increase in crop productivities through substantially enhanced water-use efficiency.

Enhanced Rainwater-use Efficiency (RUE) with Supplemental Irrigation

After storing the rainwater in soil profile through *in-situ* conservation measures the excess water is safely taken out of fields and stored in above ground tanks and dugout farm ponds, which could be used as life-saving irrigation or enhancing groundwater recharge (Osman *et al.*, 2001). In rain-fed agriculture, conjunctive use through supplemental irrigation from harvested run-off water or recharged groundwater results in increasing crop productivities substantially. The green-blue water (rain-fed systems with supplemental irrigation system) continuum proves to be more effective in terms of improving overall water-use efficiency.

Benefits of supplemental irrigation in terms of increasing and stabilizing crop production have been impressive even in dependable rainfall areas of both Alfisols and Vertisols. Good yield responses to supplemental irrigation were obtained on Alfisols in both rainy and post-rainy seasons at ICRISAT on-station watershed. The average irrigation water productivity, WP (ratio of increase in yield to depth of irrigation water applied) varied with the crop, e.g., for sorghum it was 14.9 kg/ha-mm and for pearl millet 8.8 to 10.2 kg/ha-mm. On Vertisols the average additional gross returns due to supplemental irrigation were about INR* 830 per ha for safflower, INR 2400 per ha for chickpea and INR 3720/ha for chillies. In the sorghum + pigeonpea intercrop, two irrigations of 40 millimetres each, gave an additional gross return of Rs 3950/ha. The largest additional gross return from the supplemental irrigation was obtained by growing tomatoes (INR 13870/ha).

At Bhopal, India, supplemental irrigation with stored rainwater along with improved landform treatment increased RUE and productivity. Water-use efficiency of chickpea was higher under BBF (11.37 kg/ha-mm) than flat on grade (FOG) land treatment, which was 8.65 kg/ha-mm. The grain yield of soybean in sole soybean treatment was 1830 and 1580 kg ha^{-1} in BBF and FOG land treatments, respectively. Thus BBF registered 15.8 percent higher soybean grain yield than FOG. Similarly, grain yield of maize in sole maize treatment (3640 kg ha^{-1}) under BBF was 11.8 percent higher than the same treatment (3250 kg ha^{-1}) under FOG land configuration. In soybean/maize and soybean/pigeonpea intercropping systems, grain yield of soybean and maize were also higher in BBF than FOG (Misra, 2004).

Bright Spot: Benchmark Watersheds

Adarsha (Model) watershed, Kothapally in Andhra Pradesh and other benchmark watersheds established by ICRISAT led consortium in Madhya Pradesh,

*(INR=Indian Rupees, IUSD = 45 INR).

Rajasthan and Gujarat in India and northern Vietnam, northeast Thailand and south China are excellent examples of convergence. This model of watershed management with technical backstopping is being evaluated by ICRISAT, DPAP, CRIDA, NRSA and non-governmental organization (MV Foundation, BAIF and others) with the participation and involvement of farmers at Kothapally in Andhra Pradesh. This is the best option to scale-up the benefits of watershed programs through appropriate convergence and technical backstopping provided by ICRISAT-led consortium. The income-generating activities in integrated watershed management approach through convergence mode includes village seed banks through self-help groups, value addition through seed material, product processing such as *Daal* (pulses) making, poultry feed, animal feed, grading and marketability, poultry rearing for eggs and meat production and local hatching to provide chicks, and quality compost preparation through vermi-composting using cow dung, fodder waste and weeds locally. These activities are income-generating options for landless and women groups, which in turn bring increased incomes, improve the rural livelihoods in a sustainable way in the participatory approach and address the equity issues in the watershed mainly for landless, marginal farmers' groups and women groups who could benefit from the watersheds. The issues of equity for all in the watershed call for innovative approaches, institutions and policy guidelines for equitable use of water resources. Alongwith the water use the equity issues concerning sustainable use of common property resources in the watersheds also need to be addressed.

Integrated Nutrient Management (INM)

The importance of leguminous green manures such as *Gliricidia* in maintaining soil and crop productivity is widely accepted. Comparative evaluation of decomposition of *Gliricidia* and pigeonpea plant residues showed that the leaves of *Gliricidia* decomposed faster than pigeonpea plant parts (leaves, stem and roots). Highest N mineralization (119 mg N kg^{-1} soil) occurred with the *Gliricidia* leaf surface application to soil compared to the *Gliricidia* stems (93 mg N kg^{-1} soil) during 150 days of incubation. Along with *in-situ* generation of organic matter, use of crop residue compost, biofertilisers such as *rhizobia* for legumes, inclusion of legumes and need based application of deficient nutrients are used as INM package.

In Tad Fa Watershed, northeastern Thailand, application of chemical fertilizers to cash crops is a common practice to harvest decent yields. Since chemical fertilizers are one of the costliest inputs and there is not much scope to use farmyard manure (FYM) (as farm animals are replaced by farm machines), use of legumes in the cropping system is a viable alternative or supplement source to overcome nutrient constraints. In order to recommend suitable legumes in cropping systems so that farmers can reduce fertilizer N application, rice bean (*Vigna umbellata*), black gram (*Vigna mungo*), sword bean (*Canavalia gladiata*) and sunnhemp (*Crotolaria juncea*) were evaluated for quantifying nitrogen fixation and the benefits of legumes using ^{15}N abundance method and ^{15}N isotope dilution method on farmer's fields at Ban Koke Mon located near Ban Tad Fa where ICRISAT benchmark watershed is situated. The cropping systems of Ban Koke Mon are similar to those of Ban Tad Fa.

The results showed that the actual realized benefits from legumes in terms of increased N uptake by a succeeding maize crop varied from 5.3 to 19.3 kg N ha[1] whereas the expected benefits from legumes through biological nitrogen fixation and soil N sparing effect over a maize crop varied from 15 to 64 kg N ha^{-1} (Table 2). These results of strategic research revealed that for quick benefits for succeeding maize crop farmers would be benefitted by growing legumes, such as rice bean, sunnhemp and black gram.

In Than Ha watershed, Hoa Binh province of Vietnam, farmers could reduce 95 to 120 kg N ha^{-1} without sacrificing the maize yield due to inclusion of legumes in the system and application of 10 t FYM ha^{-1}. *Gliricdia* loppings from the plants on bunds provided 30 kg N ha^{-1} yr^{-1} in India and 50 kg N ha^{-1} yr^{-1} in Vietnam.

Table 2. Amount of nitrogen fixed (kg ha^{-1}), net N benefit expected, total N uptake by a succeeding maize crop and N benefit realized from the legumes in the maize-based systems

Crop	N fixed by legume (kg ha^{-1})	Net N benefit expected[1] (kg ha^{-1})	Total N uptake by succeeding maize (kg ha^{-1})	N benefit realized from legume over maize[2] (kg ha^{-1})	Expected benefit from BNF+N saving benefit[3] (kg ha^{-1})
Rice bean	20	2	75.9	19.1	15
Sunhemp	90	31	76.1	19.3	44
Sword bean	104	51	62.1	5.3	64
Black gram	27	8	68.9	12.1	21
Maize	-	-13	56.8	-	-

1. Net N benefit: N_2 fixed –seed N.
2. Total N uptake by succeeding maize –total N uptake by maize grown after maize.
3. Net N benefit + soil N depleted by maize in column 3.

Source: Wani *et al.*, 2003a.

Baseline characterization of soils in different benchmark watersheds indicated that these soils are not only thirsty but also hungry for micronutrients, such as zinc (Zn), boron (B) and secondary nutrients sulphur (S) in addition to primary plant nutrients such as N, P and K.

Successful demand driven interventions and farmer participatory evaluation of B and S nutrient amendments studies in farmers' fields in Guna district, Madhya Pradesh (India) showed that S application at the rate of 30 kg ha^{-1} increased yields of soybean by 34 percent over the recommended N and P doses alone and with B and S application yield increase ranged from 22 to 53 percent over control. Higher grain yields (48% over control with B+S application) of chickpea were recorded over control with residual effect of B, S and B+S application treatments (Table 3).

In Lalatora (Vidisha, Madhya Pradesh) in order to increase the RUE, micronutrient amendments were targeted for increasing crop production at farmers' level. During 2001, the RUE of soybean was 1.6 kg/mm of rainwater under farmers

Table 3. Residual effect of B, S and B+S nutrient amendments applied to soybean on grain and straw yield of chickpea in watershed of Guna district, Madhya Pradesh, India during post-rainy season 2002-2003

Treatment	Yield ($t\ ha^{-1}$)		Increase over control (percent)	
	Grain	Straw	Grain	Straw
Boron(0.5 kg B ha^{-1})	1.61	1.66	54	10
Sulphur(30 kg S ha^{-1})	1.76	1.92	68	27
Boron + Sulphur(same as above)	1.55	1.79	48	18
Control(farmer's practice)	1.05	1.51	-	-

input condition, while it was 2.0 kg/mm of rainwater (i.e., 25% more productivity for the rain-fed systems in Madhya Pradesh) where micronutrients were applied. Application of B, S, and B+S increased soybean yields by 34-40 percent over the best-bet option treatment based on recommended fertilizer doses, which served as control without amendments. The economic analyses of these on-farm trials showed that application of B and S gave the benefit of USD 572-584 per hectare. The benefit-cost ratio was up to 1.8 for amendment addition, while it was 1.3 for control.

Integrated Pest Management (IPM) of Pigeonpea and Cotton in Kothapally Watershed

Integrated pest management was adopted to optimise crop productivity in the watershed. *Helicoverpa*, a major pest on chickpea, pigeonpea and cotton was monitored using pheromone traps. Effective indigenous methods like shaking pod borers from pigeonpea and using them for pest management, pest tolerant varieties and bio-control measures using *Helicoverpa* nuclear polyhedrosis virus (HNPV) were adopted. Studies conducted showed that in 65 percent of the 17 cases of the farmers' field trials, integrated pest management recorded higher crop yields (3.47 t ha^{-1}) over farmer's practice (2.33 t ha^{-1}) along with substantial reduction in investments in IPM plots.

Improved Crop Varieties

ICRISAT's adoption of integrated genetic management model include, short and extra-short duration crop varieties such as HHB 67 pearl millet hybrid and ICP 88039 pigeon pea that enable double cropping with mustard, chickpea and wheat in northern India. Better rooting and leaf-size pattern bred into drought tolerant varieties with conventional methods gave 10-40 percent higher grain yield. The approach includes drought resistant crops/varieties, use of high value crops such as medicinal plants for increased productivity and income with available water resources.

Micro-enterprises

The provision of training and development to farming communities in micro-enterprises forms a better way to reduce migration to urban areas for seeking employment during off-farm season. Selection of micro enterprises can be based on the locally available resources and technical backstopping for training the farmers. Some such technologies include

- Vermicomposting: Providing training to women farmers can empower them.
- Preparation of bio-fertilizers.
- Village-based seed banks.
- Livestock-based activities: Improved fodder production can improve the livestock productivity, improved breed and animal health enhance productivity and incomes.
- Fisheries and related activities: When excess rainwater is available the farmers can go in for fish or prawn culture in the water ponds/ channels. This option can be made available to the landless people in the rural communities.
- Poultry-based activities: Agro-wastes, for instance, where maize cultivation is taken up, can be diverted for poultry feed alongwith other supplemental food. Rearing of improved genotypes like broilers can increase the returns and improve the livelihood options.
- Horticulture and forestry-based activities: Teak planting, pomegranate and custard apple cultivation along the bunds and marginal lands can enhance farm incomes.

Village-based Seed Banks

One of the critical issues for increasing crop productivity is availability of good quality seeds to the farmers. The approach adopted was empowering farmers and self-help group (SHG) members under the technical guidance of the consortium partners to operate village-based seed banks where the SHGs buyback the seeds of varieties produced by the farmers using breeders' seeds of selected crop varieties. To cite micro-enterprise activities in the watersheds, under the APRLP-ICRISAT-ICAR project in 2003, two village-based seed banks became operational in Kurnool district, Andhra Pradesh, India that procured 10 tons of seeds of ICGS 11 and ICGS 76 of groundnut crop; 4.5 tons of greengram (MGG 295) and one ton of pearl millet (ICMV 221) in Nalgonda district. Further, seed banks of chickpea, sorghum and pigeonpea that started during 2002 in ADB-Tata funded projects in Madhya Pradesh and Rajasthan are successful examples of empowerment.

Rehabilitation of Common Grazing Lands/Wastelands and Participatory Biodiversity Management

Rehabilitating common grazing lands and wastelands is one of the important activities under watershed management. *Annona* spp. (custard apple) plantation on the bunds, *Gliricidia* saplings planted along the borders of the wasteland can serve as live fences. Avenue plantation (timber [teak], fuel, fruit trees) in the watershed villages through afforestation program; and bio-diesel plantation like *Pongamia* spp. and *Jatropha* spp. can help in rehabilitating the common lands through income-generating options. These activities help in rehabilitating common wastelands and enhance possibilities for expanding the income earning potential. Community participation to rehabilitate 45 ha of open grazing land of undulating terrain through stone wall fencing, planting useful grasses, bench terraces, contour trenches and silt-trap pits for *in-situ* soil-moisture conservation in Gokulpura village of Thana watershed, Bundi district, Rajasthan, India under the Tata-ICRISAT-ADB Project led to improved fodder availability and, flora [*Dhaman* (*Cenchrus setigerus*)] grass, the native *Khejri (Prosopis cineraria)* species, Neem (*Azadirachta indica*), Khejada (*Acacia leucopholia*) etc. and fauna [Nilgais (wild cow)], rabbits, hares, a host of bird species) rehabilitation.

Impact of Integrated Watershed Interventions

Appropriate technology options and scientific and technical backstopping by the consortium of institutions through the integrated watershed management model developed by ICRISAT-led consortium have yielded good results at different benchmark locations in Asia. The success is mainly because of good participation by the farmers and due to tangible economic benefits to individuals equitably through technically backstopped holistic approach. The impact assessment was based on the parameters discussed below.

Increased Productivity

In the on-farm Kothapally Adarsha (Model) watershed, (Ranga Reddy district, Andhra Pradesh), farmers evaluated improved crop management practices (INM, IPM and soil and water management) along with researchers. Farmers obtained high maize yield ranging from 2.2 to 2.5 times with improved technologies as compared to the yields of sole maize (1.5 t ha^{-1}) in 1998 (Table 4). In case of intercropped maize with pigeonpea, improved practices resulted in increased maize yield (3.1 t ha^{-1}) compared with farmers' practices where the yields were 2.0 t ha^{-1}. In case of sorghum the adoption of improved practices increased yields by three-folds within one year. Yield of intercropped pigeonpea with improved management practices increased by five times in 2003 (Wani *et al.,* 2003d). Similar results were reported from other benchmark watersheds in India, Thailand and Vietnam (Wani *et al*., 2003a)

Table 4. Average yields with improved technologies in Kothapally Adarsha Watershed, 1999–2003

Crop	Baseline yield	Yield (kg ha^{-1})				
	(1998)	1999	2000	2001	2002	2003
Sole maize	1500	3250	3750	3300	3480	3921
Intercrop maize	-	2700	2790	2800	3083	3129
(Farmers' practice)		700	1600	1600	1800	1950
Intercrop pigeonpea	190	640	940	800	720	949
(Farmers' practice)	-	200	180	-	-	-
Sole sorghum	1070	3050	3170	2600	2425	2288
Intercrop sorghum	-	1770	1940	2200	-	2109

Shift in Cropping Pattern and Crop Diversification for Increasing Incomes

Investments in crop technologies and integrated watershed management interventions have brought a shift in cropping pattern and increased yields. During 1998–2002, more pronounced impacts in terms of shift in cropping pattern and increased yields were observed in a 500-ha Kothapally Adarsha Watershed. In this watershed, the farmers grow a total of 22 crops, and a remarkable shift has occurred in the cropping patterns from cotton (200 ha in 1998 to 100 ha in 2002) to a maize/pigeonpea intercrop (40 ha in 1998 to 180 ha in 2002). This shift has increased productivity and incomes of the farmers as well as diversified the cereal-based systems using legumes (Wani *et al.*, 2003a, d). Crop diversification with inclusion of higher value crops such as vegetables, medicinal and aromatic plants have a greater market and make the systems more remunerative.

Improved Greenery

An increase in vegetation cover was observed through satellite imageries. Vegetative cover in Kothapally Adarsha Watershed during November-December increased from 129 ha in 1996 to 200 ha in 2000.

Improved Groundwater Levels

Groundwater level in the village significantly improved (around 3 m) in Adarsha Watershed, Kothapally as against untreated watershed areas where water levels were continuously declining (Wani *et al.*, 2003c).

Reduced Run-off and Soil Loss

Run-off was 12 percent of the total rainfall (Fig. 3) in the undeveloped watershed while it was only 6 percent in the developed watershed where soil and water conservation measures were undertaken.

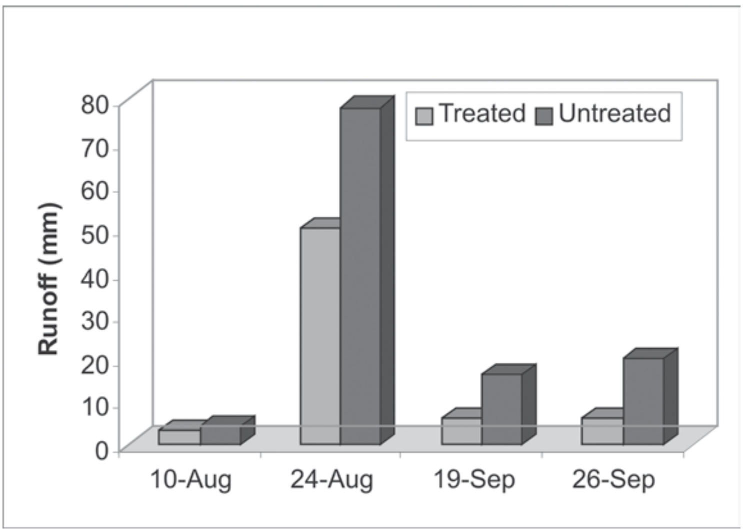

Figure 3. Run-off losses in the untreated and treated sections of Adarsha Watershed, Kothapally, 2001

Increased Incomes

The impact of integrated watershed management interventions on poverty and livelihoods of rural communities at on-farm watersheds in Adarsha Watershed, Kothapally, India clearly showed that average net returns per hectare for dryland cereals, pulse and other crops almost doubled. Adoption of the improved varieties not only increased crop yields, but also enhanced the economic profitability of other soil and water conservation investments, which may otherwise be economically less attractive to farmers. Average household income from crop production activities within and outside the watershed was INR 15400 and INR 12700 respectively. The average per capita income was INR 3400 in Adarsha Watershed and INR 1900 outside the watershed. This shows a significant impact of watershed intervention activities (initiated in 1999) towards poverty reduction in Kothapally Watershed through increased incomes for the poor. The average income from agricultural wages and non-farm activities were INR 17,700 and INR 14,300 within and outside the watershed, respectively. The increased availability of water (and hence supplementary irrigation) and better employment opportunities in watershed development related activities have contributed to diversification of income opportunities and reduced vulnerability to drought and other shocks (Wani *et al.*, 2003d).

Because of the serious drought, the average household incomes declined in 2002-03 cropping season as compared to 2001-02 in both the developed and untreated watershed villages. However, the decline in crop income was more pronounced in the untreated watershed areas as compared to developed watershed areas. The data showed that income from crop production activities in the untreated watershed villages declined by about 70 percent while it declined only by 25 percent in Adarsha (Model) watershed. This indicates that watershed management activities have significantly reduced household vulnerability to drought and enhanced the resilience of livelihoods. The effect of watershed management programs was more in the case of dryland cereals and pulses – the crops supported through ICRISAT and partners. The decline of crop production due to drought was generally compensated by increased income from non-farm activities. The change in livestock income due to the drought was not significant.

Scaling-up and Scaling-out

These micro-level studies have been critically reviewed and analysed for upscaling the interventions to stipulate the macro-level picture of the watershed benefits and people's participation. Based on the success of the participatory consortium watershed management model at Kothapally; three districts of the Andhra Pradesh Rural Livelihoods Programme (APRLP), three districts of Madhya Pradesh and Rajasthan, northeastern Thailand, north Vietnam and southern China with support from APRLP-DFID, Sir Dorabji Tata Trust, India and Asian Development Bank (ADB), the Philippines have selected this model for scaling up the benefits in nucleus and satellite watersheds. In the target ecosystems, project-implementing agencies (PIAs) were selected based on their strengths and knowledge base available in the system. Nucleus watersheds were selected for development and critical monitoring as the sites for undertaking action research. An innovative model with a consortium of institutions, as opposed to single institution approach, for technical backstopping was initiated (Fig. 4.) for project implementation (Wani *et al.*, 2003c). All the partners have worked in partnership with each other to manage the watershed sustainably.

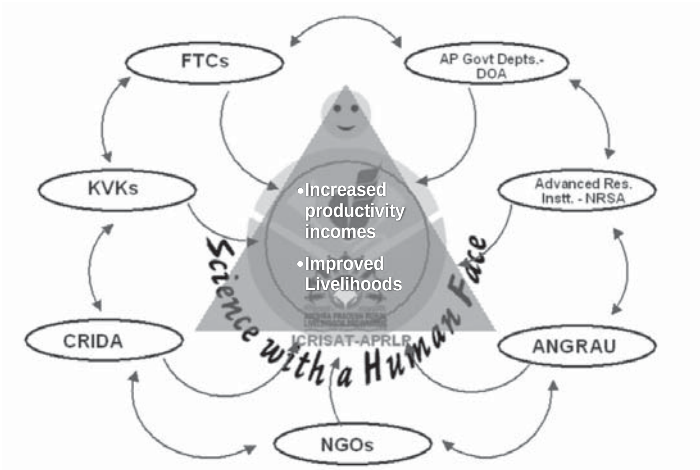

Figure 4. Farmer participatory ICRISAT-APRLP consortium for integrated watershed development. (FTC : Farmer Training Centre, KVK : Krishi Vigyan Kendra (Farmer Science Centre), ANGRAU: ANGR Agricultural University, NRSA: National Remote Sensing Agency, DoA: Department of Agriculture)

A successful partnership based on strong commitment with state and local agencies, community leaders and people is desirable. It was recognized that to shift the community participation from contractual to consultative and collegiate mode, tangible private economic benefits to individuals are must. Such tangible benefits to individuals could come from *in-situ* rainwater conservation and translating through increased farm productivity by adopting Integrated Genetic of Natural Resource Management (IGNRM) approach. Adopting the principle that 'users pay' provided no subsidies for investments on individual's farms for technologies, inputs and conservation measures. Once the individuals could realize the benefits of soil and water conservation they came forward to participate in community activities in the watershed through various organized groups.

Up-scaling Strategy for Increased Household Incomes

Unlike other Asian countries, the landholdings of Vietnamese farmers are very small. In the Thanh Ha watershed, Vietnam, the average family holding in drylands is around 0.5 to 1 ha. Efforts have been made to identify appropriate crops and crop combinations in various seasons for enhanced household incomes and food security in the backdrop of systems sustainability, soil health and potential for large-scale adoption and adaptation. For example, maize, groundnut and soybean combination gave higher incomes in spring while maize and groundnut, and maize and soybean crop combination in autumn-winter season. Crop performance differences were significant across the seasons. Spring season was more favourable in terms of grain yields and associated income gains than the autumn-winter season. Again, among the crops soybean performed better in spring and summer as compared to winter season.

Soils in the sloping land being highly vulnerable to erosion and land degradation, their influence on crop productivity and profitability is quite evident. From field studies, the grain yields of soybean, groundnut, mungbean, and maize based on the location on the toposequence in the landscape watershed have been delineated (Fig. 5 and 6).

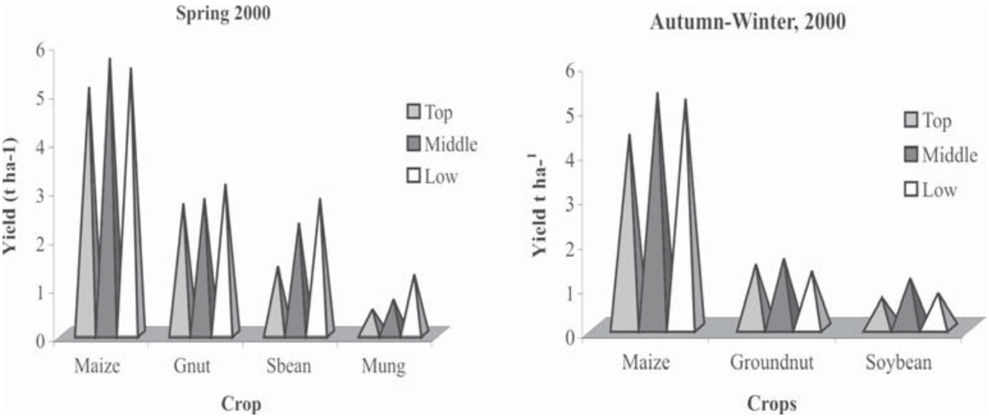

Figure 5. Influence of toposequence on crop productivity

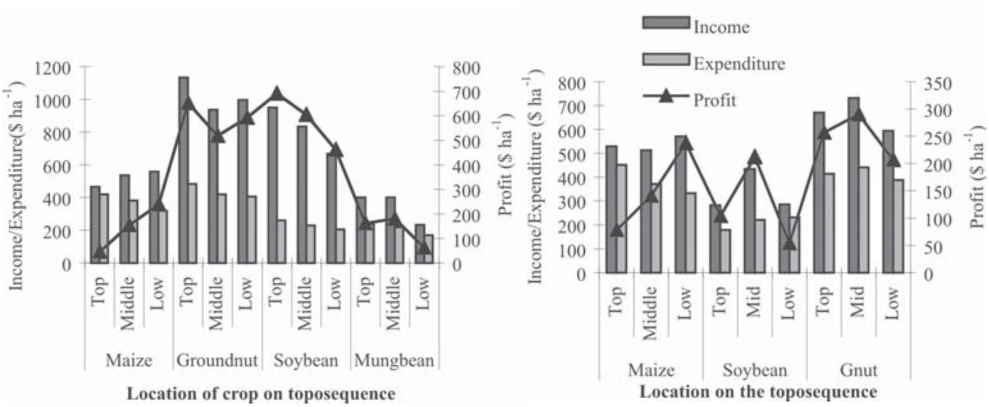

Figure 6. Influence of toposequence on crop profitability, spring and autumn-winter, 2000

In general, higher grain yields and farm incomes were obtained in the lower and middle part of the toposequence compared to the top due to lower degradation and better soil fertility. Farmers are incurring higher expenditure due to higher fertilizer usage on top of the toposequence. Among the crops groundnut can be grown successfully on top, mid and lower part of the toposequence while mungbean and soybean need high level of management on top of the toposequence for obtaining good yields. This kind of information would assist in appropriate land use planning and development of targeted nutrient management technologies for systems resilience and increased household incomes (Wani *et al.*, 2003a).

At present ICRISAT-led consortium is developing scaling-up methodology for the integrated watershed management model in 190 villages in India, China, Thailand and Vietnam with the financial support from the development investors, such as ADB, Sir Darobji Tata Trust, DFID and NARSs.

New Initiatives

Sustainability through Empowerment

Empowerment of stakeholders through capacity building is very critical in participatory integrated watershed management. In this model emphasis is on capacity building of all the stakeholders (farmers, partners, NGOs, government departments and policy makers) to facilitate the scaling-up of the benefits from the nucleus and satellite watersheds in the target districts. The strategy adopted in this module for scaling-up is depicted in Fig. 7. The nucleus watershed PIAs and farmers serve as trainers to the rest of the watersheds in a given agro-ecosystem for rapid extension of technologies.

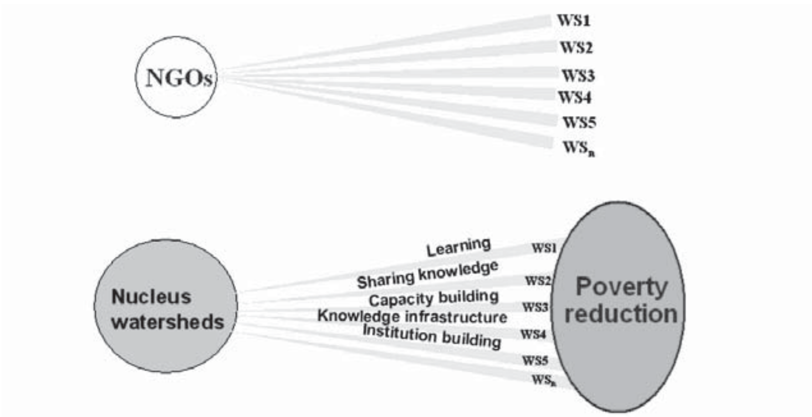

Figure 7. Knowledge transfer within the institution and the region

Mass Capacity Building Efforts

Farmers' days, field days and farmer awareness programs are important activities for effective dissemination of on-station and on-farm technologies to a wide range of farmers in the watersheds. Specialized training courses/programs on participatory watershed management, tropicultor training, use and maintenance of hydrological equipment, seed treatment and *Rhizobium* inoculation methods, integrated pest and disease management, training project personnel on socio-economic survey methods in community watersheds, information and communication technology, action learning for community mobilization, income-generating options and improving livelihoods like training of SHGs, women, youth and landless households in vermicompost preparation, *dhal* mill for milling pigeon pea are a part of this consortium model. Preparation of training materials, information brochures, bulletins, pamphlets on various watershed-based technologies, in English and regional languages and their distribution in all the nucleus watersheds. Website for the APRLP-DFID-ICRISAT project, TATA-ICRISAT-ICAR and ADB-ICRISAT projects are launched with selected datasets to be put on the website and the site is updated as and when new information is available.

ICT-enabled Farmer-centered Learning Systems for Knowledge Exchange

Modern information and communication technologies (ICTs) are intelligent options for facilitation of flow of information and knowledge to masses for upscaling the benefits. In the watersheds, community centres managed by the PIAs are functioning as a Rural Information Hub (RIH) connecting participating villages (or groups of villages, as the case may be) and also with other internet connected web sites. Each RIH centre has a computer and a suitable connectivity device (e.g. modem or VSAT technology). It is operated or managed by rural group (women or youth SHGs). To site a case, taking advantage of the established connectivity with Adarsha Society in Addakal (Mahabubnagar district), a 'distance learning program' was launched by ICRISAT.

Supporting Strategies for Improving Productivity and Rural Livelihoods – Challenges Ahead

There are two levels of challenges faced by the farmers/stakeholders that need to be properly addressed. First challenge is to increase the productivity levels and the second is to look beyond subsistence livelihoods. Our strategies need to be refined and innovative ways need to be adopted to increase productivity whilst sustaining natural resources in the rainfed areas. The approach needs integration of natural resources management with socio-economic and life support systems to look beyond plus some emerging issues of concern as categorized below:

Building Partnerships

Different groups and locations have conflicting objectives with respect to their investment priorities and enterprise choices. These need to be converted into opportunities. The action of all the farmers in the watershed should converge in such a way that the positive externalities are maximised, and negative ones are minimised. To achieve this, the community or stakeholders have to develop their own rules, which resolve their conflicting objectives. It is believed that better organised and effective people's participation would yield higher benefits.

Common Property Resources (CPR)

Equity issues of water: Competitive extraction of groundwater is leading to disastrous consequences that need to be administered through appropriate policy mechanisms, collective arrangements for groundwater use with the support of local governing bodies, state government officials and technical backstopping by scientists.

Rehabilitation of common wastelands: Innovative ways to manage common wastelands by planting saplings of useful species and diversification such as bio-diesel, medicinal and aromatic plants along the roads, field bunds and *nalas* needs to be adopted for additional support to rural livelihoods. Adoption of such initiatives by resource poor farmers in the local region even at small scale can improve the economic welfare and quality of the local and global environment.

Balancing Demand and Supply of Water

Balancing the water demand for all the purposes, such as agriculture, domestic, industry, recreational and environment purposes is a critical issue. There is an urgent need to increase water-use efficiency in agriculture and also reduce the water demand for domestic uses by adopting innovative options and increasing awareness and capacity building efforts.

Choice of Crops

Efficient utilization of existing natural resources is possible by crop zoning based approach, crop intensification, rational choice of crops and crops that are cash generating like soybean crop and medicinal and aromatic plants. As groundwater extraction is dictated by the cropping pattern, appropriate cropping systems and patterns need to be adopted for drylands where water is very scarce natural resource. Crop diversification with legume (pulses) has long-term sustainable benefits to the soil system by restoring the soil organic matter and thereby the water holding capacity in the soils.

Appropriate Policies for Groundwater Use

Water-Energy-Agriculture-Nexus

Power failures at critical irrigation dates coupled with the attitude that agricultural crops with more water supplies yield more gains make farmers irrigate crops more frequently and use water inefficiently. By ensuring quality and timely supply of electricity, over-pumping of precious groundwater can be minimized. This calls for efficient irrigation management through efficient irrigation systems, pricing electricity, efficient pumps and crops that use water efficiently. The concept of water-energy-agriculture nexus needs to be adopted for rational and sustainable use of this limiting resource. Policy options for groundwater harvesting, issues like borewells, use of working strategies and maintenance need to be addressed.

Administered Price Policy for Dryland Crops

The farmers are inclined more towards the water-intensive crops like wheat and rice over coarse cereals or pulses as these crops are favoured by procurement and pricing policies. A regulation needs to be worked out for minimum support price operations for dryland crops.

Value Addition Products in Rural Areas and Market Links for Products

There is a need to investigate and explore a range of opportunities through on-farm and off-farm activities to encourage and promote village level micro-enterprises such as vermicompost technology, giving value addition to agricultural produce (e.g. pigeon pea, *dhal* mill, extraction of oils from medicinal plants, scope for food processing, infrastructure development, etc.) to help the landless, educating youth and women to ensure a more equitable sharing of the benefits of watershed management projects. Further, promoting pathways for market links for rural produce through institutional and policy support shall be of great help.

Conclusion

The current model of ICRISAT-led consortium's integrated watershed management through its efficient rainwater management have very high potential for bringing favourable changes in drylands of the SAT. On-farm watersheds managed through community participation could sustain productivity of drylands and preserve the quality of the land resources and environment in the SAT. Holistic systems approach through integrated watershed management can result in sustainable and increased farm productivity and improve the livelihoods of rural poor in the dry regions.

Acknowledgements

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Integrated Watershed Management: Managing Valleys and Hills in the Himalayas

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Abstract

The Indian Himalayas cover an area of about 53.7 m ha which is 16.4 percent of the total geographical area of the country. Nearly 88 percent area of this region is covered with snow, forests, rivers, inaccessible hills and hardly 12 percent is under agriculture. The Himalayas have distinct production zones depending on climate and altitude. The livelihood production systems being followed are highly variable especially due to diversity in socio-cultural and micro situations. Over-exploitation of natural resources has resulted into severe land degradation problems, depletion of water resources, decrease in productivity of arable and non-arable lands, recession in snow covered area and consequently the global warming. Recent estimates indicate that nearly 39 percent area of the Indian Himalayas has potential erosion rate of more than 40 t/ha/year, which is really alarming. Participatory integrated watershed management (IWSM) approach being adopted in the recent past has shown encouraging results over the previously adopted commodity based or sectoral approaches. Operational Research Project on Watershed Management at Fakot in outer Himalayas which was implemented by Central Soil & Water Conservation Research and Training Institute (CSWCRTI) during 1975-86 is a successful example of this participatory approach. Similar trends in production increase and environmental benefits have been observed in other watersheds developed under NWDPRA, DPAP, RVP and other bilateral projects implemented during 1990s.

Development and effective utilization of water resources acts as a major catalyst to motivate the farming community to adopt watershed programs. Recent field level studies indicate that farming community willingly contributes in such activities and the contribution varies from 13 percent (Sainji; middle Himalayas) to as high as 51 percent (Bhopal Pani, Doon Valley). The contribution may be in the form of cash or kind (labour, collection of locally available materials etc.). The stakeholders of WSM have multiple objectives to be achieved under the program, many of which are conflicting. The multi-objective decision making technique employed in Fakot watershed has revealed that under the restricted capital plan, with the reorganization of farm level activities and reallocation of available resources, farm income can be increased by 18 percent, employment by 28 percent and energy production by 46 percent with a reduction in soil loss by 53 percent over the existing situation. Under unrestricted capital situation, the income, employment and energy values can be further increased by 30, 10 and 8 percent over the unrestricted situation, respectively with a marginal increase in soil loss.

Watershed management program yields a large variety of intangible benefits which are

rarely accounted for in economic evaluation studies, particularly at micro watershed level. Quantification and valuation of intangible benefits in the Fakot watershed has indicated their contribution to the extent of Rs. 30.5 lakhs. Therefore, it may be concluded that participatory integrated watershed management is a self-sustainable approach for the development of valleys and hills of Himalayas. The investment made in such programs is economically justified with higher internal rate of return and several environmental benefits. However, greater emphasis is needed on evolving cost-effective technologies for erosion control and flood moderation, and identify suitable integrated farming systems for sustained productivity and diversification of production systems.

Introduction

Himalayas, the highest range of mountains in the world, is geologically the youngest and ecologically the most fragile mountain ecosystem in the world. The Indian Himalayas cover an area of 53.7 M ha, which is 16.4 percent of the total geographical area of the country. It consists of two distinct flanks of north-western and north-eastern Himalayan ranges, which are highly divergent with respect to climate, vegetation, livestock, land management/cultivation practices and socio-economic conditions. The mountain range stretches for about 2800 km east to west and is about 380 km wide. The Himalayan mountains are a critical determinant of the climate in the Indian sub-continent. The climate varies from hot and sub-humid tropical in the southern low tracts to temperate cold alpine and cold deserts in the high mountains. The average annual precipitation varies from 80 mm in Ladakh (cold desert) to 1150 mm in Jammu and 500 to 3500 mm in Himachal Pradesh. In the north-eastern region, average annual rainfall ranges from 1320 mm to as high as 12000 mm with a mean value of 2800 mm.

It is estimated that about 50,000 sq km of glaciers equivalent to over half the permanent snow and ice fields outside the Polar regions feed into the world's largest water drainage system of the Indus, Ganga and Brahmaputra rivers. The total amount of water flowing from the Himalayas to the plains of the Indian subcontinent is estimated to be about 8.6×10^6 m^3 per year (IPCC, 2001). The contribution of snowmelt run-off in the eastern Himalayas is only 10 percent as compared to 60 percent in the western Himalayas (Sharma, 1993). About two-thirds of the available surface water resource of the country (1900 bcm) is contributed by the Ganga-Brahmaputra-Meghna (GBM) system covering one third of the country's geographical area. This water has the potential to generate 28,150 megawatts of electricity and contribute about 246000 million cubic metres of water for irrigation (Valdiya, 1997).

Problems and Constraints

The Himalayan region is characterized by marginality, inaccessibility and fragility compounded by high intensity and erratic rainfall, steep slopes, large-scale deforestation and faulty management practices. Unscientific land management with alarmingly high rates of soil erosion, low crop productivity, heavy pest and weed infestation, high population of low yielding animals, loss of biodiversity, shrinking forest cover and pasture lands, and population pressure are the major impediments in improving the socio-economic conditions of the resource poor and marginal farmers of this region. There is an increasing frequency of disasters, such as landslides, floods, droughts, cyclones, hailstorms, siltation of reservoirs and deterioration of water bodies due to accelerated deforestation, conversion of marginal/forest land into agriculture and unscientific developmental activities like road construction, mining, etc.

Over the years, the flow in natural springs and streams has sharply declined in the Himalayan watersheds owing to mismanagement of catchment areas and developmental activities. The dry weather flow in the springs has been recorded as varying from 2 to 20 lpm in Kumaon Himalayas (Srivastava, 1983), 1 to 15 lps in Tehri Garhwal (Anon., 1978) and only from 1 to 5 lps in eastern Himalayas (Prasad *et al.*, 1987). A classical example of declining discharge is Gaula river catchment in Uttaranchal where in 40 percent of the villages, spring discharge has declined from 25-75 percent during the last 5 to 50 years. Consequently, the river flow has reduced from 12000 m^3/day to 5000 m^3/day in 15 years due to over-exploitation of natural resources in spite of the fact that average annual rainfall remained static at about 2200 mm. The average annual run-off in the Himalayan watersheds is estimated to vary from 15 to 20 percent in the valleys to as high as 50 percent in the high hills.

The high intensity rains coupled with steep topography devoid of vegetative cover leads to high erosion rates and severe land degradation problems. The average annual soil loss in the Himalayas has been estimated as 20 t/ha/year and varies from less than 5 t/ha/year in dense forest areas to more than 40 t/ha/year in the shifting cultivation areas of NEH region. It is estimated that sediments from the Himalayan rivers contribute a quarter of the total ocean's sediment (Valdiya, 1997). Sediment yield from tributaries of Himalayan rivers varies from 6.0 to 98.4 cum/ha/year which is much higher than the permissible limits of 4.5 to 11.2 t/ha/year.

Recently, Central Soil and Water Conservation Research & Training Institute (CSWCRTI), Dehradun has estimated potential soil erosion rates for different states employing Universal Soil Loss Equation and using grid data of 10 sq km size in collaboration with National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), Nagpur (Sharda and Dhyani, 2004). The figures are really alarming for the Himalayan states. In north-western Himalayas, on an average, 42 percent of the area falls in very severe category with erosion rates > 40 t/ha/year while about 68 percent area has erosion rates more than the permissible rate of about 10 t/ha/year. The trends are similar in the north-eastern Himalayan states. The states of Himachal Pradesh in western Himalayas and Sikkim in NEH region have maximum area of 55 and 80.7 percent, respectively under very severe category with erosion rates of > 40 t/ha/year. Overall, about 39 percent area in the Himalayan states has potential erosion rates > 40 t/ha/year. It calls for serious efforts to employ appropriate conservation measures to check land degradation problems.

The Himalayan region is confronted with major mass erosion problems due to landslides, minespoils and torrents in the hills and valleys. Major landslides in Himalayas result in an annual loss of more than 50,000 man hours and 5000 vehicle hours/km in hill roads per year due to disruption of communication alone (Bansal and Mathur, 1976). Mining in the Himalayas cover an area of 25057 ha, majority of which is under limestone querrying. It is estimated that mining activity in Doon Valley has reduced food production by 28 percent, water resources by 50 percent and livestock production by 35 percent (Anon., 1988). In the Doon Valley and Shiwalik ranges, the damages due to torrents are extensive and showing an upward trend. Many of the perennial water streams have turned into sediment-laden torrents as a result of unscientific land use and over-exploitation of resources. It is estimated that in Doon Valley alone, the torrents are damaging about 100 ha of forest land every year with trees worth Rs. 10 million.

The various constraints in agricultural development of mountainous and valley regions may be summarized as follows:

- Steep slopes and undulating topography.
- Small and fragmented holdings and absentee land ownership.
- Poor socio-economic conditions of people with limited input and risk bearing capacity.
- Womenfolk as major workforce with lack of awareness of improved agricultural technologies.
- Subsistence agriculture with limited crop diversification.
- Limited access to improved seeds, inputs and irrigation resources.
- Lack of adequate institutional financing mechanisms.
- Inadequate marketing arrangements for the produce and post-harvest facilities.
- Non-availability of suitable implements for hill agriculture resulting in low output and high drudgery in operations.
- Slow returns from orchards due to long gestation period.

Growth of Watershed Management Programmes

CSWCRTI, Dehradun has pioneered in developing and popularizing the concept of participatory watershed management in the country. Initially, it identified 42 small watersheds for experimental purposes to monitor the impact of conservation measures and land use systems on surface hydrology and soil erosion out of which 5 were located in the Doon Valley region. The real breakthrough occurred during 1970's through the tremendous success of four pilot Operational Research Project watersheds in the country, out of which one is located at Fakot in Tehri-Garhwal district of Uttaranchal in middle Himalayas. Fakot watershed is a classical model of community-driven, self-sustainable and eco-friendly balanced development process in the Himalayas, which has proved to be a torchbearer for the subsequent massive watershed development programme in the valleys and hill regions. The drought proofing potential of watershed management programmes was amply demonstrated during the drought year of 1987, which resulted in the launching of a massive project of National Watershed Development Programme for Rainfed Areas (NWDPRA) by the Ministry of Agriculture in 1991 at a cost of Rs. 11,285 millions. This was followed by several other programmes funded by various national and international agencies including Ministry of Rural Development (MoRD), Ministry of Environment and Forests (MoEF), World Bank, Danish International Development Agency (DANIDA), European Economic Community (EEC), KfW (Germany), Department for International Development (DFID), National Bank for Agriculture and Rural Development (NABARD) and Aga Khan Foundation.

Watersheds falling in the catchments of rivers are being developed under centrally sponsored scheme of river valley projects (RVP) and flood prone rivers. Ever increasing participation of non-government organizations (NGOs) since 1982 and local community have added new dimensions to the concept of watershed management. India has developed elaborate institutional infrastructure to take care of soil and water conservation problems in different mountainous regions on watershed basis. Recently, the guidelines for watershed management have been harmonized by the Ministries of Agriculture and Rural Development with due emphasis on participatory approaches and strengthening capabilities of local people.

With the primary objective of arresting and as far as possible reversing the degradation process in the Doon Valley environment, Doon Valley Integrated Watershed Management Project (DVP) is being implemented by the Watershed Management Directorate, Govt. of Uttaranchal (erstwhile Uttar Pradesh) with financial grant provided by the European Economic Community since 1993. DVP covers seven sub-watersheds and forty-three micro watersheds mostly in Dehradun district and covers a total of 400 villages. The physical component includes forestry, livestock, horticulture, minor irrigation, agriculture, soil conservation and energy conservation. The project has three phases with first phase covering rapport building with local people and participatory rural appraisal (PRA) exercises, second comprising implementation of various project interventions and in the third, withdrawal plan is prepared in consultation with the villagers.

Strategies for Managing Hills and Valleys for Increased Productivity

The research efforts in the past 4-5 decades have identified a number of resource conservation techniques for the hills and valleys which reduce the risk of soil degradation, preserve the productive potential, decrease the level of inputs required and sustain agricultural productivity in the long run. These measures include land shaping or mechanical measures, agronomic manipulations, vegetative barriers, alternate land use systems and run-off harvesting and recycling techniques. The agronomical measures are generally recommended on mildly sloping lands with the objective of maximizing *in-situ* rainwater conservation to ensure protection against erosion and higher productivity. They include contour farming, intercropping, strip cropping, mixed cropping, cover management, mulching, crop geometry, tillage practices and diversified cropping systems. Mechanical measures are adopted to support the agronomical measures on steeper slopes or where the run-off is high by reducing the length and/or degree of slope to dissipate the energy of flowing water. They include land levelling, bunding, terracing, conservation, bench terracing and contour trenching.

Many location-specific vegetative barriers have been recommended either to supplement land shaping measures or to replace them completely, wherever feasible. They not only reduce run-off and soil losses but also provide fodder during the off-season. World Bank promoted Vetiver (*Vetivaria zizanioides*) was not found universally effective and acceptable by the people. For example, it was inferior to the species of regional importance such as *Eulaliopsis binata* and *Saccharum spontaneum* in the Shiwaliks and *Panicum maximum* in the sub-humid lower western

Himalayas (Prakash *et al.*, 1999). In the NEH region, the grasses such as *Cynodon dactylon, Cenchrus ciliaris, Panicum antidotale* and *Pennisetum polystachyon* have been found effective in reducing soil loss to < 0.5 t/ha from 40.9 t/ha under traditional shifting cultivation (Chatterjee and Maiti, 1974).

Alternate land use systems of alley cropping, agroforestry and agri-horticulture are recommended in the hilly region to optimize the use of natural resources, minimize the need for inputs derived from non-renewable resources and reduce the risk of environmental degradation. Alley cropping with Leucaena, Gliricidia and grass barriers has been found effective for mulching and erosion control on sloping lands up to 30 percent. At Dehradun, the contour-paired rows of Leucaena and Eucalyptus trees and 0.75 m wide grass barrier at 1.0 m interval in maize brought down the run-off from 40 to 30 percent and soil loss from 21 to 8 t/ha (Narain *et al.*, 1998). The total sediment deposition along the hedge and tree rows increased considerably with consequent reduction of soil loss (Table 1).

Table 1. Sediment deposition along vegetative barriers and soil loss from different landuse systems at Dehradun, India

Treatment	Average soil deposition (t/ha/yr)	Soil loss (t/ha/yr)
Leucaena hedges in turmeric field	15.77	5.57
Leucaena hedges in maize field	51.33	12.09
Leucaena trees in maize field	28.50	8.82
Leucaena trees in turmeric field	10.01	6.78
Eucalyptus trees in maize field	20.62	5.80
Eucalyptus trees in turmeric field	11.52	7.12
Eucalyptus + maize – wheat	-	7.30
Leucaena + maize – wheat	-	11.23
Cultivated fallow	-	39.01

Source : Narain *et al.* (1998).

Hydrological Evaluations and Water Harvesting

The IWSM programmes were quite effective in conserving natural resources of land, water and vegetation for sustained productivity. Run-off reduction in the range of 1.5 to 2.5 and soil loss in the range of 1.2 to 4.8 times was realized in the experimental watersheds (Table 2). In a denuded Shiwalik watershed, a package of practices comprising trenching, brushwood/stone check dams, debris detention basins, planting of *Acacia catechu* and *Dalbergia sissoo* reduced run-off from 30 percent to 10.8 percent and soil loss from 150 t/ha to 2.8 t/ha in a span of 40 years (Table 3). Hydrological investigations in the middle western Himalayan watersheds have revealed that sub-surface flow is the chief contributor to the total run-off amounting to about 46 percent of rainfall while surface run-off accounts for only 4-6 percent mostly during the heavy storms (Sharda, 2004). In small watersheds of eastern Himalayas, run-off varied from 6.33 to 47.75 percent while the soil loss ranged from 22.7 t/ha to as high as 281.6 t/ha depending upon size of the watershed, landuse and treatment imposed (Table 4). The inevitable run-off can be suitably harvested in small tanks or dugout-cum-embankment type ponds for providing life saving irrigation to the crops during dry spells in the monsoon season and also in the *rabi* season. Significant increase in the yields of crops like wheat, barley, gram, mustard, linseed, potato, etc., has been obtained with supplemental irrigation in different regions (Sharda and Shrimali, 1994). Depending upon the crop and location, supplemental irrigation increased the yield by 165-485 percent in the Shiwalik and valley regions (Table 5).

Table 2. Impact of integrated watershed management practices on run-off (flood moderation) and soil loss

Watershed management site (State)	Run-off as percent of rainfall		Soil loss (tonnes/ha)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Fakot (Uttaranchal)	42.0	14.2 (2.9)*	11.9	2.5 (4.8)
Behdala (Himachal Pradesh)	30.0	15.0 (2.0)	12.0	8.0 (1.5)
Una (Himachal Pradesh)	30.0	20.0 (1.5)	12.0	10.0 (1.2)

Table 3. Annual rainfall, run-off and sediment yield from 21-ha watershed in Haryana

Period/yea	Rainfall (mm)	Run-off		Outflow peak discharge (cumec/sq km)	Sediment yield (t/ha)
		mm	%		
Before 1956 (Estimated)	1150.0	350.0	30.00	10.000	>150
1964-65	1254.2	276.7	22.06	2.535	37.7
Average 1965-70	1026.7	116.0	11.30	2.408	12.2
Average 1970-75	1193.8	111.4	9.33	2.786	5.3
Average 1975-80	1180.0	103.3	8.75	2.211	2.1
Average 1980-85	1130.3	78.2	6.92	0.140	1.0
Average 1985-90	1139.6	111.1	9.75	1.284	1.0
Average 1990-95	1099.9	118.9	10.81	1.431	2.8

The valley region has great potential of harvesting surface and sub-surface run-off and its recycling for providing supplemental irrigation to *kharif* as well as *rabi* crops. A successful example of a participatory water resource development is a dugout pond constructed at village Kalimati in Raipur block of Dehradun district. The pond of 260 cu m capacity harvests interflow and provides irrigation to 42 ha land in villages of Kalimati and Bhopalpani benefitting 125 families through lifting and underground pipeline system (Sharda *et al.,* 2004). Out of a total cost of about Rs. 1.98 lakhs, the farmer's contribution was 35 percent in terms of labour and collection of local materials and the entire cost was recovered within a period of two years. Enthused with the benefits of sub-surface flow harvesting, another tank of 350 cu m capacity was constructed in December 2003 in a participatory mode at village Bhopalpani at a cost of Rs. 3.47 lakhs in which farmer's contribution was as high as 51 percent. This technology motivated the farmers of non-adopted adjoining village Paw-Wala-Soda who managed funds from the State agencies and from members of Parliament/ Legislative Assembly for developing water resources under the active guidance of CSWCRTI, Dehradun. Pipeline system of about 4.5 km length was laid out to divert water from a perennial source 2.5 km away from the village. The system is irrigating 25 ha agriculture land benefitting 44 farm families in which farmer's contribution was about 25 percent. Water user societies have been constituted to sell and share the harvested water to the beneficiaries with equity and mutually agreed payment basis considering the cost of diesel, payment to the operator and resource generation for the society.

Table 4. Trends of annual rainfall, total sub-surface and surface flows and soil loss in micro-watersheds of Umroi

Micro-watershed area (ha)	Landuse pattern	Rainfall from April 2003 – March 2004 (mm)	Total flow as a percentage of rainfall	Sub-surface flow as a percentage of rainfall	Surface flow as a percentage of rainfall	Soil loss (t/ha)
WS1 (12.99)	BUN Grassland and forestry	1922.5	76.3	69.9	6.4	139.88
WS2 (10.69)	Agri. in contour bund, horticulture and forestry	1922.5	19.23	16.28	2.95	87.43
WS3 (3.85)	Agri. in BUN, and forestry	1922.5	6.33	5.62	0.71	24.32
WS S1 (2.4)	Agri. in contour bund in 80 percent area BUN, horticulture	1922.5	9.56	7.00	2.56	281.6*
WS S2 (1.6)	Agri. in contour bund in 20 percent area BUN, horticulture	1922.5	8.02	3.32	4.70	22.68
WS S3 (1.06)	Agriculture BUN, horticulture	1922.5	11.23	1.58	9.65	195.58
MW (240)	Main watershed with mixed landuse	1922.5	47.75	43.32	2.43	126.46

*Higher soil loss recorded due to movement of soil from newly excavated pond in the watershed.

Table 5. Expected water yields into farm ponds and effect of supplemental irrigation (5 cm) on crop yields in different regions.

Region	Soil type	Rainfall (mm)	Expected water yield (%)	Grain yield (t/ha)		
				No irrigation	With irrigation	Increase (%)
Bunga, Haryana	Silty clay loam	1116	50.0	0.70	3.40	485
Sukhomajri, Haryana	Silty clay loam	1021	20.0	0.70	1.50	214
Dehradun, Uttaranchal	Silt loam	1600	16.5	2.14	3.55	165

Considering project life of irrigation system at Kalimati and Bhopalpani villages as 30 years and discount rate as 10 percent for the payback period, the Net Present Value works out to be Rs. 23,55,261/- with benefit-cost ratio of 1.42:1 (Table 6). The internal rate of return is as high as 94.5 percent. It may thus be concluded that water harvesting and recycling is an economically viable proposition in valley lands.

Table 6. Economic evaluation of water harvesting systems considering 30 years project life and 10 percent discount rate

Evaluation parameter	Net present value (Rs.)	Benefit-cost ratio	Payback period, years	Internal rate of return (%)
1. Average situation	23,55,261	1.42:1	4	94.5
2. Total cost of the system increased by 10 percent	17,95,492	1.29:1	5	62.6
3. Total value of output reduced by10 percent	15,59,966	1.28:1	5	59.9
4. When 2&3 occur simultaneously	10,00,197	1.16:1	6	37.94

Productivity and Sustainability

Integrated watershed management programmes will not be sustainable if improvement in productivity and generation of additional income does not commensurate with investment. Analysis of time series data in a 370 ha middle Himalayan watershed during 1974-2002 has revealed that there was remarkable improvement in average yield of all crops ranging from 2.2 to 7.4 times during the intervention phase. The local community continued to invest and sustain the productivity even after withdrawal of the implementing agency during 1986 (Table 7). Diversification of crops and water resource development resulted in manifold increase of income as evident in Table 8, which shows sustainability of the project. Highest productivity difference within and outside the watershed area was recorded in wheat irrigated (56 percent), followed by wheat rainfed (39 percent), maize (37 percent), *mandua* (29 percent), paddy irrigated (28 percent), ginger (26 percent) and *Jhingora* rainfed (22 percent).

Table 7. Average yield (qha^{-1}) of major crops in Fakot watershed, mid Himalayas (Uttaranchal)

Crops	PPP* (1974-75)	IP* (1975-86)	PIP* (1987-02)
Paddy(irrigated)	6.5	48.2 (7.4)**	37.85 (5.8)
Maize(rainfed)	5.0	33.8 (6.8)	28.9 (5.8)
Mandua(rainfed)	4.5	10.8 (2.4)	8.1 (1.8)
Jhingora(rainfed)	4.0	9.4 (2.3)	6.15 (1.5)
Chillies (rainfed)	1.5	5.8 (3.9)	7.8 (5.2)
Ginger(rainfed)	35.0	78.7 (2.2)	116.2 (3.3)
Pulses(rabi-rainfed)	3.6	10.8 (3.0)	10.4 (2.9)
Wheat(rainfed)	4.5	18.6 (4.1)	15.8 (3.5)
Onion-Garlic(irrigated)	55.6	296 (5.3)	230.2 (4.1)
Tomato(irrigated)	Not cultivated	45.0	162.5
Gram(rainfed)	-do-	17.3	16.9
Oilseed(rainfed)	-do-	6.7	7.87

* PPP:Pre-project Period, IP: Intervention Phase, PIP: Post-intervention Phase. @1q = 100 kg.
** Values in paranthesis indicate times increase over pre-project phase/Intervention phase.

Table 8. Sustainable resource development and conservation through watershed management programme at Fakot, Uttaranchal

Product	Pre-project (1974-75)	During interventions (1975-86)	After withdrawal of external interventions (1987-02)
Food crops (t)	8.82	40.15	72.95
Fruit (t)	Negligible	6.2	24.08
Milk ('000 litres)	57	185	2,61
Cash crops ('000 Rs.)	6.5	24.8	1650
Animal rearing method	Heavily grazing	Partial grazing	Stall feeding
Dependency on forest fodder (%)	60	46	12
Run-off (percent)	42	14	14
Soil loss (t/ha/annum)	11.1	2.7	< 2

Increased biomass availability and fodder production resulting from integrated management of a watershed at Bunga (Haryana) changed the composition of livestock in favour of more economical animals and reduced seasonal migration of herds due to assured supply of fodder throughout the year (Table 9).

Table 9. Response in cattle wealth to watershed management in Bunga (Haryana)

Cattle	1983-84		1991-92		Percentage increase in value	2001-02	
	Number	Value* (Rs.)	Number	Value* (Rs.)		Number	Value* (Rs.)
Cows	820	12,77,500	1205	18,73,750	47	878	13,09,000
Buffaloes	206	9,41,750	561	26,10,250	177	711	37,04,500
Goats	2174	23,31,100	652	6,97,500	(-) 234	204	2,40,000
Bullocks	140	5,60,000	186	7,44,000	33	186	7,44,000
Total	3340	51,10,350	2604	59,25,500	16	1979	59,97,500

*Value has been calculated at constant prices prevailing during 1991-92.

Participatory Processes

Integrated watershed management has emerged as a new paradigm for planning, development and management of land, water and vegetation resources with a focus on social and institutional aspects apart from bio-physical aspects following a participatory 'bottom up' approach. Sustainability and replicability of the watershed management programmes call upon people's participation in the planning, implementation, management and equitable sharing of benefits and responsibilities. Transparency, contributions, equity in sharing of benefits, involvement of women and other disadvantaged sections of the society are the essential ingredients of community participation process for sustainable development. Transparency can be ensured by opening joint accounts with the watershed community. Depending upon the location and type of activity, contributions from the stakeholders can be as high as 65 percent. As a result of effective community participation and empowerment, the farmers continue to invest their financial resources, machinery, animal and manpower for different developmental activities even after withdrawal of active support as demonstrated in Fakot watershed. There is tremendous scope of involving the NGOs in watershed development projects because they have the art of effective communication with the local community. Though some of them have performed very well, others lacked infrastructure, experience, technical skills and commitment.

Technologies for Hills, Valleys and Shiwaliks

Over the years, a large number of technologies which can be adopted in IWSM programmes for resource conservation and enhancing productivity have been developed. A few of the prominent ones are listed below:

- Organic mulching @ 4 t/ha reduced erosion losses from 37 to 6 t/ha on 8 percent slope in Doon Valley and increased yield of subsequent crop from 1.9 to 2.4 t/ha. Normal tillage with live mulching (green manure grown in between maize rows) reduced run-off by 55 percent and soil loss by 60 percent on 4 percent slope.
- Conservation Bench Terrace system is effective in reducing run-off and soil loss by 80 and 90 percent, respectively and is about 19.5 percent more remunerative in terms of maize-equivalent yields over the conventional system of maize-wheat rotation (Sharda *et al.,* 2002).
- Mandarin (Kinnow), lemon (Eureka Round and Pant-1) and sweet orange (Malta Red and Mosambi) have been identified for horticulture development in riverbed bouldry lands of Doon Valley.
- Okra-*toria* crop rotation proved to be most beneficial with net income of Rs. 7790 and Rs. 10790 and B:C ratio of 1.58 and 1.80, respectively under both mango and litchi based agri-horti system in degraded lands of Doon Valley. Intercropping of peach with cowpea and turmeric from second year was found to be quite remunerative.
- In the middle Himalayan region, 'tanks' with capacity ranging from 10 to 30 cu m and lined with low density polyethylene film (LDPE) were quite successful and cost only one-third to that of cement lining.
- Pollarding of *Morus alba* produced 165 t/ha leaf fodder as compared to coppicing (136 q/ha) and 75 percent lopping (13.0 t/ha).
- In Shiwalik region, *Saccharum munja* and *Vetiveria zizanioides* grown in association with *Acacia nilotica* were promising for run-off and sediment control. *Eulaliopsis binata* gave maximum net returns of Rs. 11,500/ha.
- Earthen dams of 13.5 m height and 13.7 ha-m storage capacity in Relmajra village (Punjab) and of 16 m height and 59.6 ha-m storage capacity in Bunga (Haryana) provided supplemental irrigation to about 25 and 243 ha respectively which significantly increased the crop yields.
- In agri-silvi-horticulture system, peach gave an average income of Rs. 6200/ ha/year. The average fodder yields of intercrops of *guar*, cowpea, *bajra* and natural grass were 13, 17, 26 and 10 t/ha/yr, respectively.
- In degraded lands of Chandigarh, *aonla* cultivation can fetch a net profit of Rs. 40,000/ha after fourth year and Rs. 1,90,000/ha after eighth year with a benefit-cost ratio of 1.66:1 at 10 percent discount rate.

- Licking of Urea Molasses Mineral Bricks (UMMB) increased the buffalo milk yield by 0.6 litres/animal/day with a market value of Rs. 8.7 while the cost of UMBB was only Rs. 1.75 per day. The milk yield further increased by 1.5-2 litres/animal/day on providing health care measures.
- As income generating activity, mushroom cultivation in hilly areas was found to be quite remunerative with net profit of Rs. 2245 per replicate (13 bags). Similarly, apiculture with Italian honey bee colonies provided net returns of Rs. 1200-1500 as compared to Rs. 350-470 from Indian bees.
- With low cost polyhouse technology (plastic sheets and bamboos), an average yield of 34 q/ha of high value off-season vegetables (capsicum, cauliflower, spinach, broccoli and peas) can be obtained which fetches high income to the farmers in mid-Himalayas.

Intangible Benefits from Integrated Watershed Management

Generally, the impact of integrated watershed management (IWSM) projects is analyzed through tangible benefits accrued out of the program in terms of productivity components. The environmental externalities and intangible benefits are rarely accounted for. Even by considering tangible benefits, IWSM programmes were found to be economically sound with benefit : cost ratio varying from 1.10:1 to 2.94:1. Data in Table 10 presents benefit-cost ratio of some of the projects in western Himalayan and Shiwalik region. The IWSM projects, in addition to increasing overall productivity, also help in moderating floods downstream, mitigate the impact of drought, improve *in-situ* moisture conservation besides groundwater augmentation and other socio-economic benefits. These are largely ignored by researchers and implementers due to inherent problems of non-availability of tools and techniques for their quantification and valuation. An attempt was made to assess and quantify the intangible benefits by taking Fakot watershed as a test case (Sharda and Dhyani, 2004). The results are presented in Table 11. It is evident that the intangible benefits alone work out to be worth Rs. 30.54 lakhs from 370 ha watershed excluding the tangible benefits. It is much higher even from the total budget allocation of Rs. 22.2 lakhs for development of this size of watershed as per new guidelines of Ministries of Agriculture and Rural Development. Hence, investment in soil and water conservation activities following integrated watershed management approach is economically justified for sustained and balanced development and for ensuring environmental security.

Table 10. Economic evaluation of watershed management programmes in western Himalayas and Shiwaliks

Watershed	Benefit: cost ratio	Project life (years)	Discount rate (percent)
Fakot	1.92	25	10
Relmajra	1.20	20	12
Sukhomajri	2.06	25	12
Nada	1.07	30	15
Bunga	2.05	30	12
Maili	1.10	50	15
Chohal	1.12	50	15

Table 11. Intangible benefits from ORP, Fakot watershed management program

Attribute of intangible benefits	Method employed	Value (Rs.)
Additional fodder produced	Travel cost approach	1,35,825
Increased availability of fuel	Travel cost approach	35,420
Land value	Existence value	12,21,750
Demonstration value	Preventive expenditure approach	3,51,775
Living standard or human development index	Asset or property value approach	57,40,047
Education or literacy	Shadow project approach	72,000
Livestock sector	Shadow price approach	4,06,385
Soil retention	Programming and functional approach	6.7 t soil loss
Reduction in out migration	Relocation approach	8,31,600
Total annual intangible benefits (excluding living standard and soil retention value)		30,54,755

Decision Support Systems for Watershed Management

A multi-objective decision support system (MODSS) for watershed management is being developed to maximize all objective functions simultaneously using multi-objective compromise programming (MOP). Four decision variables, viz., economic efficiency (from income generation), employment generation, food security (energy production) and sustainability (soil loss reduction) were optimized simultaneously by assigning different combinations of weights to each variable such that the total weight equals to unity (Dhyani *et al.*, 2003). Out of many combinations of weights, three combinations {(0.25, 0.25, 0.25, 0.25), (0.5, 0.2, 0.2, 0.1), and (0.25, 0.22, 0.18, 0.35)} were chosen for net returns (NR), employment (EM), energy (EN) and soil loss (SL), respectively. The analysis was carried out under two capital availability situations, namely, restricted and unrestricted capital. To improve the decision making, four decision variables, viz., cropping intensity (CI), crop diversification index (CDI), cultivated land utilization index (CLUI) and forest dependency (FD) were subsequently added. For assigning numerical weights to different decision making variables, the following importance order was adopted:

(Net return = Soil loss) > Employment > Forest dependency > CLUI > (CDI = CI) >Energy

Application of the MODSS model to Fakot watershed in Uttaranchal has revealed that under the restricted capital plan, economic efficiency, employment generation and energy production can be increased by 18, 28 and 46 percent, respectively over the existing adopted plan, indicating thereby a great scope for improving these outputs from the watersheds while reducing the soil loss by 53 percent (Table 12). Among other variables, CLUI can be increased by 35 percent but CI and CDI would decrease by 31 and 25 percent, respectively. Forest dependency would increase from the existing 20 to 50 percent level by this plan. A shift from cultivation of cereals and millets to cultivation of vegetables and pulses occurred which are highly remunerative, employment generating, environment-friendly and have high nutrient value. Overall, there has been a decrease of 31 percent of the area under annual crops.

Table 12. Quantities of decision variables in existing and optimal plans for Fakot watershed under restricted and unrestricted capital situations

	Existing plan	$CP2\text{-}L_1$ RC	Change over existing plan (%)	$CP2\text{-}L_\infty$ UC	Change over existing plan (%)	Change over RC (%)
Economic efficiency (Rs.)	6780752	8000451	18	10363070	53	30
Employment (man days)	60163	77227	28	92774	54	20
Energy (‘000 kcal)	4421667	6473475	46	7003291	58	8
Soil loss (tonnes)	1290.44	612.6	-53	753.1	-42	23
CI	185	127	-31	186	1	46
CDI	1.6	1.21	-24	1.32	-18	9
CLUI	0.75	1.01	35	0.75	0	-26
Forest dependency (%)	20	50		52		

CP2= Compromize Programming using (0.5, 0.2, 0.2, 0.1) weights for NR, EM, EN and SL, respectively.
L_1 & L_∞= Lower and upper bounds, respectively of each of Compromize Programming generated optimal plan.
RC = Restricted capital situation.
UC = Unrestricted capital situation.

Under the unrestricted capital plan, further improvement can be brought about in economic efficiency, employment and energy generation over that from the restricted capital plan by 30, 20 and 8 percent, respectively. As compared to restricted capital, CDI would improve by 9 percent. However, forest dependency would remain high (52 percent) in the unrestricted capital scenario.

The study has indicated that watershed development projects in the hilly regions need to lay equal or more emphasis on non-arable lands, which are the major source of fodder for the animals. The development plan should include afforestation of multi-purpose tree species, resource conservation activities in the catchment areas, create awareness about rearing of improved breeds of cattle, animal health care and technical know-how for fodder storage and community based forest protection measures in the region.

Mass Erosion Control in Watershed Management

A number of pilot projects in the Himalayan region have been initiated to evolve technologies for rehabilitation of degraded sites affected by mass erosion problems. The reclamation measures for degraded areas comprise protective, mechanical and vegetative measures to be adopted in an integrated manner. Social fencing is the cheapest and most effective measure for protection of vegetation in the degraded lands. Vegetative measures provide long-term solution for the rehabilitation of areas affected by landslides, minespoils or torrents but require the support of mechanical measures for the purpose of establishment and create conditions conducive for plant growth. The mechanical measures consist of slope stabilization structures on steep slopes for revegetation, grade stabilization structures in the drainage lines and stream bank protection measures.

Studies have shown that integrated application of reclamation measures helped in making degraded lands productive, improve water regimes and quality, extended dry weather flows, moderated flood peaks and drastically reduced the sediment flow. For example, the rehabilitation measures in Nalotanala landslide control project on Dehradun-Mussoorie highway and Sahastradhara minespoil rehabilitation project near Dehradun rejuvenated water springs and sustained water yield even during dry period (Juyal *et al.*, 1998) (Table 13).

Table 13. Effect of bioengineering measures on landslide (1964-1994) and minespoil rehabilitation (1984-1996) projects

Particulars	Landslide project		Minespoil project	
	Before treatment	After treatment	Before treatment	After treatment
Run-off, mm	55	38	57	37
Sediment load, t/ha/yr	320	5.5	550	8
Dry weather flow, days	100	250	60	240
Vegetative cover, percent	< 5	> 95	10	80

These projects were found to be economically viable and sustainable. For example, in minespoil rehabilitation project, an amount of Rs. 1.5 lakhs was saved annually which the State Public Works Department was spending in clearing the debris from the roadside. Also the water quality of the outflow improved significantly after the treatment of the watershed area.

For stabilization of landslip areas, a new material known as coir geotextile has been successfully tried in mid Himalayan watersheds. The cost of this bio-degradable material and its laying works out to only about Rs. 40/sq m. This technique quickly arrests the soil mass and helps in conservation of moisture and regeneration of natural vegetation in a period of about one year (Sharda *et al.*, 2004).

To evolve location-specific and cost-effective technology for the treatment of torrents, a study was recently taken under World Bank aided NATP in the states of Punjab, Haryana, Uttaranchal, Himachal Pradesh and J&K. A number of vegetative and mechanical measures have been tried and studied for their performance in terms of ease of establishment, growth aspects and efficiency in protecting the banks and channelizing the flow. The studies have indicated that protected length of the bank varies linearly with the spur length. Deflecting type of spurs protect longer lengths of the bank (5 times the length of spur) as compared to the attracting type of spurs (about 3 times the length of the spur). However, length of the spur has to be limited to avoid the damage to the structure by direct impact of flow. The deposited silt volume varied positively with the angle of the spur in case of attracting type of spurs. There was a direct correlation between the silt deposited (volume) and product of length and the size of angle of spur. It is concluded that apron should be provided at least up to two-thirds length on upstream side in attracting type of spurs. Short deflecting spurs (< 5 m length) with apron on nose side covering half the length and preferably with toe wall are suitable for bank protection and quick sedimentation. Apron of minimum 1.0 m depth should be provided.

Integrated Farming System in Mid Himalayas

A large number of hilly farmers are dependent on water mills for their livelihood by diverting water from perennial streams. An integrated farming system (IFS) comprising watermill, poultry, fish cultivation, piggery and crop production is being evaluated in the mid-Himalayas at Sainji watershed to supplement the income of small and marginal farmers. The synergistic benefits of each component are mutually utilized to ensure best use of the available resources. For example, remnants and wastes from the watermill serves as a feed for the poultry and fish and poultry droppings form the feed for fish. Similarly, partially digested dung of pigs enters the ponds as fish feed and can be used as fertilizers for agricultural fields. Locally available materials like agriculture and animal wastes, local grasses, sugarcane wastes (press-mud) and household wastes are being recycled as feed materials especially for pigs to maximize the benefits at lowest cost in this IFS. Preliminary results have indicated that during 4 months period, fish worth Rs. 3611/ha was produced with a net profit of Rs. 1100. Similarly, a net profit of Rs. 690 from 9 Guinea fowls occurred in three months with B/C ratio of 1.62.

Experiences of Integrated Watershed Development Program (Hills)

Among various interventions, water harvesting structures had the immediate and visible impact and the community contributed willingly in cost sharing. In a period of seven years, more than 2000 water harvesting structures were constructed with a storage capacity of 3456000 cum. An area of 175700 ha was treated at a cost of Rs. 2242 million benefitting 82,000 families with a population of 600,000. The project adequately addressed the issues of environmental conservation, food security and poverty alleviation by enlisting peoples' participation.

The major achievements of the project may be summarized as follows (Grewal *et al.*, 2000):

- The overall yield of maize increased from 0.8 to 1.34 and that of wheat from 0.9 to 1.83 t/ha. The use of fertilizer N increased from 18.1 to 32.8 and of P from 4.2 to 14.8 kg/ha during the project period.
- The overall milk yield improved from 3.0 to 7.9 litres/day which provided maximum advantage to landless farmers from animal husbandry component.
- The rate of run-off from treated sub-watersheds decreased from the range of 30-56 to 0.5-11 percent and soil loss from 45-155 to 2.8 - 62 t/ha/year in a period of 6 years. A typical example of the effect of treatments on watershed hydrology of 4 sub-watersheds in Punjab Shiwaliks is presented in Tables 14 (Dogra, 2000).

Table 14. Run-off [percent of rainfall and soil loss (t/ha/yr)] from four treated watersheds in IWDP (Hills), Punjab

Watershed	Run-off as percent of rainfall					
	1994		1995		1999	
	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss
Gurha	-	-	33.2(1521)	155.1	1.3(928)	5.0
Makowal	40.3	-	36.0(2177)	24.4	0.8(1126)	2.7
Kapahat	43.0	163.5	54.8(2049)	45.3	1.9(767)	3.2
Manjhi	50.4	419.0	56.2(2035)	48.2	0.5(935)	2.8

Figures in parentheses show seasonal rainfall in mm.

- Flood peaks were moderated and perenniality of flow in the streams improved significantly (Table 15). The water level in the wells located along the torrents rose by 2 to 7 metres and lot of area was saved from torrents menace.

Table 15. Improvement in base flow (perenniality) characteristics of watersheds before and after treatment*

Description of base flow characteristics	Unit	Pre-project status (1990)	Current status (1999)
Number of perennial torrents	No.	27	39
Length of base flow	Month		
0-3		11	3
4-6		4	4
7-9		3	4
9-12		9	28
Discharge of base flow	Cusecs		
Poor	< 0.25	14	0
Moderate	0.25-0.75	10	17
High	0.75-1.50	3	15
Very high	> 1.50	3	7

*Base flow was recorded on a given date in the watersheds before and after the treatments.

- Yield of air-dry commercial grass (*Eulaliopsis binata*), green fodder grass and air-dry fuel wood registered an increase of 1.0, 3.2 and 1.9 t/ha/year, respectively. There was significant reduction in drudgery of women in collection of fodder, grass, fuel wood and drinking water.
- There was substantial increase in employment generation and productivity, which motivated the stakeholders to take the responsibility of protection of the adjoining hilly forest catchments by forming village co-operatives.

Impact Assessment of Doon Valley Project (DVP)

DVP for integrated watershed management had the unique feature of constitution of Gaon (Village) Resource Management Associations (GAREMA) to elicit people's participation in the project. Each GAREMA has a general body of which all the village adults are members. The general body selects an executive committee (EC), which functions as a link between the villagers and the project officials. The membership of EC is limited to 7-11 with Chairperson, Secretary and Treasurer as office bearers and has adequate representation of women and lower castes. For all administrative and practical purposes, it is the EC as the representative of people, which is known as GAREMA. The main functions of GAREMA are to assist in the implementation of the project interventions by involving people in the plantation, construction of check dams etc. and sharing of cost through contributions, creation of the revolving fund, establish link between people and the government, maintain the assets after the withdrawal phase, prepare post-project plan, maintenance of records and resolution of conflicts.

The impact of the project interventions and management on productivity, environmental benefits, employment generation and socio-economic aspects may be briefly presented as follows (Sitling, 2002):

- 350 GAREMAs were formed and linked with Panchayati Raj (village council) Institutions through the process of social change.
- 50 percent of GAREMAs are functional and established. Performance of 40 percent is satisfactory.
- 350 GAREMAs belonging to 303 revenue villages have collected the revolving fund amounting to Rs. 26.36 million till March 2001, of which Rs. 4.1 million is given as loans to the members (loaning).
- 297 women Self-Help Groups (SHGs) have raised their revolving fund amounting to Rs. 20,06,710 through thrift saving as in March 2001 of which Rs. 6,11,607 is in the loaning.
- Rural employment was generated to the tune of 8.44 million mandays.
- Fuel collection reduced by 5 tonnes per family per year. Saving in time was 220 hours per family per year.
- Improved practices increased production of foodgrains, vegetables and fruit by 18 percent.
- Irrigated crop area increased by 34 percent through minor irrigation works.
- Increased fodder production encouraged stall feeding of cattle and better livestock management increased household income by 30 percent.
- Vegetative and engineering structures reduced run-off and soil loss. Availability of water in the streams during summer increased by 20 to 30 days.
- Use of energy conservation measures resulted in saving the time of women on an average by 3 hours/day which, in turn, reduced pressure on forest for fuel wood.

Future Thrust

Four decades old watershed development programme of India has evolved from externally driven, centrally controlled, target oriented and top-down approach to people-centered, bottom-up and demand driven approach based upon the recommendations of the Hanumantha Rao Committee (GOI, 1994). The harmonized guidelines of the Ministries of Agriculture and Rural Development mark the beginning of a new era in public sector rural development programmes with a focus on productive, social, environmental and equity issues. However, due to wide variability in bio-physical and socio-economic conditions in India, a certain degree of local adaptability is needed by the implementing agencies. Biophysical aspects of watershed approach are relatively better understood than socio-economic, community participation, people's empowerment, institution building, conflict resolution, equity, gender issues, activities for landless, productive employment generation, etc. Since watershed development is a dynamic activity, the research and development efforts should address the following issues on priority for effective implementation of integrated watershed management programmes in the country in future:

- There is a strong need to evolve a methodology for monitoring and evaluating the new paradigms of participatory watershed management as per new guidelines.
- Since southern and northern aspects in Himalayas have different characteristics, all interventions in the watershed programmes like afforestation, horticulture etc. need to be identified to suit their requirements.
- To combat the livestock management problem of fodder, suitable vegetative barriers and fodder species should be evolved which can be raised on agriculture fields, bunds, orchards and barren lands.
- Location-specific integrated farming systems need to be evolved for conservation and production as a comprehensive package for different categories of farmers and farming situations.
- Study of paradigm shifts on various socio-economic, environmental and sustainability aspects of the IWSM programmes.
- Institutional mechanisms and methods for management of common property resources need to be researched upon in terms of social, economical and technical aspects.
- Procedures and methodology for delineation, characterization and planning of micro-watersheds employing modern tools and procedures such as RS/GIS techniques need to be developed.
- Monitoring the hydrological impacts of watershed programmes in the upper reaches on the flow regimes in the downstream reaches needs priority.
- Conjunctive use of rain, surface and sub-surface water with efficient water application methods such as drip or sprinkler needs due emphasis.
- There is strong need for convergence and synergy among government organizations, village level institutions and NGOs to harmonize their comparative advantages.
- Quantification and valuation of intangible benefits through off-site effects of watershed programmes on groundwater recharge, drought mitigation, flood moderation, environmental externalities and hydro-ecological aspects requires due attention.
- Cost-effective bio-engineering measures need to be evolved for hills and valleys especially for mass erosion problems.

Conclusions

Natural resources of land, water and vegetation are under great stress in the hills and valley regions of Himalayas characterized by marginality, inaccessibility and fragility, compounded by high intensity erratic rainfall, steep slopes, large-scale deforestation and faulty management practices. This leads to increasing frequency of disasters, such as landslides, floods, droughts, cyclones, hailstorms, siltation of reservoirs and deterioration of water bodies. Integrated watershed management in these regions requires adoption of innovative soil conservation and crop management techniques to prevent land degradation, maintain soil fertility and ensure environmental security for achieving sustainable productivity. The strategies in IWSM programmes include land configuration systems, agronomical measures, alternate landuse systems, run-off harvesting and recycling methods and measures for control of mass erosion problems. Experience of integrated watershed development programmes in hilly and valley regions has indicated that they greatly helped in moderating floods in downstream areas, improve *in-situ* moisture conservation and groundwater recharge for increased biomass production and were economically viable with tremendous environmental externalities. However, greater emphasis is needed on people's participation, empowerment of community, gender neutrality, equity, transparency and management of common property resources by village level institutions. Water harvesting and groundwater recharge, location-specific and cost-effective technologies for erosion control and flood moderation, suitable plant materials and integrated farming systems for higher production and conservation of natural resources, contingency planning for undertaking calamity relief works for generating productive employment and diversification for new market opportunities based on demand-driven growth need to be promoted. Modern tools and procedures should be deployed for planning of watersheds and provide better opportunities to the marginalized and inaccessible hilly situations.

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Getting More from the Water and Watersheds: Multiple Use of the Resources

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Abstract

Water is a critical resource for poverty reduction. Thus, in watershed management programmes, the water resource remains pivotal as optimal and sustainable use of all other resources is dependent upon this. The strategy for managing this vital resource should be two fold: first to get maximum water from the watershed and second to get maximum return from this harvested water. The first part of the strategy requires retaining maximum possible fraction of rainwater in the watershed itself for productive use. The second part discusses how to utilize water most efficiently both in terms of production and economic development. Multiple use of water, i.e., not only for irrigation of traditional crops but also for more efficient use through low consumptive high value systems and non-consumptive productive use can achieve maximum water use efficiency. Increasing cost of watershed management from Rs 4000/- (US $ 87) per ha to to Rs. 6000/-(US $ 130) per ha has made the use of water only for irrigation unsustainable. A lot of work has been done to enhance the productivity of water through multiple uses both at experimental farm as well as at farmers' field. However, large-scale use of these systems requires suitable modification in the design parameters to accommodate the requirements of different users and site conditions, i.e., protected water body with or without continuous inflow and outflow or unprotected water body having poor management conditions. This requires a full array of multiple use options to address various livelihood strategies alongwith financial implications and conflict resolution among users. Various options of multiple uses have different impact on water rights of different water users and this needs to be adequately addressed. Thus, a comprehensive approach of technological alternatives for increasing water yield from watershed, achieving maximum return from it through different options of multiple use while taking care of water rights of various communities is required for efficient and sustainable management of watershed. This paper reviews options available for different situations and analyses them for adoption under different livelihood strategies available to various social groups.

Introduction

Watershed management is optimal management of the resources both natural, i.e. land and water as well as human and livestock. Among all these resources, water is the most critical as the efficient utilization of other resources is dependent upon its temporal and spatial availability. Thus, efficient and economic use of water becomes an important factor in improving the livelihood of the watershed inhabitants. Till now the water systems have been evaluated in terms of their ability to provide water for crop production and valued in terms of the 'crop per drop'. However, low prices of wheat, rice and other major crops produced on irrigation systems tend to make such development paradigms economically unattractive. With increasing emphasis on ecologically sound development, it is logical to integrate appropriate farming practices to enhance farm productivity and water use efficiency. This has also become important in view of increasing cost of watershed management. The avarage cost of watershed treatment in India has increased from Rs.4000/- (US $ 87) to Rs. 6000/- (US $ 130) per ha for plateau areas. It is almost 1.5 times higher for hilly terrains. Thus, the usage of water only for irrigation can no longer sustain the high cost of investment.

In view of this, the strategy for managing this vital resource should be two fold: first to enhance the availability of water within the watershed both in terms of amount and time and second to get optimal returns from it. The first part of the strategy means retaining maximum possible fraction of rainwater in the watershed for productive use. The second part means integration of water uses for multiple purposes, both consumptive, and non-consumptive to achieve maximum water use efficiency in terms of production and economic development. The integration of water for multiple uses can have the following objectives:

- Increase farm productivity/production without any net increase in water consumption.
- Enable diversification to higher value crops, including aquatic species.
- Ensure utilization of otherwise wasted on-farm resources.
- Reduce net environmental impacts of semi-intensive farming practices.
- Ensure diversification of risk through self-employment and flow of income throughout the year.
- Achieve net economic benefits by offsetting existing capital and operating farm costs.

In India, a lot of work has been done on multiple use of water under different scenarios of its availability. Some studies have been at experimental farms and others at farmers' field. Although all of these systems may not be utilized under watershed management yet an understanding of these may give new ideas for multiple use of water in watersheds. In any case to start multiple uses of water, one needs sufficient amount of water available for a longer period in the watershed and for this assessment of various measures to achieve this goal is required. This paper presents a review of work done on these two aspects. In addition, the paper also discusses measures for conflict resolution among different users and impact of multiple uses on water rights of various users.

Getting More Water from Watersheds

Depending upon the topography, vegetation and rainfall characterstics, about 20-50 percent of the rainfall flows as run-off and 5-15 percent is recharged to groundwater. The goal of conservation measures, either vegetative or engineering, is to retard the run-off, store it in surface water bodies and recharge it to ground-water. Although most conservation measures perform these functions, their success and gestation period varies, and thus priority of their adoption will also vary. A glimpse of such measures and their impact on water yield within the watershed for different rainfall regions is discussed below.

Effect of Various Watershed Management Measures on Water Availability in Watershed in Medium Rainfall Areas (750-1150 mm/annum)

The impact of watershed management measures on water availability is well documented. However, the impact varies in different agro-ecological regions. In Aravali hills (Rajasthan, India), the groundwater table rose by an average of 7.97 m after six years of watersahed development programme. Due to increased availability of water for irrigation, there was an increase of 83 percent in post-monsoon cropped area. In Yamuna ravines of UP (India), the watershed management measures resulted in rise of groundwater ranging from 1.53 to 6.05 m depending upon monsoon rainfall. In Malwa region of Madhya Pradesh (India), the average annual post-monsoon increase in groundwater was 6.79 m due to implementation of watershed management measures compared to just 1.5-2 m in pre-project era (Sethi and Jena, 2004). In Iran, Kalantari (2000) reported that due to water harvesting structures, the groundwater table rose from 50 cm to 8 m at different sites. The variation was due to characterstics of recharge sites.

Impact of Tank-cum-Well System in Watershed in High Rainfall Areas (1150-1600 mm/annum)

In high rainfall areas receiving more than 1150 mm annual rainfall, the conjunctive use of rainfall and run-off can meet the irrigation demand with proper planning (Srivastava *et al.,* 2004). Based on this hypothesis, a water harvesting system was designed at Water Technology Center for Eastern Region (Srivastava, 1996, 2001) for sub-humid region. This design showed that the system also recharges groundwater significantly to the tune of about 1000 m^3 water per ha catchment (equivalent to 100 mm of water, i.e. about additional 8 to 10% of monsoon rainfall). This recharge can be harvested back through open dug wells. By including well with the water harvesting tank, a system of micro level water resources through rain water management of tanks and wells in a series was conceptualized (Fig. 1), developed and constructed (Fig. 2) and evaluated for hydrological, well hydraulics, crop production and economics (Srivastava *et al.*, 2003, 2004). It was found that the rainwater management through tanks and wells provided reliable irrigation. Dug wells in recharge zone of the ponds provided five times more water than outside the zone. The water balance of the system (Table 1) in one transect showed that the retention capacity of the system (water retained/ tank capacity) was about 150 percent which is quite high for small systems. About 37 percent of the received run-off was lost as seepage which can be also termed as 'recharged to groundwater' out of which 14.1 percent was reharvested back through open dug wells. In absence of open dug well, the water yield/tank capacity ratio was 0.65, which increased to 0.86 due to inclusion of well. Thus, this system made more water available for productive use within watershed by about 32.6 percent. Since this also enhanced the period of water availability, its utility for multiple use of water cannot be over emphasized.

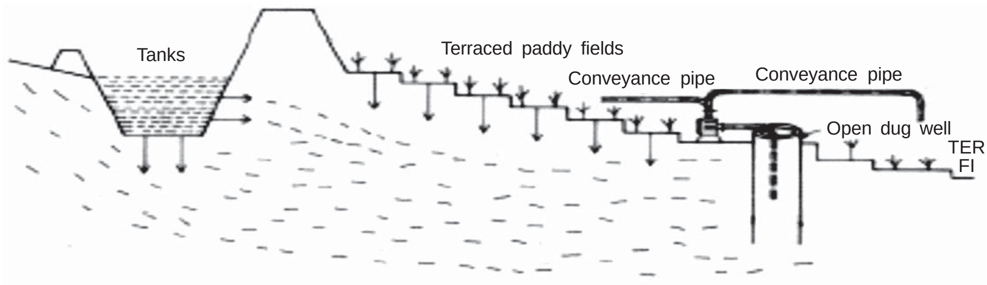

Figure 1. Schematic diagram of rain water harvesting based tank and well system

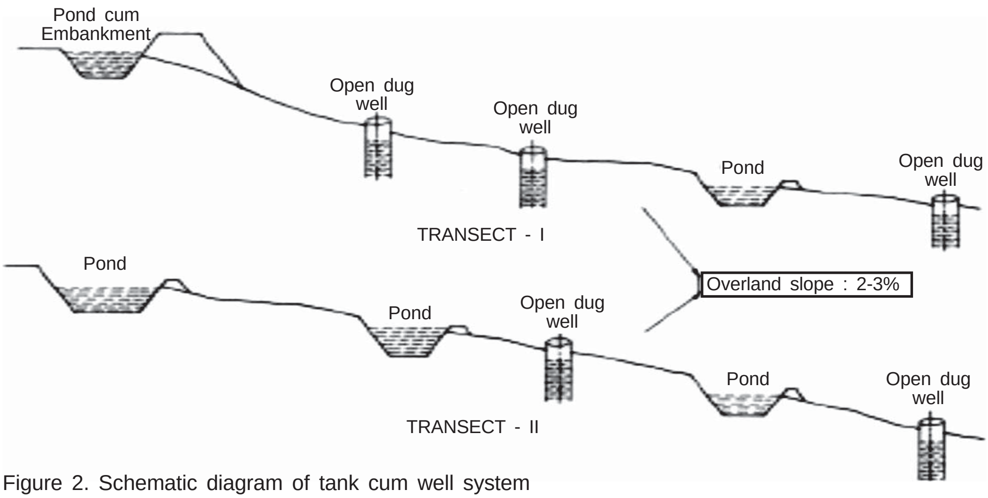

Figure 2. Schematic diagram of tank cum well system

Table 1. Water balance of tank and well system in transect II (2002-03)

Tank No.	Tank capacity, m^3	Catchment area, ha	Run-off received, m^3	Irrigation water pumped, m^3		Seepage loss, m^3	Evaporation loss, m^3	Water pumped from well, m^3	
				Kharif	*Rabi*			*Kharif*	*Rabi*
1	3100	6	5079	340	1774	2316	677	No well	
2	4680	10	5722	675	1468	2257	1022	352	285
3	4000	10	6867	1026	2340	1987	874	504	1450
Total	11780		17668	2041	5582	6560	2573	856	1635
			17668	7623 (43%)		6560 (37.1%)	2573 (14.56%)	2491 (14.1%)	

Total water utilized for irrigation = 10114 (57.24%); Water yield/tank capacity ratio = 0.86.

Water Availability Due to Water Harvesting in Very High Rainfall Areas (> 1600 mm/annum)

Small earthen dams can be used in large scale for water storage in the North-Eastern Hills (NEH) Region of India. Construction of these structures involves chiefly manual labour input and use of locally available materials as earth, stones, etc. Experience on water harvesting in dugout-cum-embankment type of pond in hilly region of north-east India clearly indicates the feasibility of harvesting run-off from watersheds to an extent of 38 percent of monsoon rainfall. Contribution of subsurface flow from upper slopes accounts for 82-90 percent of the annual rainfall into the water-harvesting pond located in the lower reaches and only 10-18 percent comes from direct interception and collection of surface run-off (Table 2). The soil in the area has extremely low water holding capacity and the seepage losses are very high. Thus water storage may be seasonal or perennial depending on the site condition. The studies indicated the decline of seepage rate with the age of pond and stabilized in a period of 7-8 years. The annual inflow into the pond can be satisfactorily predicted from the developed base flow model. Partial utilization of the farm pond is possible for irrigating crops during dry spells. Stored water, however, have more scope for fish production. Limited water available for irrigating winter crops should be used at the earliest opportunity to reduce seepage and evaporation losses. The rugged hilly terrain supports large number of perennial as well ephemeral springs with yields varying from a few litres to tens of cubic metres per hour giving rise to numerous streams and rivulets, the discharge being the highest during monsoons which gets reduced during autumn and reaches at their lowest in summer. Springs and natural outlets, through which the groundwater emerges at the ground surface as concentrated discharge from an aquifer, are the most conspicuous forms of natural return of groundwater to the surface.

Table 2. Water balance in typical water harvesting tank in hills

Year	Rainfall, mm	Direct rain, ha-m	Surface flow, ha-m	Total inflow, ha-m	Evaporation, ha-m	Seep-age, ha-m	Over-flow, ha-m	Inter-flow, ha-m	Inter- flow as % of total inflow
1	2194.6	0.557	0.029	4.25	0.112	4.11	-	3.64	85.65
2	2233.7	0.420	0.045	3.50	0.116	3.37	-	3.04	86.86
3	2309.1	0.345	0.050	3.82	0.048	2.20	1.06	3.42	89.53
4	2705.8	0.674	0.029	7.30	0.127	3.56	0.03	6.55	89.72
5	3323.8	1.190	0.636	11.34	0.193	4.78	5.92	9.52	83.95
6	2770.1	0.782	0.371	5.71	0.160	3.69	0.84	4.66	81.61
7	1982.7	0.117	0.048	1.26	0.040	0.90	-	1.10	87.85
8	2737.1	0.910	0.770	11.68	0.146	3.52	6.99	1.10	85.63

It is evident from above case studies that in all rainfall regions, the water availability can be increased substantially by adoption of different conservation measures under watershed management programme. This enhanced available water has to be utilized effectively and efficiently to achieve maximum possible returns and the same can be achieved through multiple uses of water.

Multiple Use of Water—Case Studies from Different Water Domains and Land Forms

A lot of work has been done in India on multiple use of water both at experimental farms as well as at farmers' fields. These works have been conducted starting from run-off recycling ponds to service reservoirs integrated to tubewell and canals to rice fields in low lands. The multiple use varies from just adding aquaculture to addition of horticulture on embankment, aquatic crops, ducks, pigs, etc. A summary of such studies is presented here to give an insight of the innovations and techniques used by different research workers.

Studies on Experimental Stations

Run-off Recycling Pond in Plateau Areas at WTCER, Bhubaneswar

An integrated farming approach was adopted for efficient utilization of a 1468 m^3 capacity pond to harvest run-off water from 3.0 ha area and command an area of 0.95 ha (Srivastava *et al.*, 2004). In this system, fish and prawn was grown in pond. The embankment of the pond was planted with two rows of papaya and one row of banana was planted on the free board area of inward slope. It has been reported that the benefit-cost (B-C) ratio of the system was 2.2 with crop alone which increased to 2.66 when horticulture was added and it further rose to 3.28 with inclusion of aquaculture (Table 3). Duckery was also introduced but it failed due to poaching but had the potential to raise B-C ratio beyond 3.50. The average annual water yield from the system was 2574 m^3 and utilized water was 2103 m^3. This showed that with proper planning, the water yield/storage capacity ratio can be significantly enhanced. Estimating water productivity on the basis of this utilized water yield, the annual water productivity increased from INR 3.84 /m^3 for crop alone to INR 5.35 /m^3 with multiple uses. Thus, it is evident that the multiple use of water increases the economics of run-off recycling based irrigation system to a quite high level, which can be a clinching factor for adoption of such systems.

Table 3. Benefit-cost (B-C) analysis of run-off recycling systems under different conditions

Item	For sites having seepage loss < 6 mm per day	For sites having seepage loss >6 but less than 10 mm per day	For sites having seepage loss >10 mm per day, i.e., lined tanks
Total annual cost of pond for unit command area of 1 ha	Rs 4200/-	Rs 6000/-	Rs 8000/-
Net return from crop alone	Rs. 9278/-	Rs 9278/-	Rs. 9278/-
Net return from crop + horti.@	Rs 11178/-	Rs 11178/-	Rs 11178/-
Net return from crop + horti. + fish	Rs 13778/-	Rs 14778/-*	Rs 16778/-**
B-C ratio from crop alone	2.20	1.55	1.16
B-C ratio from crop + horti.	2.66	1.86	1.40
B-C ratio from crop + horti. + fish	3.28	2.46	2.09
Expected B-C ratio from crop + horti. + fish + duckery	> 3.50	3.00 (approx)	2.50 (approx.)

*Fish production will be more as the water area will be larger. @ horti. = horticulture.
**Fish productivity will be higher as the water will be less turbid.

Groundwater-based Multiple Use System Designed at ICAR RCER, Patna

At ICAR Research Complex for Eastern Region, Patna, a secondary reservoir was integrated with tubewell to minimize the effect of uncertainties on irrigation water availability on crop production and improving the irrigation performance in terms of better efficiency by adopting appropriate scheduling. However, this reservoir can be used for fish production thereby increasing productivity of the irrigation water.

The frequent water exchange had advantage of good aeration and providing disease-free water for fish production, while it removes nutrients from the pond, which, in turn, adds fertility to the fields. During routing of irrigation, the physico-chemical quality [temperature, dissolved oxygen (DO), *p*H, turbidity, etc.] of the secondary reservoir water improves to a great extent, which enables intensive fish culture. It replenishes DO and mixing of water that maintains the DO above 4 ppm even for the bottom water layer.

Higher stocking density (40,000 to 50,000 fingerlings/ha as compared to 10,000/ha recommended) can be used under the semi-flowing conditions of secondary reservoir. Multiple harvesting with growth of the fish is beneficial to maintain proper stocking density (as per age of the fish) and it also improves the total fish capture. Polyculture of Indian major carps (Rohu, Catla and Mrigal) and grass carp, common carp or silver carp results in utilization of every niche of the reservoir and provide high production.

Results indicated that due to better quality management under the fishpond-cum-secondary reservoir, high fish harvest were made during the four years of study. During the first year when the pond was new, a yield of 10 t/ha was achieved in the semi-flowing type of system, which is about five times that of normal fish harvest in still pond water (2 t/ha). Apart from fishery components, secondary reservoir also helps in improving the irrigation efficiency and gives opportunity for other water uses, e.g., horticulture, animal and domestic uses, etc. (Bhatnagar, 2004).

Multiple Use of Water in Canal Water-based Pressurized Irrigation Systems

The canal based irrigation systems are one of the most inefficient systems. The average project efficiency of paddy areas is just 24 percent and for non-paddy areas it is 36 percent. With increasing scarcity of new sites for major irrigation projects, it is imperative that efficiency of existing irrigation projects is increased. This can be done by increasing application efficiency through pressurized irrigation system. However, with prevalent off-on schedule of canals, this shift can be achieved only after having a service reservoir as an adjunct. Under one such project at WTCER, Bhubaneswar, a 2500 m^3 capacity tank has been constructed for providing continuous water supply to 5 ha irrigated area by combination of sprinkler and drip system. To make this system economical, multiple use of reservoir was undertaken by integrating papaya on embankment and fish in the ponds. Although banana was an option but it was not planted due to elephant menace. It was found that the annual cost of the pond was recovered with returns from papaya and fish (Srivastava *et al.,* 2004). If ducks and vegetable on outward slopes could also be integrated, the total cost of the system inclusive of drip and sprinkler can be recovered from multiple use of reservoir itself.

Multiple Use of Water in Rainfed Lowlands

Rainfed lowlands in India are mostly characterized by monocropping of traditional rice under a varying degree of hydrologic, biotic and socio-economic conditions. Rice productivity is usually unstable and low (less than 1 to 1.5 t/ha).

Lowland rice occupies 17.3 m ha of the total 42.2 m ha rice area in the country, out of which 14.2 m ha is in eastern and northeastern India. To achieve higher productivity from this under-utilized otherwise high potential area, technology has been developed for rice-fish integrated farming system (Sinhababu and Venkateswarlu, 1996). The system involves construction of dikes and refuge/ trenches. A refuge is a pond, trench or low point in rice-fish field which shelters the fish. The land use pattern for these structures is normally around 10-15 percent for bunds, 10 percent for refuge and rest for growing rice and sequence crops. However, when vegetables, horticultural crops and other bird system is envisaged for integration, the bund area may increase upto 20 percent and the area for refuge and trench to 12-15 percent.

Case Studies at Farmers' Fields

Several of the systems designed and evaluated at research farm have also been studied at farmers' field, in real life situation. This has given an idea of constraints in transferring of this system on farmers' field. Following section presents results of few studies.

Run-off Recycling System at Dumuria, Keonjhar, Orissa (India): In this system, located in plateau areas of Orissa, six tanks and five wells in series in two transects were constructed. The water was primarily used for irrigation and farmers were persuaded to go for multiple use of water. Out of six ponds, four were on community land and two were on private land. One of the pond on community land was embankment type.

In case of ponds at private land, farmer went for aquaculture, duckery and papaya vegetables and pigeonpea on embankment. This was also an additional factor that both ponds were near to their homestead. The detail of earnings from multiple use system is presented in Table 6 (Srivastava *et al.,* 2003).

It is evident from data that both farmers could manage a sizeable additional income from multiple use of water. As these were initial years and the traditional rainfed farmers were just learning the benefits of the water, it is hoped that returns will further increase in coming years.

Raised and Sunken Bed System in Medium Lands: The medium lands lying in canal commands of eastern region are cropped by a rice-rice cropping sequence. This sequence is adopted not due to high returns but a forced one due to high rainfall and high water table conditions, where the farmer has no other option except to grow rice since field remain invariably inundated for long durations. To achieve crop diversification, a field study was undertaken by modifying landscape from flat to raised and sunken bed. For this purpose, fields were modified into alternating raised and sunken beds by digging soil of one strip (5m × 30 m) to a depth of 30 cm and putting the dugout soil over the adjacent strip (5m × 30 m). The raised beds were thus 60 cm higher than the adjacent sunken beds. The rice equivalent of all the crop sequences were significantly higher in alternate raised and sunken bed system than rice yield in non-modified field. Among different cropping sequence treatments, rice grown in sunken bed and cabbage followed by Malabar spinach grown in raised bed produced the highest rice equivalent yield of 21.61 t/ha. This was followed by rice+ tomato+ ridge gourd sequence with rice equivalent yield of 16.74 t/ha. In the conventional farmer's practice treatment, the rice equivalent yield was only 3.19 t/ha. The irrigation water use efficiency in case of rice + cabbage + Malabar spinach sequence was 212.86 kg/ha-cm compared to only 26.6 kg/ha-cm in case of conventional farmer's practice. The benefit cost ratio in case of rice+ cabbage + Malabar spinach sequence was 3.01 in comparison to just 1.13 in case of conventional farmer's practice. The rice+ tomato+ ridge gourd sequence had a benefit-cost ratio of 2.76 (Singh *et al.*, 2003)

Table 6. Abstract of economic analysis of tank system for crop year 2003-2004

Sl. No.	Item	Amount in Rs.*
1	Total gross additional return in *kharif* 2003 compared to outside command including labour cost which is family labour	159880
2	Total additional input cost supplied in command (fertilizer/seed etc.).	16500
3	Total net return from *kharif* crop 2003	143380
4	Gross return from *rabi* crop	320166
5	Cost of inputs in *rabi* crops including pumping excluding labour cost which is family labour and had little opportunity cost	67000
6	Net return from *rabi* crops 2003-2004	253166
7	Net return from multiple use	4500
8	Cost of maintenance	5000 (approx)
9	Total annual net return (3+6+7-8)	396046
10	Total net return in 2001-02 and 2002-2003 and 2003-04	834512
11	Total cost of tanks and wells	863000
12.	Present investment recovered	96.58%

*1USD = Rs.45.

To further enhance the income, the farmer used the sunken bed for rearing fingerlings. As the water was available in sunken beds from July to November, the fish fry were stocked in July/August and harvested as fingerlings in November. Since the area is a fish-growing region, there was readily available market for fingerlings.

Integrated Farming System in Lowlands

This integrated farming system developed by farmers located in Khentalo of Cuttack district of Orissa is an example that how threats of waterlogging, high rainfall and high water table can be converted into poverty alleviating opportunity. The farmer converted his 2.47 ha waterlogged area into 1.64 ha of pond and 0.83 ha of raised embankment (Samra *et al.*, 2003). While pond area was utilized for fish and prawn culture, 21 m wide embankments were used for planting mango, teak, arecanut, coconut, banana, papaya, pineapple, mushroom etc. He also constructed poultry sheds on embankment for rearing 4000 birds in such a way that their droppings could fall into the ponds as organic manure and feed for fish. The gross and net return from the total system (2.47 ha) in 2002 was Rs. 6,51,110/- and Rs. 3,62,515/- respectively, while the net return from adjacent waterlogged paddy field was just Rs. 4,166/- per ha only (2.8% of integrated farming system). The farmer has his house on one end of the pond and therefore was available for full time supervision.

Systems for Multiple Use of Water in Coastal Areas

The coastal areas of India suffer from floods during monsoon and lack of water in winter season. With groundwater being saline, there is little scope of irrigation development. However, working in supercyclone ravaged areas it was found that properly designed and constructed Subsurface Water Harvesting Structures (SSWHS) will mitigate the early drought in monsoon season and provide irrigation during post-monsoon and summer season. To increase the returns from these SSWHS, aquaculture was integrated in the system. The fish crop income ratio varied from 1:1.85 to 1:3.16 in different SSWHS. Income from fish per cubic metre capacity of SSWHS varied from Rs. 2.96/- to Rs. 12.23/-. The total income from SSWHS varied from Rs. 12.93/m^3 to Rs. 47.20/m^3 in the first year itself. Low income from crop is sustained by high income from fish as the SSWHS is being fed continuously by sub-surface seepage water in coastal waterlogged area. The net return per unit of rupee invested varied from 0.98 to 3.43 in the first year itself.

Water productivity varied from Rs. 15.84/m^3 to Rs. 80.43/m^3 with an average of Rs. 36.20/m^3 (Sahoo *et al.*, 2003; Sahoo and Verma, 2003).

Multiple Use System in North-Eastern Hill Region

There is immense scope of integration of fishery and livestock in a waterbody, as the crop – livestock system is a rule rather than exception for a hill farmer. It is evident from large livestock population in the region with pigs being 53/100 persons (all India average 1/100) and poultry birds at 63/100 persons (all India average 24/100). The technologies of pig-cum-fish farming, poultry-cum-fish farming and duck-cum-fish farming can be utilized for multiple uses of water and this requires less input with high rate of return. However, some modifications are required for achieving multiple use of water. Water supply to ponds in hills generally depends on rainfall, run-off water, springs or wells. Water can also be fed from stream, river or lake depending on the site of location. The soils are generally acidic in nature and need proper management during the construction of ponds/ tanks for fish culture. The various types of ponds which can be excavated or constructed in hill slopes are barrage ponds, diversion ponds, recirculating ponds and running water channels. Construction of ponds in hills or converting water bodies to fish culture practices needs special attention with regard to building of proper drainage system, sealing of pond bottom with clay/polythene or plastic sheet or other sealing materials/and putting net/wire net etc. in sluice gate to prevent escape of fish. The composite fish culture using six species of fish with three Indian major carps is quite profitable in the lower altitudes with warmer climate and the results were very encouraging.

Tubewell Based Multiple Water Use Innovations by Tubewell Farmers in Punjab Plains

Groundwater can be used for multiple use before irrigating crops and this has been effectively illustrated by an innovative farmer (S. Darshan Singh), who has adopted the concept of integration of agriculture – fishery – horticulture – forestry – livestock on his farm at village Haiyatpura, Ludhiana (Punjab). He has developed his own system to irrigate field crops, orchards and forestry with the fishpond water. Innovatively, he developed floating fish feed dispenser and aerator. With mixed fish culture and multiple harvesting, he uses pigs and poultry droppings to fertilize the fishpond. He has harvested 5-6 t/ha fish along with rice (2.2-3.0 t/ha) and wheat (1.8-2.5 t/ha) along with other earnings from piggery, poultry, and dairy (Bhatnagar, 2004).

Constraints in Adoption of Multiple Use System

An analysis of different systems showed that although multiple use of water has tremendous potential in crop diversification, increasing income manifold and above all productivity of available water, there are several constraints in its wide spread adoption.

- For multiple use, especially aquaculture, duckery and vegetables on embankment, the water body has to be near the homestead for better management and security.
- The community based water bodies pose greater challenges to put them under multiple use.
- Although the farmers are a bit aware of options of multiple use and their benefits, they lack adequate skills to design and operate appropriate systems.
- Multiple use system is capital-intensive and invariably there is lack of adequate funds for initial investment specially among the resource poor groups.

Research and Technological Requirement for Widespread Application of Multiple Use

As stated earlier, the multiple use through aquaculture, duckery etc. is limited to the water bodies, which are near to homestead. For spreading it to other water bodies, there is need for exploring other crops/systems that can survive even in poor management conditions. Makhana (*Euryle ferox*) and water chestnut (*Trapa bispinosa)* are two such crops which are less prone to poaching. Aquaculture with specific type of fishes can be integrated with these aquatic crops. Due to thorny spread of these crops, the poaching of fish will not be very easy. However, the cultivation of these crops are on a very limited scale and there is need to develop technology for integrating these crops with other systems.

In plateau areas, where water availability is upto March, two approaches can be adopted: design the pond in such a way so that there is additional water available in a small refuge during dry season or pump water from the well to maintain desired water level or harvest it at earlier stage and sell it as fingerling.

Alternatively, a system of one small tank adjunct to big tank can be developed for fish production. The smaller tank can be lined and filled up with the water pumped from the well. This will maintain fingerlings of 50-100 gm during summer and can be stocked during succeeding monsoon.

The system for utilizing groundwater for fish culture before its delievery to the field has immense potential. However, its design parameters for various pump sizes and command area need to be standardized.

The aquaculture in canals also has tremendous potential given the vast area available. However, the present technology base is insufficient to harness this potential. A sustained and systematic research effort should be initiated to develop technology suitable for various flow conditions. If a suitable technology could be developed for utilizing this water, it can serve as a tool of increasing the number of stakeholders in canal system while involving landless people in the enterprise. The effect of multiple uses on hydraulics of the canal also needs to be studied in detail.

Water Rights, Conflicts and Solutions

Water rights are at the heart of any water allocation system. Reallocation has to take care of not only efficiency but also fundamental issue of equity. The delineation of water rights is further complicated when we take into consideration multiple uses as well as multiple users. The demands of multiple users may be in conflict both in terms of quantity and time. Each case requires a separate understanding of the problem and probably an innovative solution.

The solution of the conflict arising out of reallocation of the water to multiple users may be technological or social or both and require an in-depth study both by engineers and social scientists to come out with solutions for few standard systems.

Conclusions

Potential of multiple use of water exists in all domains of water, i.e., surface water stored in ponds and tanks, groundwater being pumped and conveyed to fields, canal water while being conveyed, etc. However, these designs require standardisation and its large scale field-testing. Most of the systems are feasible only under intensively supervised management conditions. Research efforts are required for formulating technological solutions to minimise intensive supervision. More technological innovations are required to further improve the productivity of water. Last but not the least, the water rights scenario needs to be studied to let the multiple use system fit under varying socio-economic conditions.

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Crop and Non-crop Productivity Gains: Livestock in Water Scarce Watersheds

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Abstract

Watershed Development Programmes (WDPs) aim at improvements in farming systems through investments in soil and water conservation (SWC) and natural resource management (NRM) in rainfed areas. Livestock production is an integral part of the farming systems in rainfed areas and especially in the ecologically fragile areas of semi-arid watersheds. They make an important contribution to the survival of the economically weaker sections, small ruminants in particular playing an important role in ensuring rural livelihoods against drought. Poor access to water and fodder are the most critical production constraints for livestock development in semi-arid areas. Some interventions in WDPs, though not directly targeted at livestock, have resulted in giving a fillip to small scale dairy production, where market access was conducive. Although in some cases WDPs have tried to improve biomass production on commons, in most cases livestock production needs have been insufficiently recognized and addressed, neglecting critical pathways by which to improve the livelihoods of the watershed poor who depend on the commons for fodder needs of their indigenous cattle and small ruminants. Evidence shows that market access defines the degree of livestock exploitation and watershed treatments through their investments in local institution building and NRM can enhance the productivity and sustainability of livestock production. However, there is enormous scope for improving the effectiveness through focussed interventions. Considering that large and especially small ruminants are critical to the livelihoods of the resource-poor in watersheds and that livestock development is an integral coping mechanism for combating adverse impact of drought on livelihoods, this paper suggests some potential interventions for enabling sustainable livestock production in water-scarce watersheds.

Watershed Development Approach and Livestock in India

The Government of India accords high priority to the holistic and sustainable development of rainfed areas through integrated watershed development approach. India implements one of the largest watershed development programs in the world. Some 28 million hectares of degraded rainfed land, comprising nearly 20,000 micro-watersheds have been treated so far with a total investment of about US $ 2000 million (Sharma, 2002).

Watersheds in the Indian context have come to be acknowledged as key and discrete units in rural development and the approach adopted for their development has been dynamic. The watershed development schemes started with classical soil and water conservation approach and technology. As the schemes progressed it was realised that the primary objective and concern of the land users in a watershed was the improvement of their production systems through water conservation. As a result the National Watershed Development Project for Rainfed Areas (NWDPRA) was launched in the Sixth Five-Year Plan which adopted a Farming Systems Approach (Seth, 2004). The watershed development programs (WDPs) evolved from being techno-centered and top-down soil and water conservation programs to those which attempt participatory and demand driven integrated WDPs with the objectives of: (1) increase in production and availability of food, fodder and fuel; (2) restoration of agro-ecological balance; and (3) improving the livelihood status of the village communities.

The predominant farming system in almost all watershed areas is the 'mixed crop-livestock farming system' under rain fed conditions. In addition to providing income through animal and dairy sales, livestock has an important function for crop production by providing manure and draught power. Especially in the ecologically fragile areas of semi-arid watersheds, livestock makes an important contribution to the survival of the economically weaker sections (Govt. of India Task Force, 1987), small ruminants in particular playing an important role in ensuring rural livelihoods against drought (Pasha, 2000). Livestock constitutes an important asset base on which village communities depend for supplementary incomes, especially in times of stress.

Land holdings in India are in general small and fragmented; medium and large holdings account for less than 10 percent of the holdings. Distribution of land is grossly inequitable with marginal and small holders accounting for over 78 percent of the holdings, but operating less than 33 percent of the total farming land. In 1961 the average holding size for all categories together was 2.52 ha per holding, but by 1992 this had shrunk to 1.34 ha making the individual holdings unviable. Diversification in agriculture thus became an unavoidable compulsion for the vast majority of the farming community in order to protect livelihoods and livestock invariably was their first option, especially in water scarce areas where recurrent droughts and inadequate moisture adversely affect crop production.

Livestock holding in general and milch animal holding in particular, appear to be far less iniquitous compared to land holding. Marginal and small holders together owned over 67 percent of all milking animals in 1992. The *Gini Coefficient* representing the index of inequity in ownership of dairy stock shows perceptible decline from 0.43 in 1961 to 0.37 in 1971 and further to 0.28 in 1991. Milch animals among crossbred cattle too tend to concentrate (78 %) in the marginal and small holdings. Distribution of small ruminant, pig and *desi* poultry follow more or less the same pattern as in the case of bovine: 86.6 percent of sheep and goat, over 90 percent of pig and *desi* poultry are owned by the marginal / small holders and the landless, with marginal holders alone accounting for nearly three-fourths of the *desi* poultry (Kurup, 2003).

Traditionally, livestock production played an important role in the rural economy of India's semi-arid zones (Walker and Ryan, 1990). On an average, 15 percent of household income was derived from livestock production. For poor households, like landless shepherds and women, the importance of livestock production is much larger. Two-thirds of the rural poor have livestock for income and drought insurance. Whereas landless and marginal landowners would mainly depend on goat and sheep, large ruminants were mostly held by landowners, as the costs of maintenance were high due to fodder scarcity (Walker and Ryan, 1990).

Impacts of Watershed Development Programs on Livestock

Water and fodder are the most critical constraints for livestock development in semi-arid areas. The watershed policy/approach of the government accords high priority to mixed farming systems and emphasises on meeting fodder and livestock drinking water needs under its programs. Recognising the significant role of livestock, under NWDPRA not less than 10 percent of the project cost was earmarked for livestock including poultry, pig rearing etc. The general principle was to supplement the activities of the Animal Husbandry Department and activities suggested for funding included:

- *Gopaal* (Livestock farmer) training, financial support, provision of instruments and seed money for medicines.
- Emphasis to primary health care and preventive medication.
- Castration of scrub bulls.
- Fodder seed production and storage, seed banks and pasture development, etc.
- Animal drinking points revitalization- existing animal drinking ponds were given high priority.

The guidelines envisioned livestock-centered development of common lands and their optimal management recognising the training needs of watershed communities in agro-forestry and 3-tier management of common lands for optimum promotion of animal husbandry and vegetation.

- Grasses for grazers like sheep, cattle, etc.
- Shrubs for browsers like goats.
- Trees as source of fodder for stall-fed animals as well as fuel and fruit for humans (Guidelines for NWDPRA, Min of Agric., 1990).

Subsequent guidelines emphasise the importance of mixed farming systems and livelihood support systems for landless households. But the focus that was given to livestock development in the guidelines of 1990 have been blurred in the guidelines for 2000 and thereafter. No specific funds have been provided for livestock components and crop and agro-forestry have taken the central place in the production system without adequate consideration for crop-livestock interactions. Though livestock is generally considered as of high importance particularly for resource poor families, there is a lack of an explicitly spelled out priority. If included, livestock activities are considered under income generating activities, restricting its perspective and focus. In fact, interventions in many cases sought reduction in small ruminant production.

Several studies by IWMI and partners have shown how the intensification of land use resulting from WDPs has increased the availability and utilisation of run-off water and soil moisture in the upstream reaches, which in the semi-arid agro-ecosystems has tended to result in diminished run-off flows to downstream users (whether tanks, irrigation reservoirs, etc.). A secondary dimension of increased water availability in upper watersheds is the relative availability for agricultural lands vs. soil moisture and run-off conservation for pasture and forest lands, i.e., water availability for biomass production. This latter element has crucial implications for livestock dependent populations. While large ruminants, particularly milch buffaloes, remain dependent on irrigated fodder or crop residues, the small ruminants and to a lesser extent non-lactating or non-draft cattle remain heavily dependent on biomass produced on the common lands. This raises an important policy and management challenge vis-a-vis the relative investment (financial, government, NGO, or community management) in WDPs on private vs. common or public lands (Puskur *et al.,* 2004).

Very few studies have studied/documented the watershed development-livestock production interactions. The various collaborative WDPs that have been implemented are, in general, believed to have brought out certain changes in livestock production systems involving shift from extensive system with low productive stock to stall-fed systems with relatively high producing animals, using increased quantity of forages and improved use of common property resources including upper marginal areas. This, of course, may not be true in all situations. Watershed development programmes are often not recognized as providing substantial benefits to livestock-based livelihood dependence, especially through enhanced productivity of biomass that is or should be accessible to marginal farmers or landless.

Generally with the development of irrigation and consequent improvements in crop production and feed, the demand for draught animals and indigenous stock tapers off while that for buffaloes/better milk yielders increases and the small ruminant population declines (India, 1987). Dairy appears to make an increasing contribution to the income from livestock. In a Rajasthan watershed, even in a drought year at least 40 percent of the families in the village were able to maintain improved breeds of cows and buffaloes. In a typical Shiwalik foothill village, which experienced integrated watershed management, the village derived 54 percent of its total income from animal husbandry (Arya *et al.,* 1994).

Available studies reveal that there is no great increase in total livestock population as a result of the WDPs, but there is a change in composition of the population. Labour availability, family or hired, becomes a critical factor affecting the type of ruminants reared. In improved/treated watershed villages, location of land determines the crop options, fodder options and consequently livestock options (Ramdas, 1995). A gradual shift from local stock to crossbred animals was observed in cases where markets were accessible. Intensification has occurred only in cases where the biophysical environment and market access are conducive and in fragile ecosystems the livestock sector productivity has not increased much despite the WDPs and the resulting changes (Ruedi and Luethi-Bourgeois, 1994). Where water resources and agriculture have not developed significantly due to the WDPs, migration continues to be a major livelihood option due to lack of economic opportunities and overgrazing (Pradeep, 2001).

Most WDPs result in a decline in fallow lands, increasing the net sown area and therefore the additional fodder availability through crop residues, leading to a momentum in stall-feeding of dairy cattle (Pagire and Shinde, 2000; BAIF, 2001). Clear indications are available from many cases that dairy as an enterprise gained momentum due to the WDPs where stall-feeding was promoted on account of higher feed/fodder availability from crop lands (positive choice) and a ban on grazing (negative choice). In peri-urban watersheds where no direct livestock interventions were taken up, the milk production increased by almost four times along with an increase in improved stock, underlining the critical role of market access and promotion of a milk producers' society. The cases of increased green fodder availability due to the WDPs are however limited (Vaswani, 1995).

Although the impact of watershed development on cropping pattern is well documented, barring a few (Jurg von Niederhasern, 1996; Kulkarni *et al.,* 1999; NABARD, 2001), there are hardly any reports to show as to whether and how it affected the quantity and quality of stovers/straws as livestock feeding materials. If the increase in number of ruminant livestock is an indicator of improved availability of biomass, particularly the crop residues, it can be said that the fodder availability has increased in various degrees in most of the watersheds. On completion of Shiwaliks project, the availability of green fodder, dry fodder and concentrates increased by 144, 56 and 95 percent, respectively. However, the gap, between demand and supply did not narrow significantly because of the change in the livestock composition (Arya *et al.,* 1994).

There is contrasting evidence as to the impacts on bullock population. With the increase in number of tractors, bullock population decreased and use of hired tractor has become more economical over the use of hired/own bullocks. Increase and/or stability of number of bullocks was observed in Khairaya nala (Hazra, 1998), Bhnagadewadi (NABARD, 2001), Ralegaon Siddhi (NABARD, 1995), Hivare Bazar (Pagire and Shinde, 2000), Manchal (Singh, 2000). In Zaheerabad in Andhra Pradesh (India), possession of the bullocks determined not only the stability of the crops, provided value addition to household labour but also influenced the household capacity to take additional land on lease basis and to convert the fallow land to cultivated land (Ravi Kumar and Gandhimati, 2001). In the Dalit (scheduled caste dominated) watersheds in the same district, plough bullocks formed a part of the program investments and consequently their numbers increased by 39 percent and their contribution as wage income to total income increased significantly.

Proportion of poor households depending on CPRs for fuel, fodder and food items ranged between 84 and 100 percent in different villages. Maintaining the animals without CPRs would have implied diversion of a substantial proportion (48-55 %) of crop lands from food and cash crops to fodder crops (Jodha, 2001). Karnataka Watershed Development project shows that three quarters of the rural poor in the watershed areas depend on common lands for fuel, fodder and even some food. Development of pasture lands is closely linked with the management and distribution of usufructs; unless a set procedure and discipline is established in the village, sustaining ability of the developed pasture was always in doubt (Srinivas, 1998).

Due to reduction in grazing space and ban on grazing imposed as a part of the WDPs, small ruminants especially goats kept by poor small farmers were sold in western Maharashtra (Lobo *et al.*, 1995). In Bundelkhand (Hazra, 1998), bovine population increased by 80 percent while small ruminants declined by 63 percent (Kulkarni *et al.*, 1999). In these cases, the positive impact of the grazing ban on environment and livestock was clear but it is not clear as to how the landless and other poor livestock owners which were dependent on public and private grazing resources were rehabilitated (Kerr, 2002).

The evidence available is also variable with regard to the impacts of these changes on women's drudgery. The IFPRI/NCAP study showed that women in 53 percent of the sample villages said their drudgery increased as they had to go farther in search of fuel wood and fodder due to restrictions on village commons and forest lands. In Manhere watershed project, even though women's issues were not addressed directly, they received indirect benefits through easy access to fuel, fodder and water facility. The time spent on bringing grass reduced by about 36 percent and that on fuel collection almost by 50 percent (BAIF, 2001).

There is a fast growing demand for livestock products and the increasing dependency on livestock for sustainable livelihood systems in developing countries. Therefore, a critical understanding of and the need for evolving appropriate measures to promote livestock while preserving the natural resource base is imminent for countries such as India. There is lack of systematic research and documentation of livestock activities in government and donor sponsored projects in India. In relation to small ruminants, there is a widespread bias concerning their negative role on environment.

Data and Methods

A study was undertaken by the International Water Management Institute together with five NGO partners (Sampark, Samuha, Sevamandir, WASSAN and WOTR) and with the support of CALPI/SDC and LEAD-FAO to identify, research and document livestock-environment-livelihood interactions in five watersheds in semi-arid India. The study focussed on not only the interlinkages between livestock production, resource endowment and market conditions, but also on the management of resources and policy environment. This paper presents some results of the study focussing on the role of livestock in livelihoods in various biophysical envrionments, importance of market linkages for promoting viable and sustainable livestock production systems and contribution of WDPs in the form of institution building to promote sustainable production.

The five watersheds chosen for the study provide a representative sample of the broad diversity of semi-arid areas of India and have varying degrees of production potential based on their biophysical endowments and external linkages. They also differ with respect to implementing partnership arrangements (GO, NGO, GO-NGO, NGO-CBO), and scale of the watersheds. Criteria for site selection were relative resource scarcity and economic integration, resource scarcity being estimated by average rainfall and economic integration by location and market access (Table 1).

Table 1. Study sites

	Low rainfall (<500 mm/annum)	Medium rainfall (>500mm/annum)
Remote area	Kanakanala, Karnataka	Kalyanpur, Rajasthan, Ladki nadi, Madhya Pradesh
Integrated area	Vaiju Babulgaon, Maharashtra	Kosgi, Andhra Pradesh

Hydrological and land use analysis employing GIS/RS techniques has been used to explore the biophysical characteristics in relation to livestock management practices. For the socio-economic and institutional assessments, primary information regarding livestock and livelihood patterns, resource management and institutions was collected at the village/hamlet level in all the watersheds through focussed PRAs and key informant interviews. These qualitative data were ranked by the partner organisations, using the methodological framework provided by Quantified Participatory Analysis (QPA) (James, 2003). Household level data was collected from a sample of 200 households in each watershed through questionnaire surveys.

Watershed Potential and Livestock Production

At the level of the watershed, the two factors which determine the watershed potential to support livestock production are the resource endowment and management. The biophysical livestock production potential is determined by a set of factors, which includes the water availability, topography, soil (type, moisture, fertility, erosion), cropping diversity, cropping intensity, vegetative cover, biodiversity, etc. The study watersheds were characterised on the basis of some precise information on slope, soil type, erosion levels, vegetation and, water availability to assess their biophysical potential for livestock production. Clearly, livestock production does not depend on the biophysical characteristics of the watershed alone. Feed can be imported and livestock migrate and graze on lands outside the watershed. In general, however, the biophysical characteristics are an important determinant for the potential and sustainability of livestock production in a watershed.

Table 2 compares the different climatic and water resource characteristics of the five watersheds studied by IWMI and partners, and provides a relative ranking of the watersheds for their robustness based on various indicators. Of the five, aridity (difference between water inflow and outflow through natural loss) is highest in Kanakanala and is much lower in Kosgi and Ladki Nadi, where rainfall is higher. In all the five watersheds rainfall is confined to 2-3 months a year.

The final ranking based on the total score based on multi-criteria analysis shows that Kosgi has the highest biophysical potential and Kalyanpur the lowest (Table 2). The biophysical robustness or natural resource endowment of the watersheds as defined here provides good understanding of the potential for crop/ livestock production.

However, the resource management regime and access to the markets and other such opportunities determine the pathways in which livestock sector develops. Some general socio-economic characteristics of the study watersheds which relate to and have a bearing on livestock production are presented in Table 3. Irrigation is better developed in watersheds with higher rainfall and the consequent lower dependence on livestock is reflected in proportion of livestock owning households and smaller holdings especially in Kosgi. Livestock holdings are higher especially of small ruminants in watersheds with low rainfall and poor biophysical conditions like Kalyanpur and Kanakanala. Interestingly, the watershed with the lowest rainfall, Vaiju Babulgaon has the most intensive of livestock production systems among the five.

Table 2. Some biophysical features of the watersheds studied

Name of watershed	V. Babulgaon	Kanakanala	Kalyanpur	Kosgi	Ladki Nadi
LEAD partner	WOTR	Samuha	Sevamandir	WASSAN	Sampark
Implementing arrangement	NGO	GO-NGO to NGO-CBO	NGO and GO	GO	GO-NGO
Watershed area (ha)	4876	13064	7488	3460	5838
Average annual rainfall (mm)	430	499	584	739	1024
Arable land (%)	77.5	85.4	52.9	93.9	55.0
Rainfall variability (%)	31	32	33	29	33
Aridity index (P/PET)	0.32	0.31	0.39	0.50	0.71
Tank storage capacity (m^3)	0.8	1.3	3.2	4.8	3.4
Total biomass production*	0.36	0.26	0.32	0.38	0.31
Residual biomass dry season**	0.19	0.2	0.18	0.21	0.17
Length of dry season (No. of days)**	58	120	64	40	88
Irrigation rate (% of total area)	4	2	4	28	23
Strong erosion (% area)	12	5	18	2	14
Moderate erosion (% area)	12	4	11	2	17
Unprotected, slope > 10 % (%)	8.63	2.72	11.78	0	1.92
Bare and sparse vegetation (%)	19	16	20	4	8
Surface stoniness (%)	32	13	31	4	16
Total score for watershed robustness	0.4	0.4	0.18	0.9	0.5

*Mean NDVI (for 1 Dec 2001 – 27 Dec 2002).
**Averaged over 26 Feb 2000 to 23 Apr 2003 for Kosgi, Vaiju Babulgaon and Kanakanala, and between 1 Jan 2001 to 27 Dec 2002 for Kalyanpur and Ladki Nadi.
Source: LEAD PRA reports, LEAD Hydrological and biophysical characterization (2004), agricultural census 2002-2003.

Table 3. Socio-economic household characteristics in studied watersheds

Name of watershed	V.Babulgaon	Kanakanala	Kalyanpur	Kosgi	Ladki Nadi
Livestock intensity (ACU/ha)	0.99	1.39	1.54	0.71	1.56
Treated area (%)	24	43	44	56	90
Caste composition*	1% ST	10.6% ST	94% ST	15% SC	87% ST
	8.8% SC	5.6% SC	1.5% SC	67.5% BC	13% OC
	8.8% BC	70.6% BC	4.5% OC	12.3% OC	
	81.4% OC	13.1% OC			
Average HH size	5.6	6.7	6.6	6.6	5.9
Average education per HH (years)	5.14	1.61	2.69	3.12	2.27
Average landholding (acres)	5.40	8.89	2.64	3.10	3.72
Average irrigated area (acres)	0.38	0.92	0.78	1.25	2.19
% Irrigated area	7	10.4	29.5	40.3	58.9
Landless HH (%)	8	5.5	0	25.5	0.5
HH with SR (%)	67	34	86	14	58
HH with LR (%)	78	67	93	35	86
Large ruminants/HH	3.21	3.04	4.39	2.45	3.59
Small ruminants/HH	4.24	6.48	6.29	1.04	2.53

HH=Household, LR=Large ruminants, SR=Small ruminants, ACU=Adult cattle units.
Source: Lead Household Survey (2004). * ST=Scheduled tribe, SC=Scheduled caste, BC=Backward Caste, OC=Other castes, SR=Small ruminants, LR=Large ruminants, HH=Household.

The figures on land holding vs livestock ownership show that the distribution of large ruminant holding is more unequal and correlated to land holding size than the distribution of small ruminants (Table 4).

Table 4. Livestock holdings by land holding size

Land holding	V. Babulgaon		Kanakanala		Kalyanpur		Kosgi		Ladki Nadi	
	LR*	SR**	LR	SR	LR	SR	LR	SR	LR	SR
Landless	0.50	1.69	0.64	3.36	-	-	0.12	1.06	1.00	0.00
Marginal	1.67	3.06	0.64	4.27	3.55	4.71	1.47	0.66	3.00	2.80
Small	3.11	5.44	1.31	5.13	5.00	9.12	3.31	1.10	3.42	2.16
Semi medium	4.00	4.19	2.91	6.21	7.68	9.59	5.54	2.14	3.97	2.75
Medium	7.60	7.07	4.57	5.10	10.50	11.50	4.11	0.44	7.71	1.50
Large	6.57	2.14	8.33	42.50	5.00	14.00	29.00	0.00	6.00	9.00

Source: LEAD Household Survey (2004). *LR=Large ruminants, **SR=Small ruminants.

In Kosgi, trends over the last 10 years indicate that livestock holdings have been greatly reduced, mainly because of increased migration and mechanisation. A shift from cows to buffaloes and from sheep to goat has taken place. In V.Babulgaon, large ruminants are mostly cross-bred cows (Fig 1), mainly for dairy production and there is widespread stall-feeding. Bullocks are also many, mainly for draught power, but the numbers are decreasing. There are twice as many goat as sheep, because of social preferences. In Kanakanala, goats and sheep (only in one village) are most popular, with few buffaloes. Large ruminants are reared for draught (hardly any mechanization) and manure, small ruminants for liquidity and insurance. Dairying is a limited activity, but increasing in villages close to the town. Kalyanpur has an average livestock holding of 5-6 animals per family. Each family owns a pair of bullocks since mechanization is low. Goats are also popular since the meat fetches a good price. Over the last decade there has been a great

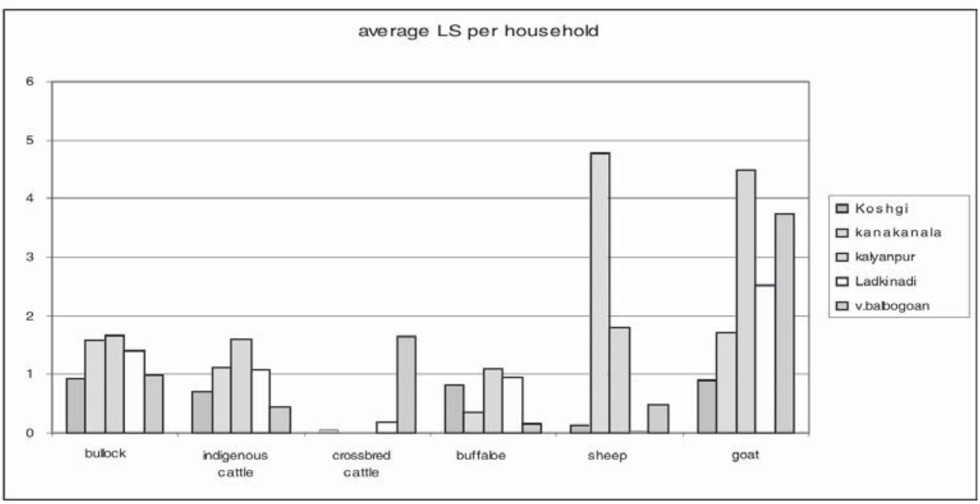

Figure 1. Average livestock holding by species per household in study watersheds

decline in livestock holdings, mainly because of drought and diseases. The differences between livestock population among villages in Ladki Nadi are large. Livestock population has reduced due to the fodder and drinking water shortages because of recurring droughts.

In both the watersheds, Kosgi and Vaiju Babulgaon which are relatively better embedded in the market, dairy production has developed. In Kosgi, the strategy has been to reduce the cow and bullock population and develop buffalo milk production and this ensures the best livestock-crop integration. In Vaiju Babulgaon, despite the unfavourable biophysical endowments, a good organization and management system enables to cope with the low rainfall pattern better. Through forest protection, restricted access to common lands, and soil and water conservation, the watershed robustness and the biomass production has increased. The strategy here has been to exploit the good market linkages, introducing crossbred cows and external feeds in case of crop failure. The protection of the forest area and controlled grazing strategy also ensured feed for the goat population. However, this watershed in times of drought faces severe feed/fodder shortage and the cattle camps organized by the government help them tide through these times, but there is very high mortality and sales of animals to cope with the situation making the production unsustainable and risky.

Dependence on bullocks for draught power is high in all watersheds except Kosgi as also the importance of manure (Table 5). In watersheds where the biophysical conditions are harsher, and market linkages are poor, the dependence on small ruminants is higher. In Ladki Nadi, three consecutive years of drought led to change towards cash crop production and goat rearing, the goats insuring the livelihood in drought periods and being able to survive in harsher conditions. In the arid climate of Kanakanala, the same tendency was observed. In Kalyanpur, where the terrain is very hilly and more than half the area is uncultivable, the dependence on small ruminants and draught animal power is very high.

Table 5. Benefits from livestock production

	V. Babulgaon	Kanakanala	Kalyanpur	Kosgi	Ladki Nadi
HH owning bullock (%)	65.6	74	93.2	53.8	92
HH rents bullock (%)	34	26	7	46	8
Hours draught power (hrs/HH)	38.8	75.1	27.2	29.3	16.4
Tractor hours/HH	2.92	1.79	1.51	2.25	1.29
Proportion of dung collected (%)	77	63	91	37	82
Proportion used for fertilizer (%)	92	51	94	92	85
Fuel (%)	1	6	5	4	15
Other purposes (%)	4	3	1	1	0
Sold (%)	14 (overlap)	1	0	4	0

HH=households, hrs= hours.
Source: LEAD Household Survey (2004).

The correlation between the biophysical robustness of the watershed and the intensity of the livestock reared is positive at 76 percent and stronger with the density of large ruminants than with the density of small ruminants. The results show that aridity is not a limiting factor towards livestock rearing and that it increases the dependence of the communities on the livestock production. However, a very strong positive correlation (98.8%) is found between the availability of biomass/vegetative cover and livestock intensity. The correlation is higher between availability of biomass and the density of large ruminants than between the availability of biomass and the density of small ruminant, corroborating the fact that small ruminants can survive in harsher conditions and are the preferred species in case of drought or arid conditions.

Land ownership is an important determinant of livestock holding in all the watersheds, although it differs whether it is irrigated land holding, fallow land or a combination of factors that is more important. The total income is a positive determinant of livestock ownership (more the income, more is the livestock), whereas the proportion of non-farm income (labour, migration) affects livestock holding in a negative way. Location of the household in the watershed is only significant in Ladki Nadi, downstream villages having more livestock than households located upstream. The number of household members is a positive determinant of livestock holding. For the marginal farms, the mortality of the animals plays a significant role. Higher the incidence of deaths, more is the number of animals they would like to hold. In Kalyanpur the extent of fallow lands or lands available for grazing plays an important role for the marginal and small farms. Cultivated area and off-farm income are also significant positive determinants for small farms.

The large ruminant holding is largely determined by land holding, especially the irrigated land, except in Kosgi where access to irrigation is a negative determinant. A significant and relatively large determinant is the location of households in the watershed: the more downstream the household is located the more large ruminants it is likely to have.

The amount of irrigated land and cultivated area turn out to be important determinants of the number of small ruminants a household is likely to hold. The hypothesis that small ruminant holders tend to be the poorer households is supported by the analysis: the more income the household has, the less small ruminants it is likely to own. Also, if the household has less than the average watershed income, the small ruminant holding is increased. Interestingly, the implementation of watershed development and involvement of an NGO are negative determinants for small ruminant holding: both factors tend to reduce small ruminant holding, which is exactly what both proponents and opponents to watershed development programs state (of course, whereas proponents argue that this increases environmental sustainability in the watershed, opponents argue that it reduces income for those households that are already poor. The analysis does not prove either).

Table 6 presents the characteristics of livestock and non-livestock owning households in the five study watersheds. The most important difference between the two categories seems to be the proportion of income earned from outside: while non-livestock owners earn 81 percent of their income from non-farm sources, for livestock owners only 43 percent of total income comes from off-farm labour and migration. Average income per head is higher for pure small ruminant holders since 40 percent of this sample is from Vaiju Babulgaon. However, if we look in relative terms, households dependent solely on small ruminants tend to be worse off: 80 percent of these households earn an income below the average of the watershed they are in.

Table 6. Characteristics of livestock (LS) owners vs non-LS owners

	LS owners (821 HH)	Non-LS owners (185 HH)	Only small ruminants (71 HH)*
Caste : Schedule tribe	47%	7%	29%
Schedule caste	4%	16%	15%
Backward class	24%	54%	22%
Other castes	26%	22%	34%
Household size	6.4 (2.35)	5.56 (2.29)	5.19 (2.23)
Education	2.96 (2.51)	2.95 (2.64)	2.76 (2.44)
Average land holding (acres)	5.27 (6.88)	2.39 (3.05)	2.25 (2.49)
Irrigated area (acres)	1.26 (2.56)	0.43 (1.52)	0.27 (0.56)
Average annual income/head (Rs)	4,692 (6,018)	3,292 (3,561)	4,656 (4,874)
Proportion of off-farm income in total income (%)	43	81	69
Proportion of HH below mean watershed income (%)	63	72	80
Proportion of HH active in WSD (%)	32	7	17

Source: Lead Household Survey 2004. Figures in parentheses are standard deviations.
*10 HH in Kosgi, 13 HH in Kanakanala, 4 HH in Kalyanpur, 16 HH in Ladki Nadi and 28 HH in V.Babulgaon.

Livestock Feeding Systems and Resource Management Regimes

Although at least 10 percent of livestock feed in mixed farming systems comes from crop residue and fodder from own sources, livestock production depends, to a large extent, on external sources for feed (Staal *et al.*, 2001). Especially in the subsistence based livestock production system prevalent in most semi-arid watersheds and in times when the feed production from own farm resources is low, the primary source of non-farm livestock feed are common lands including forests, pasture lands, nala bunds and roadside plantations. For landless households and marginal farmers, common lands are the main source of livestock feed, these households being fully dependent on biomass from them (Rajora, 1998; Kishore, 2000). Generally in semi-arid watersheds of India, free grazing and stall feeding are not mutually exclusive, but co-exist with the relative importance varying depending on the cropping intensity; proximity to forests, wastelands, and fallow lands; and access to markets for milk and fodder (Puskur, 2002). In general, large ruminants are partly stall-fed and partly left to graze, whereas small ruminants are left to graze. Figure 2 illustrates the feed sources for various livestock species in the Vaiju Babulgaon.

More market production means more dairy cattle and higher the value of dairy production, more is the market dependence on inputs for livestock production. In Kosgi, some households mainly depend on market purchased feed, and in

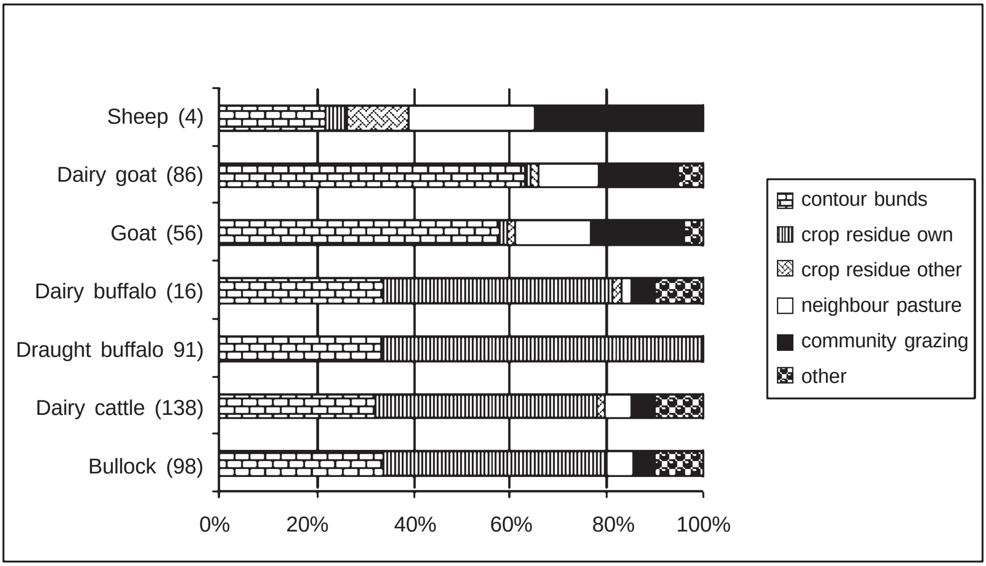

Figure 2. Main feed sources by livestock species in Vaiju Babulgaon watershed

V.Babulgaon supplements play an important role. Subsistence farmers tend to spend much less on their livestock, and all the feed needs to come from the watershed itself.

The system of cut-and-carry implemented in Vaiju Babulgaon, forest protection and controlled grazing of the goat population had a positive impact on reducing the land degradation. This watershed, despite the lowest average precipitation, has been able to produce higher biomass. In Ladki Nadi and Kalyanpur, a similar system has been instituted where grasslands are protected either by the forest department or private farmers and collectively harvested at maturation. This method has proved to be beneficial, with increased fodder production and rapid improvement in soil quality. The use of crop residue and the feed-on-farm system, as practised in Kosgi, demonstrates good crop-livestock integration, with a fairly closed nutrient cycle. However, the privatization of common land has had an impact on the livelihoods of goat-rearers, who now mainly depend on feed from outside the watershed.

Crop residues are so critical in Kosgi that in case of non-availability of crop residues, farmers sell their livestock. In Ladki Nadi their importance has been increasing due to reduction in forests and grazing lands. In about 30 percent of the villages, some farmers report an improvement in crop residue availability due to increased crop production as a result of yield improvements, which are attributed to employment of improved agricultural techniques and access to irrigation (Fig 3). In all villages in Kosgi, some farmers report a decline due to the increasing cultivation of red gram and cash crops. Higher usage of pesticides is perceived to have resulted in deterioration in quality. In Kanakanala, most farmers report a decline in crop residue availability and quality. In Vaiju Babulgaon while in some villages, most farmers report an increase in crop residue availability and quality due to use of HYV seeds and chemical fertilizers leading to good crop growth in the others, most farmers report a decline due to stunted HYV crop growth because of scarce irrigation water. Some report a decline due to land degradation and resulting bad land texture and frequent drought. The implications this has had for livestock composition and feeding practices remains however unclear.

In about 58 percent of the villages, no fodder is cultivated. Some seasonal fodder cultivation is observed in Ladki Nadi, promoted by the watershed project. In some villages of Vaiju Babulgaon, substantial seasonal fodder cultivation is reported due to high awareness regarding livestock and milk business and therefore extensive use of green fodder from farms.

The differences between watersheds in local natural resource management are large. In Kanakanala watershed, only in one village, Mydardokki, are some permanent grazing restrictions enforced. In others, bans on tree felling and grazing apply only in plantation areas. These restrictions are enforced through a forest guard paid by the NGO. Forest committees and/or common land management groups do not exist in Kanakanala, although in some cases the watershed committee or village organization does take the responsibility. In Kalyanpur, ban on grazing is enforced in all forests during *kharif* by the forest department with some penalties imposed for default. Although in some villages the forest department has invested in rehabilitation of degraded land, maintenance is only undertaken if a village forest committee exists. Hence, village forest committees have been established in several villages to control grazing and maintain the common lands. In Ladki Nadi, fewer initiatives regarding forest management exist. Although 'Sampark' has attempted to stimulate social fencing to control the heavy overgrazing in this watershed, the initiative failed due to high migration rates. In the village with most forest, Hamirgarh, a joint forest committee has been established, with a forest guard paid by the forest department to enforce the anti-grazing rules. In general, the forest department does control grazing on forestlands, but access to fodder is low. To improve access to biomass, 'Sampark' has encouraged fodder cultivation. In V.Babulgaon watershed, free grazing is banned in the forest area, enforced by the department which has invested substantially in forest regeneration, investments that have largely been maintained by village forest committees and social fencing.

Common lands are managed in only 5 of the 26 study villages, with no management in more than half of the cases where common lands exist (Fig. 4). Encroachment is a serious problem. Only in 9 villages do any grazing restrictions apply, but only in half of these villages the rules and regulations are actually enforced. This means that in most of the villages, grazing lands are used as an open access resource, with no control on the intensity of use. Under these circumstances, the only limitation to livestock grazing is resource availability. The well-known 'Tragedy of the commons' grimly illustrates that under conditions of open access, households will continue to reap the benefits of free grazing until no biomass is left (Ostrom, 1990; Balland and Platteau, 2001; Dasgupta, 1982). This is exactly what has happened in most watersheds, farm households indicating that there is nothing left to graze.

Economic considerations drive the decisions of households with regard to grazing. Puskur (2002) observed that if economic costs are considered but environmental and social costs to the community ignored, free grazing is the only system that gives a positive gross margin. Stall-feeding is only sustainable when farmers disregard the cost of own labour, capital, and crop residues and gross

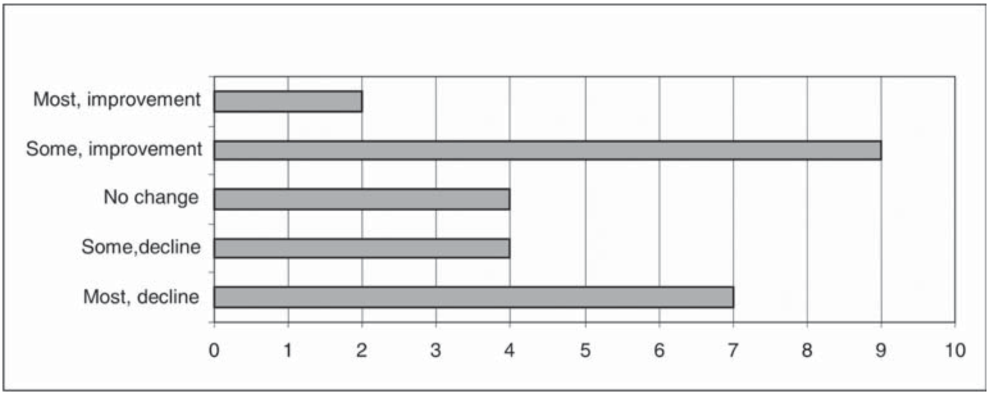

Figure 3. Crop residue avaibility

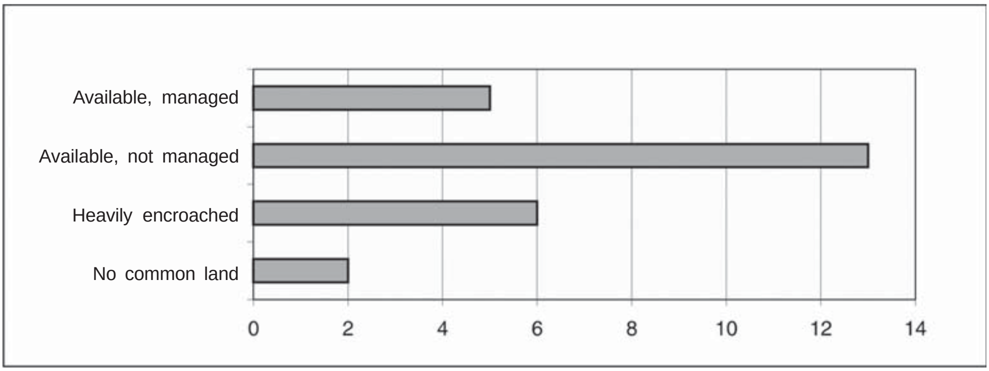

Figure 4. Status of common lands

margins and cash flows drop dramatically when herd sizes are extended beyond the numbers that farmers can feed with their own crop residues, and they have to purchase fodder to cover the deficit. At current prices, a high dependence on stall-feeding is unlikely to become a viable option unless the quality and quantity of homegrown crop residues can be increased substantially on a year-round basis at low or no additional cost, and the conversion efficiency of animals considerably increased through low-cost genetic improvements.

An important critique of watershed development projects has been that they tend to restrict grazing on upstream lands (Mangurkar *et al.,* 2001; Kerr, 2002). As Kerr (2002) illustrated in his paper, restrictions on grazing can easily adversely affect poor and marginal households if no options are provided to meet their fodder requirements in the short-term. However, if prior to the intervention these lands were so degraded that no biomass was there, restricting free grazing can be beneficial if the costs and benefits of restricted grazing are equally shared. Examples of such solutions exist in several of the study sites. In Bicchiwara and Depur, for example, fodder from common pasturelands is collectively harvested and equally shared (*see* box) and in V.Babulgaon free grazing is controlled by the community with the consent of all. Establishing local agreements for community pasture management is usually not without conflicts, however, and requires extensive facilitation. Besides, for community agreements to be sustainable, strong local institutions are required in which all stakeholders have a say.

In some of the LEAD study villages, some significant investments in community resource management were made, whereas in others either no watershed development was undertaken or investments in local resource management were superficial and non-participatory. In the study watersheds, in all NGO villages local institutions for NRM like watershed committees and forest committees were established, whereas in non-NGO villages few NRM organizations seem to function in an effective way. Investing in institution building however does not necessarily result in sustainable resource management over time. The community's perceptions revealed that more than 50 percent feel that local NRM is poor. Only in 20-25 percent of the villages are land, water and biomass resources apparently managed in a sustainable way.

These figures do indicate that while local institution building by NGOs has had significant success; local natural resource management does not depend on the interventions by NGOs and local community management alone. Formally, the responsibility for the management of common property resources lies with the Panchayat. In 90 percent of the villages, the role of the Panchayat Raj institutions (PRI) in NRM was said to be non-effective, most panchayats seeing their role in natural resource management as small (ODI *et al.*, 2002). The forest department plays a more active role in natural resource management, where forest lands exist. Typically, the relationship between villagers and the forest department is strained with the forest department hesitantly permitting villagers to co-manage and develop forest lands for use. Even where communities invest in plantations and biomass development, the user rights of these newly created assets are not secure. Several examples exist of villagers investing in plantations and the forest department later forbidding the biomass to be used. In Kanakanala watershed the insecurity of user rights is refraining villagers from investing in biomass enhancement. Similarly, local panchayats have been obstructing initiatives for community resource management, by either refusing to relinquish control over degraded revenue lands and/or for appropriating the benefits after investments have been made as in Kalyanpur. To enhance and stimulate local resource management, clearer agreements between government departments, panchayats and villagers are needed, that clearly define roles, responsibilities and sharing of benefits. Although NGOs play an important role in facilitating local institution building and creating incentives for institutional change, ultimately it is the panchayat, community and government departments that need to jointly manage natural resources in the watershed.

For the management of biomass, land and water resources to be sustainable it is not only important to have a clear division of responsibilities and user rights, it is important that the institutions for natural resource management (NRM) function in a participatory and equitable way. If marginal households have no access to community decision making or if the local rules and regulations affect certain households in a negative way, improvements in natural resource availability are likely to reduce equity and threaten the sustainability of resource use in the long run (Farrington *et al.,* 1999).

The critique on watershed development projects has been that interventions have largely neglected livestock production (Mangurkar *et al.,* 2001) and have

Community pasture management

Seva Mandir started work in Depur village as early as 1973 through an adult literacy programme. In 1978 a 'samuh' (group) of 40 people was organized. In 1984-85 silvi-pasture development was initiated in a 60 ha patch of community pastureland that used to be open grazing ground with some bushes and very little amount of grasses. The villagers were motivated by Seva Mandir to regenerate the pastureland. Initially only 8-10 families took interest in developing the pastureland. During the initial developmental phase, some conflicts arose between the villagers regarding the use and maintenance. In April 1985 when there was acute fodder scarcity, the villagers found that some animals were grazing inside the plantation at night. Upon enquiry, it was found that the defaulters threatened the watchman that his salary would not be paid if he prevented them from grazing their animals. A fight broke out in the village, which resulted in destruction of the pastureland. Seva Mandir reorganized the village group and replanted the pastureland in 1986. Soon the difference resurfaced and community pasture was ruined again. In order to facilitate conflict resolution, Seva Mandir mediated between villagers and in 1989, they resolved their outstanding conflicts and took over the responsibility of protecting and managing the community resource. Initially, social fencing was used to protect the pastureland. As not all families complied with their responsibilities, a watchman was hired for Rs 500 per month, each family contributing Rs 10 per month. In return, participating families get on an average 300 'pullas' (1 pulla = 1.5 - 2 kg) of grass annually. Today around 87 families are benefitting from the community pastureland.

mainly benefitted the larger land and well owners downstream (Batchelor *et al.*, 2003; Kerr, 2002). With regard to the first point, in the LEAD study sites explicit attention to livestock production has only been paid in Ladki Nadi, through breed improvement, vaccination and fodder cultivation. However, in the other sites except for Kosgi watershed, the programs have indirectly benefitted livestock production through investments for biomass enhancement and NRM. Livestock camps have been organized and fodder purchase facilitated in times of drought. However, the main focus of most NRM interventions and investments in biomass production has not increased livestock productivity, but rehabilitation of the degraded resource base. Only in Kalyanpur, with a relatively high livestock population, and V.Babulgaon, where livestock production is a major income source, explicit attention to livestock production seems to have been paid. Livestock producer organizations have not explicitly been involved in watershed planning and implementation. Although only in Kosgi and Kanakanala, sheep and goat rearers organizations and in V.Babulgaon strong dairy cooperatives exist, involving these organizations seems important since they play an important role in times of drought.

With regard to the second point, participation of livestock owners in watershed planning and implementation is crucial. If we look at the LEAD study sites, the fact that 82 percent of the households own livestock indicates that most participants in watershed development will own livestock themselves. However, participation is especially crucial of those households that depend on common lands for their livestock feed requirements. If we look across the 5 watersheds at the participation of different landholding categories in village decision-making and natural resource management, the following picture emerges (Table 7).

Table 7. Participation of small landowners in WSD decision-making

Parameters	Landless	Marginal (<2.5 acres)	Small (2.5-5 acres)	S-Medium (5-10 acres)	Medium (10-25 acres)	Large (>25 acres)
% of population	8	38	25	19	8	2
% of livestock owners	25	84	86	89	95	100
Average small ruminants	1.5	3.1	4.5	5.2	5	17.6
Average large ruminants	0.3	2.6	3.4	4.4	5.7	9.6
% active in WSD	3	30	33	26	24	13
% member of SHG*	20	35	36	41	42	31
% able to influence decisions	12	45	51	54	63	69

*SHG= Self Help Group.

Interestingly, across the watersheds, the proportion of households that feels able to influence village level decision making increases with landholding size. Participation in village organizations seems less defined by landholding size with small landowning households being most strongly represented across the watersheds. Landless households are relatively few, and mainly concentrated in Kosgi. Their influence in village decision-making is notably less, but since most of these households are weaver families dependant on migration, their dependence on the natural resource base is less too. Overall involvement of livestock owners and more specifically, of small and marginal landowners in village level decision making seems to be good. However, the extent to which village level institutions can operate freely or are dominated by a few large landowning households remains to be seen. The figures do indicate that even without being represented, these households feel able to influence decision making.

Interventions for Sustainable Livestock Development in Watersheds

One of the most clear cut findings of the LEAD study, which reinforced an existing notion, was that livestock is an important means of livelihood (income and security) for the resource poor households in drought prone watersheds who depend on rainfed mixed farming.

Using the study findings, we arrive at specific interventions and improvements that would be useful for optimising the positive benefits and minimizing the negative impact of watershed development on livestock and vice versa. These interventions or improvements can be at various levels – policy or operational and implementation procedures (administrative instruments) or in terms of awareness, training and capacity building.

- One of the most important issues that seriously hampers livestock and watershed development is that coordination among various government departments that work in related fields and between government and NGOs is not strong enough for a holistic development policy for an area to be adopted. The list of government departments itself is long enough (water resources, agriculture, animal husbandry, forests, panchayati raj, rural development, etc.) and achieving effective coordination between all of them at the field level, middle level and the top levels is a challenge. Only through such coordination will it be possible to include the crucial dimensions of livelihood dependence of poor on the livestock sector and the value of livestock assets in poverty reduction (especially small ruminants) in the watershed development strategy of the Government.

- The importance of common property resources and pasturelands, for sustainable livestock activity in watersheds needs to be emphasised. From the watershed point of view the degradation of land due to overgrazing and other reasons needs to be seriously addressed and there is a need for greater policy directions and ground-level interventions for controlled grazing and community management of common and revenue lands with clear usufruct rights regarding investments in biomass. The problem of encroachment is more complex, but various options for addressing this problem need to be explored as in low input-low output livestock production systems, CPRs play an important role.
- On a related note the problem of shortage of fodder and feed because of an inadequate fodder policy is another aspect that needs attention. Emphasis needs to be placed on developing CPRs. There is also a need for assessment and inclusion of livestock fodder needs in forestry projects.
- Treatment in resource scarce watersheds may introduce tradeoff between livestock and crop development, between upstream and downstream users, or between free grazing and stall-fed livestock. Long-term sustainability of natural resources and livelihood assets like livestock must be given a priority while planning watershed development programmes.
- The importance of draught animals for marginal farming has been neglected in India. Despite increasing mechanisation of traction, electrification of pumps and post-harvest operations, draught animals still provide most of the power for marginal and small farmers in many semi-arid areas. A clear policy needs to be worked out for draught animals in areas where their use is still extensive.
- The government it seems has also not made too much effort to organise the livestock owners into user, self-help or beneficiary groups. Some organisations at district level do exist but there is a need to take them down to the watershed/panchayat level for the livestock owners in semi-arid areas to have a strong voice in the local decision making process. Also being organised will allow the livestock owners to take advantage of institutional support like credit etc.
- Market access for livestock producers also needs attention. Except for areas where dairy cooperatives are very active and for large-scale poultry farming, the marketing of livestock and livestock products is not well organised. The government does not play a major role in livestock marketing and the livestock owners are mainly dependent on middlemen. The dependence on middlemen is especially acute in meat markets and serious policy interventions are required in this regard as the share of the actual producer is extremely low compared to the market price of meat. Effective use of watershed development programmes and institutions created thereby needs to be made to build necessary linkages to develop and exploit markets for livestock and their products.

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Policy and Institutional Processes of Participatory Watershed Management in India: Past Lessons Learnt and Future Strategies

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Abstract

About 83 percent of the world agriculture is unirrigated or rain dependent and researchers are making sincere efforts to enhance its productivity. After having developed all the water resources about 50 percent of the Indian agriculture shall still remain rain dependent. Groundwater recharging is expected to play major role in sustaining intensively irrigated ecosystems. Internalization of bio-physical research with the participation of communities, enabling policies and right kind of institutions is vital for sustainable watershed development programs. Public investments in India during 1930 to 1970s established R&D infrastructure and generated several technologies mostly bio-physical in nature. These technologies were scaled up in the treatment of river catchments since 1961-62, soil and water conservation in arable lands, drought prone areas (1970-71), desert development (1977-78), flood prone river catchments (1980-81), rainfed agriculture (1991-92) and development of wastelands (1994-95). Four pilot projects for analyzing role of social capital in watershed management were initiated by ICAR in 1977 and scaled up through 47 model watersheds in 1982 when a few NGOs also joined in a tripartite partnership. Till 1994 implementation was almost an exclusive domain of public agencies. A significant shift was made after that and NGOs, research institutions and any organization registered under cooperative or charitable trust acts also implemented the program. People's participation was internalized through the institutions of watershed associations, self-help groups, and user groups with adequate empowerment, decentralization, contributions and social equity. Detailed guidelines facilitated an extensive and relevant capacity building. Seventy Third and Seventy Fourth Amendment of the Indian Constitution allocated watershed management and many other businesses to the democratically elected *Panchayati Raj* institutions (PRI). The recent *Haryali* guidelines of Ministry of Rural Development declared PRIs as project implementing agencies in 2003. Several multiple level conflicts were resolved and process continued to be dynamic during 1995-2004. This process is going to be dovetailed for ensuring a minimum of 100 days employment per family in 150 most backward (out of 487) districts of the country prioritized for intensive and targeted development.

Introduction

The ancient Indian literature carry frequent references about the then concept of resource conservation and rainwater management. Tank irrigation of south India and drinking water filtration wells constructed in the centre of the ponds especially where underground aquifers were saline represented the indigenous practices evolved through continued experience. *Haveli* cultivation of Madhya Pradesh and *Khadin* system of Rajasthan consisting of rainwater harvesting against an embankment for groundwater recharging and cultivation in the ponding area after the recession of water are the other classical examples of ancient ingeniousness. Kings were considered responsible to construct ponds, lakes and other water features especially near the religious structures. The present era of planned rainwater conservation started with the setting up of a research centre at Manjri near Pune during 1920s, which was further scaled up to, four centres during 1930s. Damoder Valley Corporation Act was enacted in 1949, which laid emphasis on the resource conservation in the catchments to prevent siltation of the water reservoirs. Subsequently, a chain of the Central Soil and Water Conservation, Research, Training and Demonstration Centres was set up in 1954. Technologies generated were internalized for the conservation of catchments of river valley projects in 18 out of 26 states since 1961-62. Similar scheme was also implemented in the catchments of flood prone rivers of eight states since 1980-81. However, all these public investments focussed on the major agenda of preventing siltation. People's participation for realizing a larger cause of enhancing equitable livelihood, employment generation and resource conservation was experimented in four watersheds by Central Soil & Water Conservation, Research and Training Institute, Dehra Dun with the support of Ford Foundation. This concept was further expanded to 47 watersheds in 1983 with the joint investments of Indian Council of Agriculture Research (ICAR) and Department of Agriculture, Government of India. An NGO (MYRADA) also entered into this development process in partnership with SIDA and the then Dryland Development Department of the Karnataka state around 1980. The severe drought of 1987 demonstrated potentialities of watershed management as a mitigating strategy (Fig.1). As a result of that the

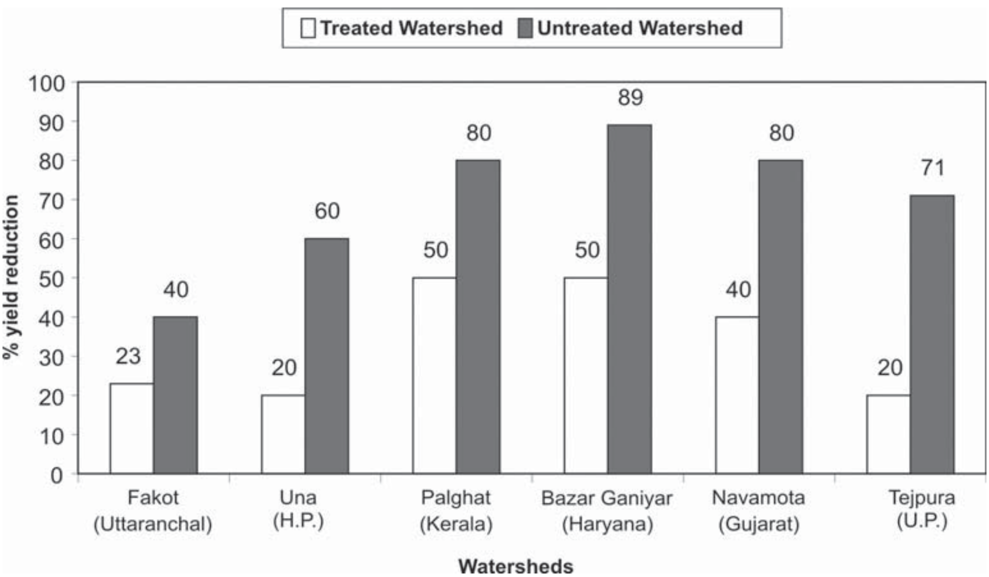

Figure 1. Effect of watershed management on drought moderation (1987)

program was scaled up at the national level with larger public investments during 1991 in the schemes like National Watershed Development Program for Rainfed Area (NWDPRA), Integrated Wasteland Development Project (IWDP) and several other initiatives supported by World Bank and other international donors.

Council for Advancement of People's Action & Rural Technology issued guidelines (CAPART, 1992) to enhance the role of NGOs in resource conservation and watershed management. A technical committee appointed under Chairpersonship of Shri Hanumantha Rao by the Ministry of Rural Development (GOI, 1994 a) for reviewing Desert Development and Drought Prone Area Program (DDP and DPAP) concluded disregard to watershed approach, people's participation and coordination did not produce desired impact.

In response to above conclusions, comprehensive guidelines for participatory watershed management process were issued (GOI, 1994 b). Another high-level committee under the Chairpersonship of Shri Mohan Dharia of Gandhian philosophy in 1995 introduced a major policy shift in terms of governance, institutions and delivery system (GOI, 1995). Participatory process of rural development on watershed basis incorporating bio-physical, socio-economic, institutional and policy innovations was reviewed by Samra (2000). The guidelines issued after 1994 were further amended in January 2003 and village level democratically elected institution of Panchayats (Village Council) was made a major player of the rural development process (GOI, 2003).

Elements of Participatory Process

Before 1994 most of the public investments were implemented through various state departments in compartmentalized approach without any inter-sectoral coordination. In a World Bank aided project (IWDP) in the states of J&K, Punjab, Haryana, Himachal Pradesh and Rajasthan a shift was made in 1991 by converging departments of agriculture, horticulture, animal husbandry and forests under a single administrative and financial umbrella or a single window system by creating a separate cell to be managed by a Project Director. However, this approach was further refined or distilled through various mechanisms in subsequent policy and alternative institutional mechanisms.

Alternative Institutions

Monopoly of the government departments in the implementation of programs was diffused by recognizing NGOs, any registered institution or organization for implementing watershed projects. Remittances of the central government investments were sent to the basic development unit of a district, routing of the funds through Chief Secretaries of the states was discouraged and diversion of funds to non-development activities was averted. A lot of decentralization of related functions to the district level was also a progressive initiative in the right direction. Empowerment of watershed level institutions and decentralization of decision-making process to the village communities ensured active participation of grassroot level stakeholders.

Project Implementing Agency (PIA)

The district level management was empowered to select any organization for implementing watershed management program. If a government department, say Agriculture Department, became PIA it was also made responsible to take up activities on livestock, horticulture, micro-enterprising and any other interventions analyzed by the participatory rural appraisal. Each PIA was expected to handle 10-12 watersheds each of around 500 ha by setting up multi-disciplinary watershed development team (WDT). PIA was responsible to register a Watershed Association (WA) by arranging a meeting with all eligible voters of the watershed. Day-to-day work of the Watershed Association was discharged by elected or volunteered office bearers. There was also an emphasis to have self-help groups (SHGs) or users groups (UGs) of like minded persons or those engaged in a common group of activities. These institutions were considered alternative to the government organizations to create healthy competition or complementarity and a typical variety of institutions is given in Table 1. Panchayati Raj institutions (PRI) of elected representative was also taken on board of these organizations to harness various complementarities of social capital. The recent amendment (*Haryali* guidelines) of the Ministry of Rural Development has declared PRIs as PIA (GOI, 2003) and impact of this revision is being debated.

Table 1. Types of villages institutions (VIs) in the Aga Khan Rural Support Program in different districts of Gujarat, India

District	GVM	MVM	SHG	WSG	UG	LIG	CIG	CG	Total
Bharuch	51	40	0	0	0	13	6	2	112
Junagarh	24	48	15	0	28	2	1	16	134
Surendranagar	17	15	2	29	0	1	1	0	65
Total	92	103	17	29	28	16	8	18	311

GVM = Gram Vikas Mandal; UG = User's Group; MVM = Mahila Vikas Mandal; CG = Children's Group; SHG = Self-Help Group; LIG = Lift Irrigation Group; WSG = Watershed Group; CIG = Canal Irrigation Group.

Transparency

In order to enhance integrity of the service providers and to eliminate doubts of leakages of public investments, PIA opened and operated joint account with the office bearers of WA as co-signatories to all the financial transactions. Cashbook and other records were maintained and kept with the Secretary of the WA in the village, which could be examined by any watershed resident. Details of the budget and funds received were displayed prominently on the display boards. Collective decision-making process with the participation of all stakeholders irrespective of social groups, gender and economic status was also a key element of removing misgivings or apprehensions. Initially there were lot of misgivings about this instrumentality in the minds of government officials and attempted sabotaging of this progressive policy. They argued that cashbook and other records kept with the Secretary of Watershed Association (non-government functionary), if misplaced or lost will create problems for the officials. Many such misgivings were removed from their minds during training program and changing of mind set was the most difficult part of the capacity building program.

Entry Point Activities

About 3 percent of the budget was earmarked to take up any activity in the watershed, which was most appreciated by the majority of the people. It could be desilting of a community pond, installing a hand pump for drinking water or repairing a religious structure so as to establish credentials by striking the most effective social chord. The whole idea was to create an impression of a service provider rather than a top down official approach of doling out cash benefits. The whole process was designed to mobilize community participation without any opposition, conflict or resistance. This activity proved very effective for ensuring participation of majority of the communities by building bridges of mutual trust and confidence.

Community Contributions

A 10 percent contribution in cash or kind for activities or investment on private land was envisaged. The rate was scaled down to 5 percent for socially disadvantaged participants. The contribution rate was also 5 percent for the activities to be taken up on open access or community owned resources and activities. The idea was to induce a thinking process in the minds of participants of evaluating pros and cons of activities since their investments were also involved. If an activity was totally financed from the public funds they would normally demand anything without keeping in mind ultimate utility. Contributions in the form of labour or material (in kind) were generally monetized in the records. Sharing of cost inculcated sense of belongingness and sustainability of the development process. These contributions constituted a corpus fund for the future use of the WA. Since it was not a tax to the government rather a welfare fund, the contribution percentages were generally much higher than the stipulated minimum and varied a lot among various interventions (Table 2). This community revenue was invested in the building of schools, dispensaries for livestock/human being, culverts, community halls, brick lining of village lanes and drainage channels for disposing domestic effluents, etc. This also promoted utilization of locally available skills of artisans and material (sand, stones, labour, etc.) as community contributions. The villagers also showed great interest in ensuring quality of materials, construction and services.

Exit Protocol

The active intervention period of most of the projects in India is about five years after which the service provider is expected to withdraw and move to other watersheds/areas. Maintenance of the created infrastructure was a serious handicap prior to the concept of people's participation. All contributions mentioned previously were kept into a separate account called Watershed Development Fund (WDF). The watershed inhabitants were explained and convinced that their contributions was not a tax to the Government but was meant for creating a corpus. This account was also in the name of watershed associations and was to be operated upon generally after the exit of the service provider. Wherever participants could be convinced about the philosophy of cost sharing, overall contribution per watershed went up beyond the 5-10 percent of the stipulations since it was meant for welfare of the community and maintenance of the infrastructure being created under the watershed program.

Table 2. Activitywise contributions made by villagers for creating corpus for watershed maintenance in different cases

S. No.	Interventions	Contributions (%)
1.	*Anganpur Bhagwasi, Patiala, Punjab*	
	Poplar plantation	58%
	Horticulture plantation	51%
	Land levelling	30%
2.	*Pushkar Gap (ICEF), Rajasthan*	
	Irrigated land	19%
	Pastures	15%
	Livestock	14%
	Drainage line treatment	5%
3.	*Dehradun, Uttaranchal*	
	Irrigated tank	35%
4.	*IFFDC, Madhya Pradesh*	
	Composite rate	12%

ICEF = India Canada Environment Fund.

Capacity Building

Knowledge and skills of the local communities and service provider (PIA) was very important for internalizing potentials of the new technologies and indigenous technical experience. A sizeable (12.5%) of the budget was earmarked for training, exposure visits and skills enhancing activities. This input also brought out a better understanding among stakeholders, improved inter-personal relationships and raised value of the social capital. Micro-enterprising like mushroom cultivation, bee keeping, sericulture, livestock rearing, contract services, nursery raising, tailoring, carpentry, etc. targeted landless, small and marginal farmers, and empowered disadvantaged sections of the rural communities.

Equity

Landless, physically handicapped, assetless, women and other socially or economically disadvantaged persons were specifically targeted so as to minimize inequalities and social conflicts. About Rs.100,000 were earmarked as a revolving fund for each watershed to meet immediate credit requirements of SHGs. Each SHG was given an amount of Rs.10,000 which they could use for providing loans at mutually agreed rate of interest to their members. Repayment and the interest earned were recycled for giving loans to the remaining unserviced members. They also set up micro-enterprises to provide supporting services for agriculture, livestock, poultry or piggery rearing or even for setting up grocery shops, tailoring and any other activities. The following equity incorporated into budgetary allocation of the Ministry of Agriculture was quite interesting (Table 3).

Table 3. Budgetary sub-heads of NWDPRA scheme for ensuring equity of delivery

S.No.	Components	Allocation of fund (%)
1.	Management component	
	• Administration cost	10.0
	• Community organization	7.5
	• Training program	5.0
	Sub-total (A)	22.5
2.	Development component	
	• Natural resource management	50.0
	• Farm production system for land owning families	20.0
	• Livelihood support system for land-less families	7.5
	Sub-total (B)	77.5
	Grand Total	100.0

In a model project more than 27000 ha of wasteland leased for 30 years was managed by 28,000 members organized into 45 societies and 778 SHGs on watershed basis (Samra and Kareemulla, 2004). The benefits were equitably shared by women (Table 4) and far more by socially disadvantaged (Table 5) as well as economically backwards (Table 6).

Table 4. Genderwise membership of cooperative societies (as on 31 March 2003)

Gender	Number	Percentage
Male	1774	55.5
Female	1412	44.5
Sample size	3186	100

Table 5. Social structure of members of the societies (as on 31 March 2003)

Caste category	Number	Percentage
General	384	12.06
Other backward classes	1192	37.41
Scheduled castes/tribes	1610	50.53
Sample size	3186	100

Table 6. Economic status-wise distribution of membership of the societies

Holding size	Number	Percentage
Landless	2443	76.7
Marginal (<1 ha)	313	9.8
Small (1-2 ha)	427	13.5
Medium/large (>2 ha)	3	Negligible
Sample size	3186	100

User Group

Like-minded persons doing similar activity at a small scale or small land holders could pool together to scale up their production unit for realizing economies of higher scale. They could purchase machinery jointly which an individual member could have not afforded or pooled their output for selling in distant markets with minimized transaction cost to realize better returns. They generally rallied around a water harvesting structure for irrigation, installing of a tube well, sprayers for plant protection, raising of nursery, pooling of milk and vegetables for selling to remunerative markets, etc. Small land holders of Fakot watershed in mid-Himalayas (Uttaranchal) got interested in the cultivation of gladiolus flowers to be marketed 300 km away at Delhi. It was calculated that a consignment of 120 dozen (1440 units) at a time was only economical because of high transportation and other transaction cost. A single farmer did not have that much land to operate at this scale. Eleven small holders pooled their land holdings for joint cultivation of gladiolus and distributed profit in the proportion of land and labour contributed. The group was very successful and planned the construction of a glass house to scale up their enterprises. Meeting credit requirements of its members was also an attractive function of some other UGs (Table 7).

Table 7. Revolving funds in different villages of Seetla Rao micro-watershed management project of Doon Valley undertaken jointly by European Union and U.P. Government

Criteria	Villages			
	Nahar	Dhalani	Koti	Kotra
Number of households	45	82	32	120
Date of forming GAREMA*	April 95	April 94	Oct. 93	June 96
Date of first loan	Sept. 96	Dec-Jan 98	Jan. 97	Nov. 97
Number of loans granted (1999)	31	8	20	18
Upper limit of loan (Rs.)	2,000	3,000	5,000	2,000
Interest rate per month	2%	2%	2%	2%
Average loan size (Rs.)	1,742	3,000	1,375	941
Guarantors: Number of persons	2	2	2	2
Defaulters: Number	0	-	1	0
(1998) Value of revolving fund (Rs.)	58,000	78,000	72,000	56,000
Amount held in bank fixed deposit (Rs.)	0	30,000	20,000	0
Total value of loans to date (Rs.)	54,000	24,000	32,000	16,000

*Gaon (village) Resources Management Association.

Budgetary Regulations

Salary component in almost all projects was restricted to 10 percent and another 12.5 percent was earmarked for capacity building (Table 3). For ensuring equity, Ministry of Agriculture provided 7.5 percent of the budget specifically for landless communities for income generating activities. Another 20.5 percent budget was provided for micro enterprising especially for small and marginal land holders to supplement their livelihood and employment opportunities. Remaining 50 percent of the investments were earmarked for resource conserving mostly land and bio-diversity based activities. It was quite contrasting to many previous schemes, which sometimes consumed 60-70 percent of funds as salary.

Conflicts

Any alternative development process involving communities of different interests, social, economic and political groups is expected to manage inherent contradictions by adequately designed resolution mechanisms. Some important conflict levels contemplated and experienced are described below.

Federal Level Conflicts : Major players in the watershed development process at the federal level are Ministry of Agriculture, Ministry of Rural Development and other small initiatives including donors and NGOs. The Ministry of Rural Development enforced relatively better participation by issuing very comprehensive and well-meaning guidelines in 1994. However, Ministry of Agriculture took another eight years to internalize fully a typical participatory process by accepting common guidelines. Earlier approach of Ministry of Agriculture was mostly designed for the landowners with a larger emphasis on production for meeting requirements of food for large population. Ministry of Rural Development on the other hand concentrated more on poverty reduction; employment generation and goals of the two ministries were quite contrasting and conflicting in the implementation process. Both the ministries still claim that the entire watershed activity should be allocated to them. After a lot of discussions they at least agreed to adopt common guidelines in 2002, which have again been modified by the Ministry of Rural Development in January 2003 by assigning greater role to the democratically elected village institutions of Panchayats. The watershed approach calls upon treatment from ridge to valley by the PIA and whenever there is a forest in a part of the watershed the foresters do not allow other agencies to operate in the forest area and insist to implement that part themselves.

Federal Versus State Level Conflicts: In some of the states development funds provided by federal system were diverted towards non-productive expenditures like payment of the salaries, etc. As mentioned earlier Chief Secretaries of the states were bypassed and federal funds were remitted directly to the district level by Rural Development Ministry for ensuring prompt delivery of the finances for quicker implementation of development process. Initially some of the Chief Secretaries of the states did not feel comfortable with the decentralization and even disowned the program while others tried to subvert the process by various means. However, this conflict could be resolved by engaging them in a constant dialogue and sensitization process.

District Level Conflicts: There are following two competing centres of power at the district level which is a basic administrative and development unit:

i) District Collector / Commissioner / Magistrate representing bureaucracy with a well-established hierarchy, command and control system of an organized service.

ii) *Zila Parishad*: They are elected representatives and represent the powerful political stream of grassroot level contacts.

Both these centres of power are struggling to exercise the control over the development funds received from the state or federal structure. In some of the states elected representative (*Zila Parishad)* have upper hand while in others the organized services operates all levers of public administration. In some other states the relative upper hand of these two powers keeps on changing depending upon which of the political party is ruling. The organized services exercised most of the administrative and financial powers in the past and are feeling threatened with the dilution of their authority, command and control structure. *Zila Parishad,* on the other hand, view that they are public representatives, have come up through the process of election and know ground realities more intimately and can provide better solutions. It is, therefore, necessary to internalize relative strengths of the two centres of power so as to complement overall development process by minimizing conflicts.

Watershed / Village Level Conflicts: Panchayati Raj (elected) institutions, of late, complained that watershed associations are not statutory institutions for taking up the development activities. Elected institutions also argued that the 73rd and 74th amendments of the Constitution has allocated watershed management business to the Panchayats and they should have upper hand in the implementation process. The Ministry of Rural Development, which administered the Panchayati Raj institution had already obliged elected institutions declaring them PIA to handle development funds. The watershed boundaries being a natural geo-hydrological unit may not coincide with the administrative boundaries and many a times a watershed may fall into two Panchayats which inhibit treatment from ridge to valley as envisaged scientifically. Impact of this change will be realized, may be after a few years, and will certainly be argued in future deliberations.

GOs and NGOs Conflicts: In the past NGOs were mostly active in the area of health, education, social services, etc. and their role in natural resource management became significant after 1995. On the other hand well-established government departments have been implementing projects in the past and they did not like competition from the alternative institutions of NGOs. As a result of that there was a lot of dogmatism and unhealthy competition between the GOs and NGOs, which was expressed in many ways. As on today NGOs are relatively better equipped or experienced to handle socio-economic and capacity building issues and are not very strong in technical matters. GOs on the other hand have technically highly experienced or trained manpower and are more competitive to implement bio-physical aspects of the development process. A conflict resolution mechanism should aim at harmonizing relative strengths of the GOs and NGOs so as to internalize their complementarities to convert conflicts into opportunities.

Upstream / Downstream Conflicts: Any activity in the upper reaches of a watershed generally causes cascading effects (both positive and negative) downstream. A small dam or embankment may curtail surface water supplies in lower reaches but may recharge soil profile and enhance interflows beneficial to downstream participants. A structure built on upper slopes may check movement or flow of debris to lower reaches and save their crops and infrastructure. Recognizing the need to involve the local community in the protection of Ranthombhore National Park of Rajasthan, the World Wildlife Fund (WWF) – India embarked on an eco-developmental project for the villages on the eastern periphery of the park (Mamgain, 1999). Village Forest Protection Committees (VFPCs) were set up to involve village communities in the protection and management of nearly degraded forests supporting wildlife and tourism. Six VFPCs in the cluster of villages protected 320 ha of degraded forests and grazing lands. Conservation activities in the forest area increased water availability in the wells dug upon the nearby private lands and farmers made contributions of about 15-20 percent because of their interest in the groundwater (Table 8). Many conflicts have been highlighted excessively without analyzing upstream and downstream complementarities. If still some conflicts appear they can be resolved by mutually agreed sharing system of water or compensatory payments.

Table 8. Contributions in the form of labour (15-20% of total cost) in Ranthambhore National Park of Rajasthan (Mamgain, 1999)

Name of village forest committee	Name of bank	Contribution (Rs.)
Gram Van Suraksha Evam Prabandh Smiti, Fariya*	SBBJ, Khandar	51,990
Gram Mahila Van Suraksha Evam Prabandh Smiti, Fariya**	SBBJ, Khandar	50,505
Gram Van Suraksha Evam Prabandha Smiti, Gopalpura A*	BOB, B.Khurd	38,715
Gram Van Suraksha Evam Prabandha Smiti, Gopalpura B*	BOB, B.Khurd	34,940
Gram Van Suraksha Evam Prabandha Smiti, Pawandi*	AKGB, Khandar	54,020
Gram Vikas Evam Charagah Vikas Smiti, Khandeola***	AKGB, Khandar	59,784

*Village forest protection and management committee, ** Village women forest protection and management commeettee, *** Village development and grazing land development committee.

Lessons Learnt

It is evident from the above that a lot of churning process in several fold dimensions is going on with the aim of enlisting people's participation for sustainable development. Competition created by alternative institutions of NGOs, challenged quality of the services provided by the GOs and compelled improvement in the public delivery system. Many states observed that empowerment of the women, other socially and economically weaker sections of the society, small and marginal farmers realized social harmony. Mushrooming of NGOs after 1995 all of a sudden represented a vast shade of questionable organizations into the management of natural resources. Retired or retiring bureaucrats and politicians were behind many of the new NGOs, some of them developed into matured organization whereas others had dubious mottos of grabbing public investments for different purposes. In order to regulate NGOs, Ministry of Rural Development introduced the concept of recognition and de-recognition of NGOs depending upon quality of their services in the participatory development of natural resources. They also tried categorization of NGOs into different categories. Recently, registered NGOs (A category) were supposed to work on limited scale with a better experienced NGO (B category) and then graduate for larger programs (C category). Some court cases with the NGOs also appeared and recoiled on the mushroom growth of the NGOs. GOs were also ultimately sensitized to share and scale down their authority. They operated joint accounts with the representatives of village level communities as a demonstration of transparency in the transaction of day-to-day business of rural development. Of late, Panchayati Raj institutions have become aware and vocal to take on the business of development allocated to them through the constitutional amendments. In some of the cases PIAs have been very effective in the matters of equity, transparency and creation of livelihood and employment opportunities. On the other hand the output of some other PRIs is not very satisfactory. In this way PRIs are developing into matured institutions with contrasting rate depending upon the state and regions. Any way there is a difference in the implementation of development process and following a right track is upper most in the minds of civil societies.

Future Strategies

Policy, institutions, empowerment and equity-based reforms are still in the dynamic formative stage and demand a constant vigil, conflict resolution and improvements. Diversification in livelihood, income and employment generation opportunities is called upon to address emerging demands of market driven competition for delivering social justice. Planning Commission of India has identified 150 (out of 487) hot spot districts by scoring with six criteria for immediate investments to guarantee at least 100 days employment per family per year. Poor families may be engaged in wasteland development under Food for Work Program (Rs.200 crore or US$ 4.4 billions) by dovetailing with participatory watershed development process. The concept of watershed plus or value addition by linking with input agencies, industry and food processing units will be prioritized. High success rate was realized where water for limited irrigation could be harvested. Similar success with *in-situ* moisture conservation has been on a limited scale. Medicinal plants, dryland horticulture, agroforestry system and livestock rearing provide many unexplored opportunities to remove poverty. Long-term leasing and contracting of wastelands by creating cooperative institutions of economically and socially disadvantaged communities and developing on watershed basis has tremendous potential of poverty and inequity reduction. Creation of livestock assets and micro-enterprising for landless, small and marginal farmers require better targeting. Groundwater recharging services of watershed management play significant role in maintaining water supplies during lean period of scarcity. These benefits are accruing to all inhabitants of watershed as free or common access resources. Equitable sharing of these benefits are less understood for their greater focussing in the proposed strategies and may be improved upon.

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Participatory Watershed Development in India – A Sustainable Approach

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Abstract

Watershed conservation can be achieved through top-down approaches or by means of participatory approaches, where local communities actively participate in the conservation efforts. This paper explores which approach is more effective in achieving conservation in four semi-arid regions in India, and analyses what factors explain project success. We find that the bottom-up participatory approach favored by NGOs is more effective in inducing households to invest in soil and water conservation (SWC) than the government-led, top-down approach. Contextual factors like market integration and resource scarcity play a crucial role – watershed conservation in subsistence economies with high aridity is more difficult to achieve than in low aridity, market integrated zones. We also find that if no explicit attention is paid to long-term maintenance in the long run, participatory approaches do not ensure household commitment to SWC maintenance. This threatens the sustainability of participatory watershed development.

Introduction

Participatory watershed development (WSD) is one of the main strategies for rural development in India's semi-arid regions. Over the last decades the Government of India annually invested approximately $ 500 million (Government of India, 2000). In the beginning, investments were rather technical and implementation mostly top-down. The success of the bottom-up approach of non-governmental organizations (NGO) (Kerr *et al.*, 2000) caused the program to evolve towards participatory watershed development, decentralizing the planning, implementation and management of soil and water conservation (SWC) to local user groups at the village scale. The NGO approach of participatory watershed development has proven difficult to scale up. The long-term commitment of NGO's combined with their context specific approach has been hard to replicate and the number of professional NGO's is too small to implement watershed development at a much larger scale. Also, household management of land and water resources in the watershed has in many cases turned out to be unsustainable. Households are hardly taking responsibility for the operation and maintenance of conservation structures and the allocation of stored water resources is not done in a sustainable way (Batchelor *et al.*, 2003; ODI *et al.*, 2002).

Although a lot of research has been done to analyze the impacts of participatory vs non-participatory WSD approaches on the productivity of resource use and distribution of benefits (Kerr *et al.*, 2000; Springgate-Baginski *et al.*, 2001; Batchelor *et al.*, 2003), the importance of contextual variables in explaining project results and long-term impact of project interventions on soil and water conservation has been insufficiently addressed. An important reason is the 'case study approach' most studies have taken, which does not allow for a systematic comparison of the relative importance of factors explaining project success (Agarwal, 2001). The objective of this paper is to analyze the expected short and long-term impacts of watershed development projects on soil and water conservation with specific attention for the importance of external factors in explaining project results. The methodology used is a cross-sectional analysis of data from 800 randomly selected households from 22 villages in 4 meso-scale watersheds. To distinguish between short-term and long-term impacts, we studied the effect of interventions on –stated–actual household investments in both SWC in the past, and on the intention of households to contribute to the operation and maintenance of these structures in the future.

Conceptual Framework

With relatively poor resource endowments and low and erratic rainfall, the uncertainty of agricultural production in India's semi-arid regions is high. Soil fertility and water scarcity are major constraints for agricultural production and the average productivity of dryland agriculture is low. With the intensification of agriculture, groundwater depletion and soil erosion have become serious threats. Technological development and investments in rural infrastructure (electricity, roads) did improve living standards through access to markets, inputs and groundwater irrigation (Fan *et al.*, 1999), but with less than half of the households having access to irrigation, water scarcity and rainfall insecurity remain crucial constraints for most (Ryan and Spencer, 2001).

Extensive research has shown that soil and water conservation and groundwater recharge can increase the productivity of dryland agriculture and improve the sustainability of resource use (Wani *et al.*, 2002, 2003), but farm households have proven reluctant to invest (Barbier, 1990; Heerink *et al.*, 1999; Pender and Kerr, 1998). There are several reasons why this is the case. First, the benefit-cost ratio of SWC is rather low, especially when compared to investments in (groundwater) irrigation and agricultural intensification. Low farm gate prices, uncertain revenues and increasing opportunity costs of labour due to improved off-farm employment opportunities reduce the incentives for resource conservation (Scherr, 2000). Hence, investments in dryland agriculture are not preferred in the highly uncertain and capital-constrained societies that characterize India's semi-arid zones (Walker and Ryan, 1990). Second, investments in SWC and WSD have important public good externalities, that reduce the incentive for individual households to invest (Baland and Platteau, 1997). With part of the benefits of SWC being shared, the decision of households to contribute to SWC does not only depend on the private costs and benefits of SWC but on the behavioural strategy of the household and the existing institutional arrangements as well (Finus, 2001).

For decades, governmental and non-governmental organizations have attempted to induce households to invest in soil and water conservation. The low benefit-cost ratio was addressed by offering soil and water conservation investments at highly subsidized rates. Households still had to contribute by giving up part of their land for investment and in some cases by supplying free labour up to 25 percent of the costs, but the main part of investments were born by the external agent. The public externalities of soil and water conservation and groundwater recharge were addressed by planning and implementing soil and water conservation at the scale of the micro-watershed. By taking the watershed as basic unit for planning and implementation, the externalities of soil and water conservation were internalized in village decision-making, thus allowing for an optimization of conservation results (Knox *et al.,* 2001; Wani *et al.,* 2003; Swallow *et al.,* 2001).

A common assumption is that participatory approaches to WSD have been more successful than technical approaches because they better succeed in addressing the disincentives for household investments in SWC. Participatory approaches not only subsidize the costs of investment, but also pay attention to wider constraints for farm household production. This may involve investments in micro-credit and agricultural extension (Farrington *et al.,* 1999). Not only does this directly improve household welfare through better access to production factors, it also influences the benefit-cost ratio of SWC. In addition, a larger part of the funds received for soil and water conservation tends to reach farm households when project implementation is participatory. Government officials tending to display rent-seeking behaviour, if villagers are directly involved in planning and implementation rent seeking behaviour can be better controlled (Bardhan and Udry, 1999). Second, participatory approaches include local awareness raising, institution building and empowerment. Thus, coordination mechanisms are created that are indispensable for a successful implementation of WSD, as they facilitate cooperation and collective decision-making needed for long-term operation and maintenance of SWC (Farrington *et al.,* 1999).

However, external interventions cannot change the socio-economic and agro-ecological context in which dryland farming takes place. From the literature on farm household decision making and local resource management, it is well-known that contextual factors have a great impact on resource conservation (Bardhan and Udry, 1999; Copeland and Taylor, 2003). Is the literature on the factors influencing farm household investments in soil and water conservation rather straight forward (Heerink *et al.,* 1999; Barbier, 1990; Pender and Kerr, 1998) and the effect of market integration and resource scarcity on farm household cooperation are less clear. For example, Wade (1988) argues that increased resource scarcity induces households to cooperate, whereas Kadekodi and Chopra (1999) argue that the relationship between resource scarcity and cooperation is non-linear. Users will not cooperate to invest in heavily degraded resources as expected benefits are low, but may decide to cooperate if the resource base is rehabilitated and the expected benefits of cooperation increase. The effects of increased market integration on local resource management are also ambiguous. The increased value of resource use affects the conditions for local management positively, but the increase in 'exit options' and volatility of income negatively affect resource management (Kurian *et al.,* 2002; Copeland and Taylor, 2003).

Based on the literature, we expect the following two hypotheses to hold. First, participatory (bottom-up) approaches are more successful than technical (top-down) approaches because they structurally address the incentives for household investment in SWC. Second, participatory approaches are more sustainable because through institution building and awareness raising they create household commitment to contribute to operation and maintenance in the long run.

Methodology and Data Collection

To explore these issues, we specify two empirical models for a cross-sectional analysis of data collected from 800 randomly selected households in 4 meso-scale watersheds[1]. In the first model, the regressand is a binominal variable that reflects whether the household has invested in soil and water conservation or not. In the second model, the regressand is a binominal variable that tells whether the household has the intention to contribute to soil and water conservation in the future through operation and maintenance of private or collective structures, the use of less water or other means. Since in both cases the regressand is a discrete variable, a probit analysis[2] was used to determine the factors of influence on the probability of household investing in respectively intending to contribute to the operation and maintenance of SWC at the village scale.

In the first model, our main interest is whether participatory, non-technical approaches influence the probability of household SWC investment in a positive and structural way and what the importance is of external factors. With this aim, we tested the following model:

$$(1) \quad SW_i = \text{constant} + C_i\beta_1 + I_i\beta_2 + X_i\beta_3 + \varepsilon_i$$

where SW_i is a discrete measure of household investment in soil and water conservation, C_i is a vector of contextual variables, I_i is a vector of variables measuring the type of intervention and X_i is a vector of control variables including income per capita, land holding, access to irrigation, family size, land quality, education, village size, and Gini indicators for income and irrigation.

With regard to C_i, the set of contextual variables is derived from the location of the watershed in the region and the agro-hydrological zone. When the socio-economic conditions of the remote watersheds are characterized as subsistence economy, the integrated watersheds are typified as cash economies. Similarly, aridity in the watersheds with very low rainfall is notably higher than aridity in the watersheds with higher rainfall. The characteristics of the four watersheds are shown in Table 1.

I_i, or the vector of intervention variables is defined by the interventions performed by WSD implementing agents at the village scale. In Karnataka investments were taken up by a non-governmental organisation, in Maharastra

[1]The sites form part of the study sites of the LEAD project "Livestock-Environment Interactions in Watersheds', a study undertaken by IWMI-India and partners and financed by the Swiss Development Cooperation (SDC) and the FAO.

[2]Although without specific knowledge about the distribution of data no general criteria exist to determine whether probit is the most suitable method to use (Greene, 2003), the fact that the outcomes of Logit and Probit were quite similar indicates that the distribution is normal and Probit is most suitable.

Table 1. Characteristics of the study sites

Area	Very low rainfall (<500 mm)	Low rainfall (>500 mm)
Remote area	Kanakanala watershed, Koppal (Karnataka)	Kalyanpur watershed, Udaipur (Rajasthan)
Integrated area	Vaiju Babulgaon watershed, Ahmadnagar (Maharastra)	Kosgi watershed, Mahbubnagar (A. Pradesh)

and Rajasthan investments in some villages were taken up by the government and in others by non-governmental organisations, whereas in Andhra Pradesh watershed development was undertaken by a government agency alone[3]. In all four sites, at least one of the study villages had not been treated at all. The intensity of treatment in the four watersheds and whether WSD was implemented by a GO, NGO or a combination of both is shown in Table 2.

Table 2. Investments in soil and water conservation per watershed

Watershed	Implementing agent	Watershed area (ha)	Area treated (%)	Costs per ha treated area (Rs/ha)
Kosgi	DPAP* (government)	3,460 ha	58%	3553
Kanakanala	SAMUHA (NGO)	13,064 ha	48%	2582
Kalyanpur	DPAP (government) & Seva Mandir (NGO)	7,488 ha	27%	5,488
V.Babulgoan	DPAP (government) & WOTR (NGO)	4,876 ha	24%	6,826

*DPAP : Draught Prone Areas Programme.

Although since 1999 the government guidelines for watershed rehabilitation have promoted participatory approaches, the government investments made in the study watersheds date back before that time. Before 1999, government implementation of watershed development can be characterized as technical, non-participatory and top-down. NGO investments on the contrary spent a considerable amount of time on the non-technical aspects of watershed development like local institution building, and empowerment and implementing soil and water conservation measures in a participatory way. Hence, to assess whether participatory, non-technical approaches structurally influence the incentives to invest in soil and water conservation, we can simply compare the NGO with the GO approach. To control the intensity of WSD treatment, we have included a dummy at the watershed level. This dummy reflects the intensity of NGO treatment (the intensity and costs of GO treatment being roughly the same in all sites): can the participatory NGO approach in Kanakanala watershed be characterized as a first generation and low cost participatory approach, in Kalyanpur and Vaiju Babulgoan more intensive attention was paid to the formation of user groups and creation of maintenance funds at the village scale. More information about the study sites can be found in Annex 2.

Summary statistics for X_i, or the vector of control variables is shown in Table 3. Average land holding in Kosgi is rather low because of the high population

[3]Villages in the process of treatment were included under the 'not treated' category.

density (0.92 households per ha as compared to 0.37 in Kalyanpur and V.Babulgoan and only 0.20 for Kanakanala), but average land holding is even lower in Kalyanpur, because 50 percent of the watershed has a slope of more than 50 percent (as compared to 0% in Kosgi, 17% in Kanakanala and 40% in V.Babulgoan).

Because of the poor quality of slope data at the plot level, the importance of slope in determining household investment in SWC could unfortunately not be accounted for. The distribution of land is relatively unequal in all four watersheds: only in Kanakanala is the Gini coefficient for average land holding below 0.5.

Table 3. Summary statistics

Statistics	Kosgi	Kanakanala	Kalyanpur	V. Babulgoan
No. of observations	203	200	200	200
Average income per capita (Rs)	2,824 (3,752)	2,531 (1,825)	1,808 (1,681)	10,668 (8,172)
Gini coefficient for income	0.44	0.36	0.46	0.37
Average education of household (HH) (years)	3.12 (2.38)	1.61 (1.71)	2.69 (2.29)	5.14 (2.41)
Average land holding (acres)	3.10 (5.12)	8.89 (7.75)	2.64 (4.31)	5.40 (7.84)
Average irrigated area (acres)	1.25 (3.23)	0.92 (2.75)	0.78 (1.29)	0.38 (1.01)
Gini coefficient irrigation	0.54	0.35	0.52	0.42
HH with access to irrigation (%)	58	17	75	95
HH with black soil in plot 1 (%)	33	17	21	31
Average village size (# HH)	424 (146)	174 (58)	249 (116)	209 (56)

Source: LEAD household survey 2004 (figures between parentheses are standard deviations).

In general, the level of economic development in V.Babulgoan is notably higher than in the other watersheds. This is partly explained by the historical background of Maharastra, which is one of India's more developed states. Also, the population in Babulgoan consists of 82 percent of high caste farmers, whereas for example in Kalyanpur 94 percent of the population are tribals with no agricultural background at all. Kosgi and Kanakanala have a more heterogeneous population, with 70 percent backward caste households constituting the largest group. Access to irrigation is defined as a dummy representing whether a household has access to surface water (village tank), deep groundwater (tubewell) or shallow groundwater (open well) irrigation through the ownership of pumps, wells or land located near irrigation canal. Whereas surface water and open well irrigation are relatively drought sensitive, tubewell irrigation is not. This explains the low average irrigated area in Babulgoan and, to a lesser extent, Kalyanpur where respectively open wells and tank irrigation are the main sources of irrigation. Kosgi, on the other hand, mainly depends on tubewell irrigation, which even in the drought year 2002 was not affected much. Most households own different plots of land with different soil type, slope and access to irrigation. For analysis, we have used only the soil type and slope information with regard to plot 1, or the plot where investments in SWC were made.

The second model basically uses the same set of control variables except that for the variables estimated in the first model. Predicted values are used to correct for potential endogeneity problems.

$$(2)\quad \text{PlanOM} = \text{constant} + F_i\beta_1 + I_i\beta_2 + PI_i\beta_3 + X_i\beta_4 + \varepsilon_i$$

I_i again is a vector of WSD interventions. PI_i is a vector of predicted values. With this vector, we measure the indirect effect of WSD interventions on the intention of households to contribute to soil and water conservation on the longer term. In other words, we expect WSD intervention to influence household intention to contribute in two ways. First, we expect WSD interventions to directly influence the households' intention to contribute to soil and water conservation through increased awareness and willingness to cooperate. Second, we expect an indirect effect because the number of active households with investments in soil and water conservation will have increased. We derived predicted values for three variables: individual household investment in SWC, average village investments in SWC (% of other households participating) and active household participation in WSD. The first variable follows from model 1, and the other variables were estimated separately as they failed to be significant in model 1.

Data were collected from October 2003 till March 2004. Data collection took place in three stages. First, village meetings were organized to collect baseline information. Based on this information and the location of villages in the watershed, 4-6 villages were selected. In these villages, a second round of more extensive village meetings were organized. The information from these meetings was used for a quantitative ranking of village performance indicators. Third, in the selected villages 200 households were randomly selected for an extensive household survey. Per village, 20 percent of the households were interviewed for the survey, each questionnaire taking 1-2 hours. Data collection and entry was undertaken by the non-governmental organizations that had been involved with WSD implementation from the start. For data collection, 4-8 surveyers per watershed were trained and sent to question the households in pairs. Afterwards, questionnaires were cross-checked for mistakes and omissions.

Results

The results of the first model[5] are presented in Table 4.

First, the impact of NGO interventions on household investment in SWC is positive and significant. The probability of households investing in SWC increases by 24 percent in watersheds subjected to participatory intervention. Government intervention, in contrast, does not seem to have a significant effect. This is in

[4]Although data were collected in 2003-2004, questions regarding agricultural production and land use refer back to the previous year, or 2002. This year was a drought year in all 4 sites. 2003 was a drought year in V.Babulgoan and Kanakanala, Kosgi and Kalyanpur received respectively average and good rains

[5]The same model was estimated with watershed fixed effects. The outcome of this model was exactly the same as the results presented, the vector of contextual variables fully capturing the watershed fixed effects.

Table 4. Impact of WSD interventions on household investment in soil water conservation

Parameter	Coefficients (SD)	Marginal effects
Cash economy (dummy)	0.575 (0.164)***	0.22***
Very low rainfall region (dummy)	-0.256 (0.153)*	-0.10*
High intensity WSD treatment (dummy)	0.204 (0.142)	0.08
NGO investment WSD (dummy)	0.605 (0.19)***	0.24***
GO investment WSD (dummy)	0.133 (0.176)	0.05
Middle location in watershed (dummy)	0.243 (0.181)	0.09
Upstream location in watershed (dummy)	0.375 (0.173)**	0.15**
HH access to irrigation (dummy)	0.219 (0.14)	0.08
Land holding size (acres)	0.038 (0.01)***	0.015***
Income per capita (Rs '000)	0.013 (0.012)	0.005
Gini coeff. income per capita	-2.29 (1.08)**	-0.89**
Gini coeff. irrigation	-1.08 (0.485)**	-0.42 **
Black soil (dummy)	0.274 (0.119)**	0.11 **
Village size (# households)	-0.001 (0.0006)**	-0.0005**
Constant	0.122 (0.357)	
# Observations	693	
Log likelihood	-409.81	
LR Chi^2 (df)	123.23 (14)	
Pseudo R^2	0.13	

*10% significant; ** 5% significant; and *** 1% significant.

accordance with earlier findings that indicated the participatory NGO approach to be more effective (Kerr *et al.,* 2000).

Second, as expected, contextual variables turnout to be important determinants for household investment in SWC. Living in cash economies increases the probability of SWC investment by 22 percent (relative to subsistence economies), and very low rainfall decreases this probability by 10 percent. This is consistent with standard economic intuition that farm households are more likely to invest when the benefit-cost ratio is higher. While the payoff is positively affected by higher returns from cash crop production, under conditions of high aridity potential water savings from SWC are relatively low. Nevertheless, these findings are interesting as they contradict popular wisdom that market development might erode the incentives for SWC, and also the suggestion that high resource scarcity increases incentives for SWC (e.g. Shah, 2004). While these effects might materialize elsewhere, we find no evidence for them in our four watersheds.

Third, and perhaps unsurprisingly, households located in upstream villages tend to invest more in SWC than villages located downstream. This result follows naturally from the geography of most watersheds, where land with a slope and no access to irrigation (e.g. where the relative benefit-cost ratio is more favourable) are mostly allocated upstream. Private costs and benefits also explain the importance of land holding size and soil type with regard to land holding, SWC has important costs in terms of the loss of cultivatable land. While the costs for small landowners are relatively high, larger landowners can better afford to use part of their land for SWC.

Fourth, inequality and village size have a negative influence on the probability of investing in SWC. Income inequality has the largest effect, but inequality in irrigated land holding is important too. With regard to income, high inequality increases the likelihood that poor households go for off-farm employment for most of the year. In Kosgi, for example, where inequality is high, poor households migrate for wage labour, which reduces the incentive to invest time and resources in their marginal land. With regard to irrigation, this is significant because surface and groundwater recharge are important public good externalities of SWC, but benefits that can be reaped only by those with access to irrigation. High inequality lowers the incentive for majority of the households to contribute to these benefits, especially if the private benefits of investment are low. Access to irrigation and income per capita *per se* do not influence the probability of household SWC investment. Overall, the predictive value of the model is relatively low with a likelihood ratio statistic of only 0.13. Much of the variation in household SWC investments is left unexplained.

To test whether participatory approaches indeed have a structural effect on household investment in SWC, and how this effect compares with the impact of contextual factors, we performed a Chow to test the likelihood of all coefficients being the same.[6] Results are reported in Table 5.

Table 5. Chow test

Parameter	LR
Treated vs not treated	14.64
NGO vs rest	27.00 ***
Cash vs subsistence	39.07 ***
Low rainfall vs very low rainfall	31.17 ***

*** 1% significant.

In the first test we compare GO and NGO treated villages with villages where no treatment has taken place. Surprisingly, WSD treatment as such does not structurally influence the determinants for household SW investment. What does structurally influence the determinants of household investment in soil and water conservation are whether WSD investments have been made by an NGO and whether the household is located in a watershed with very low rainfall and/or integrated in the market, as the results of last three tests clearly show. This is a significant result, as it proves that the participatory NGO approach indeed has a more structural effect on household SWC investment than the subsidization of investment costs alone. Not surprisingly, contextual variables structurally influence the incentives for household investment in soil and water conservation as well. This is in accordance with earlier work, suggesting resource scarcity and market

[6]The Chow test is conducted by first estimating the model with the full set of observations and second estimating separate models for the subsets of observations between which a structural difference is expected. By comparing the sum of the log likelihood of the unrestricted models with the log likelihood of the restricted model the likelihood ratio of the two models can be derived (Greene, 2003).

integration to have a significant effect (Wade, 1988; Ostrom, 1990; Copeland and Taylor, 2003; Kurian, 2002; Kadekodi and Chopra, 1999).

In Table 6, the results are presented for model 2. Unlike the regressand in the first model, household contribution to future soil and water conservation refers to both private and collective investments, twenty five percent of the households having expressed the intention to maintain soil and water conservation investments on their land, 13 percent contribute to the maintenance of collective structures and 6 percent to reduced resource demand.

Table 6. Impact of WSD interventions on the households (HH) intention to contribute to O&M

Parameter	Coefficients (SD)	Marginal effects
Cash economy (dummy)	0.43 (0.301)	0.17
Very low rainfall region (dummy)	1.04 (0.228)***	0.39***
High intensity WSD treatment (dummy)	1.63 (0.201)***	0.58***
NGO investment WSD (dummy)	-0.753 (0.33)**	-0.29**
GO investment WSD (dummy)	-0.045 (0.22)	-0.02
Middle location in watershed (dummy)	-0.54 (0.225)**	-0.21**
Upstream location in watershed (dummy)	0.012 (0.20)	0.005
Household size (# HH members)	0.045 (0.027)*	0.02*
HH access to irrigation (dummy)	0.41 (0.178)**	0.16**
Gini coeff. irrigation	1.82 (0.973)*	0.72*
Predicted probability of HH investment in SW (%)	-0.257 (0.823)	-0.10
Predicted average SW investment in village (%)	1.20 (1.23)	0.475
Predicted probability of HH participation in WSD (%)	2.03 (0.69)***	0.80***
Black soil (dummy)	0.370 (0.167)**	0.14**
Constant	-2.65 (0.846)***	
# Observations	693	
Log likelihood	-253.69	
LR Chi^2 (df)	452.79 (14)	
Pseudo R^2	0.47	

*90% significant; ** 95% significant; and *** 99% significant.

Surprisingly, the direct effect of NGO involvement on the intention of households to contribute is negative and significant. NGO involvement reduces the probability of household contribution to operation and maintenance by 29 percent. However, there is also an indirect effect to consider. NGO intervention increases the number of households that are actively involved in SWC, and these households are more likely to contribute in the long run (the probability of household

[7] From the regression of WSD effect on the watershed fixed effects, NGO or GO intervention, village size and the perceived influence of households on village decision-making, the marginal effect of NGO intervention on the probability of households being active was 45%. To derive the total effect of NGO intervention, we first calculate the relative importance of the positive effect (0.45*0.8=0.36). When we add this to the negative direct effect of NGO intervention (-0.29) the total effect is 0.07. A separate regression including only NGO (and not the predicted value of active participation in WSD) gives the same result.

contribution increases by 80%). Adding the direct and indirect effect implies that the total effect of NGO involvement on the intention to contribute is insignificant and negligible.[7]

Might this result be rather surprising, if we consider the significant and positive effect of the dummy variable representing intensity of WSD treatment. We speculate the sustainability of participatory approaches to depend on the intensity of treatment and attention given to maintenance funds and user groups.

Contextual variables also play an interesting role. High aridity now has a positive impact on the intention of households to maintain SWC structures, but cash economy characteristics do not play a significant role. An explanation for this could be that whereas the costs of operation and maintenance are low, the interest of households in arid zones to maintain conservation investments are higher because the marginal benefits of water conservation are higher as well. Access to irrigation, black soils and household size also have a positive impact on the intention to contribute, which can be explained through the positive effect of these factors on the private costs and benefits of SWC.[8] For households with large families, the costs of maintenance are relatively lower, labour being less scarce than for households of a smaller size. Unequal access to irrigation is a positive determinant for long-term operation and maintenance. This is in accordance with Olson's theorem that the larger the share of individual households in the public good, the larger their incentive to privately provide it (Olson, cited in Baland and Platteau 2001). Finally, the non-significance of household investment in SWC on the intention to contribute to future O&M could be an indication that adverse incentives play a role. Because of high unemployment, households may contribute labour to SWC not out of appreciation of the associated conservation benefits, but to exploit employment opportunities in the short term (Joshi *et al.*, 2004; Farrington *et al.*, 1999). Whether this is indeed the case or whether other factors explain this behaviour is something that would require further research.

Conclusion

We have examined whether participatory approaches to watershed development are more successful and yield more sustainable results than technical 'top-down' approaches. We find some rather mixed evidence. While participatory approaches are associated with larger investments in SWC in the short term, we also find that NGO interventions have no net impact on the intention of households to contribute to operation and maintenance in the long run. 'Intensity of treatment' does seem to play an important role – more intensive (costly) interventions have a greater probability of being sustained in the long term. This would tally with the evolution of participatory approaches that have started to make special provisions for operation and maintenance by establishing user groups and operation and maintenance funds at the village scale.

We have considered the effect of various contextual variables, finding that

[8] For example, households with access to irrigation benefit from the maintenance of soil and water conservation structures through the positive effect on water availability. For households with black soil the soil moisture benefits are relatively good.

some of these are important for investment decisions in SWC. Some variables have clear-cut effects. For example, the degree of market development positively affects the incentive to invest in SWC, and has no impact on the incentive to maintain conservation structures. In other cases, the impacts are more subtle. For example, high aridity was shown to negatively affect investment in SWC because of the low benefit-cost ratio. But once investments are made, households do choose to maintain the conservation structures because of significant marginal effects. This may be interpreted as an argument in favour of public investments in SWC in arid regions – while the private costs of investment in these regions are too high, private maintenance may be forthcoming.

We found that inequality at the village level reduces investments in SWC, but promotes maintenance in the long run. This suggests that in order to ensure long term watershed development, the role of village level inequality should be recognized – involving all stakeholders and ensuring access to conservation benefits in the long run are crucial determinants for continued investment in SWC.

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Annex 1 Details of WSD Interventions in Project Sites

In Kosgi, watershed implementation by the Government was finished in 2001, investments focussing on ground and surface water recharge, horticulture development, bunding and percolation pits. Implementation was not participatory and few investments in institution building were made. Of the 4 villages selected for the study, 3 were treated.

In Kanakanala, the NGO SAMUHA is implementing watershed development. Of the villages selected for the study, watershed work is ongoing in two villages and treatment is finalized in three. In one village, no watershed work has taken place. Overall, investments focus on increasing soil moisture and biomass, erosion reduction, and improved access to supplemental irrigation. Implementation has been participatory and considerable investments in local institution and capacity building are made. For investments on private lands, households contribute 25 percent of the costs, for investments on common lands the community contributes 10 percent with voluntary labour.

In Kalyanpur, the NGO Seva Mandir has implemented watershed development in three of the selected villages, whereas in three villages the Government invested in watershed development. Investments focussed on soil moisture and biomass improvement, reduction of soil erosion and improved access to supplemental irrigation. In the Seva Mandir villages, substantial investments in institution and capacity building were made, but government implementation was non-participatory and top-down. In one village, no WSD treatment took place. For investments by Seva Mandir on private land, households contributed 15 percent of the costs, for investments on common land the community contributed 10 percent in labour. If investments were made by the government, contributions were 10 percent and 5 percent, respectively.

In Vaiju Babulgoan, the NGO WOTR invested in 2 out of 5 selected villages and in one other village government investments were made. Government investments were not participatory and badly implemented, but investments by WOTR were such that one of the two villages is considered a model site. Households contributed 16 percent to the costs for both investments on private and common land. In the remaining 2 villages no structural investments in watershed development were undertaken, although under drought relief some investments did take place.

Annex 2. Hydrological and Biophysical Characteristics of the Study Sites

Hydrological and biophysical data were collected for the entire watershed area with the help of remote sensing images, field visits, primary hydrological data collection (rainfall, run-off, temperature), maps and secondary data regarding land use, groundwater, rainfall, soil type and climate. Primary data were collected for 2003-2004, a year with above average rainfall in Kosgi, average rainfall in Kalyanpur, but below average rainfall in Kanakanala and V. Babulgoan.

Table A. Biophysical and demographic characteristics of the study watersheds

Parameter	Kosgi	Kanakanala	Kalyanpur	V.Babulgoan
State	Andhra Pradesh	Karnataka	Rajasthan	Maharastra
Total households	4242	2643	1711	1298
Total villages	9	21	11	7
Total area, ha	4590	13402	4664	3472
Watershed area, ha	3460	13064	7488	4876
Area treated, %	58	48	27	24
Average rainfall, mm	739	499	584	430
P/Pet (*)	0.5	0.31	0.39	0.32
Tank storage	4.8 (133)	1.3 (9)	3.2 (43)	0.8 (16)
% irrigation	30	1-5	10-20	10-15
5% slope/total	0	17%	49%	42%

Source: Agricultural Census (Government of India) 1999-2003; District level statistical data (2003).

Table A presents the biophysical and demographic characteristics of the study sites. The total area is the total geographical area of the villages located in the watershed. Since some of this land might be located outside the watershed, total area differs from total watershed area. In Maharastra and Kalyanpur, the difference between total area and watershed area is caused by the relatively large share of government owned forest land. Total arable land is again based on the geographical area of the watershed villages, arable land defined as cultivated and cultivatable land. In Kosgi watershed, conditions for agricultural production are most favourable whereas in Kanakanala,, conditions are relatively poor. Aridity (precipitation/ evapotranspiration) is highest in this watershed and level of water storage and biomass availability is relatively low. WSD interventions in study sites are given in Table B.

Table B. Characteristics of WSD interventions in the study sites

	Not treated	GO treated	NGO treated
No. of sample villages	7	7	8
No. of sample households	234	320	249
Location in watershed (% of sample HH)	Up 0 Middle 68% Down 32%	Up 37% Middle 63% Down 0	Up 54% Middle 0 Down 46%

Source: LEAD Household Survey 2004.

Improved Livelihoods in Improved Watersheds: Can Migration be Mitigated?

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Abstract

There is compelling evidence from all over India that the temporary migration of labourers (especially rural-urban) is on the increase. While many poor people perceive migration as an opportunity because they can tap remunerative labour markets, the mainstream view remains rather negative and many rural development programmes aim to reduce migration. An important objective of watershed development (WSD) programmes has been to reduce rural-urban migration. This paper synthesises the available evidence to show that the relationship between migration and WSD is complex and depends on a variety of factors ranging from rural-urban wage differences, personal aspirations and education levels. It argues that more empirical research is urgently needed in this area. The paper concludes that policy makers should be prepared to face increasing migration levels and embrace accumulative migration as a valid livelihood strategy that can be combined with WSD efforts to create win-win situations for the poor and overall economic development.

Introduction

Contrary to mainstream views on rural livelihoods, a growing number of "rural" people have lives that are inextricably linked with urban areas. A large number of village studies from different parts of the country conducted in the last five years show a marked increase in temporary migration for work. This includes seasonal migration, circular migration and other forms of short-term migration. While some of these studies are based on resurveys of villages (see for instance the work by Singh and Karan, 2001; Karan, 2003 in Bihar, Dayal and Karan 2003 in Jharkhand) others have used recall to arrive at this conclusion (Rao, 2001 in Ananthapur; APRLP, 2003 in Mahbubnagar; Khandelwal and Katiyar, 2003 in South Rajasthan; Rogaly *et al.,* 2001; Rafique and Rogaly, 2003 in West Bengal).

While it is certainly true that people migrate out because there is not enough work locally, interpretations of this phenomenon have varied. The policy and academic discourse has remained rather negative (see for example Breman, 1985 on migration in Gujarat; Reddy, 1990 on migration in Andhra Pradesh), viewing migration as forced and a symptom of rural distress. However, many poor people perceive migration as an opportunity that has opened up to them with improved roads, communication networks and the expanding informal economy, not least because it allows them to escape highly exploitative patron-client relationships[1] in the village. Many erstwhile disadvantaged communities earn far more through migration than they would ever be able to in their own villages (see especially Deshingkar and Start, 2003; Deshingkar 2004a, b; Deshingkar and Anderson, 2004; Deshingkar and Grimm, 2004; Karan, 2003; Rao, 2001).

An interesting dimension is the relationship between agriculture, natural resources and migration. A common assumption that underpins many rural development programmes including watershed development programmes is that deteriorating agriculture leads to outmigration and improving the natural resource base and generating employment in rural areas can reduce or reverse migration. This paper synthesises the available evidence on migration patterns in watershed development areas and how policy should address continuing migration. The paper begins with a brief overview of watershed development programmes, in terms of their objectives and coverage. It then provides an overview of watershed evaluation studies that have assessed the impact on migration patterns. Following on from this is a discussion of the factors, which cause migration. Finally, policy recommendations are presented.

Watershed Development in India

Currently $1000 million is invested yearly in watershed development programmes (WSD) that are implemented by a range of departments at the centre and state level. The Department of Agriculture and Cooperation (GOI) implements the National Watershed Development Projects for Rainfed Areas (NWDPRA). The Ministry of Rural Development (MoRD) implements the Integrated Wasteland Development Programme (IWDP), the Drought Prone Area Program (DPAP) and the Desert Development Program (DDP). The watershed approach has been adopted in other schemes for the development of catchment areas, flood prone areas and control of shifting cultivation in north-eastern regions. In addition to the centrally sponsored schemes several state governments are also implementing schemes for soil and moisture/water conservation on watershed lines. There are also a number of donor-funded and research oriented watershed development projects.

The goal of most watershed projects is to increase agricultural productivity through soil and water conservation and rainwater harvesting at the micro-watershed scale. There are effectively three routes through which the rehabilitation and development of water scarce watersheds is expected to contribute to rural development: increased agricultural productivity, improved natural resource conservation, and more equitable and sustainable management of common property resources.

Halting Migration has been an Important Objective of Watershed Development Programmes

In addition to the above objectives, watershed development aims to increase employment through labour-intensive soil and water conservation. Besides the

[1]Although many Marxist analysts such as Olsen and Ramana Murthy have argued that migrant employment contracts are equally exploitative, the bargaining power of labourers has increased significantly where the availability of work has increased *vis a vis* the labour pool.

short term effects of watershed development on rural employment, there is a widespread belief that if watershed management (WSD) programmes succeed then they will reduce the flow of migration. WSD implementation can affect migration through an increase in short-term employment as well as long-term productivity gains. The evidence indicates that many WSD programmes do succeed in reducing migration rates at least during the implementation phase. For example a study by the Central Research Institute of Dryland Agriculture (CRIDA) of 37 watersheds located across different agro-ecological zones and managed by a range of different project implementing agencies (PIAs) showed that migration rates had been reduced in nearly all of them and the reduction ranged from 22 percent in the MoRD implemented watersheds to 42 percent in NGO implemented ones (Sastry *et al.,* 2003). Additional employment generated ranged from 20 days /person/ year in government implemented watersheds to 25 days per person per year in NGO implemented ones. This was attributed to the improvement in physical and biological factors: groundwater tables improved by 1.05 metres in arid, 1.57 metres in semi-arid and 1.38 metres in humid areas. The improvement was better in non-government/donor supported projects compared to government-supported watersheds. Soil erosion and water run-off improved by 25 and 33 percent. Employment generation improved by about 12.5 percent in arid areas, 25 percent in semi-arid areas and 21 percent in humid areas. Another large evaluation of 2000 odd watersheds in AP by the State Water Conservation Mission between 1998 and 1999 showed that migration declined between 10 and 40 percent. Other examples are the study by Dilasa, an NGO, in six DPAP WSD programmes in western India launched in 1996, which found a reduction in migration rates (Hanumantha Rao 2000). Similarly, the WSD programme in Jhabua (Madhya Pradesh) has shown a reduction in migration.

Migration reduction impacts seem to be more marked in intensively treated, NGO managed watersheds during non-drought years as shown by preliminary results from the IWMI Livestock, Environment and Development (LEAD) project. Only in a handful of cases has a near complete halt or reversal of migration been achieved. Examples include the Indo-German Watershed Development Programme in Maharashtra and the Integrated Micro Watershed Development Programme of the N.M. Sadguru Water and Development Foundation in Gujarat where very high migration rates of 78-80 percent were reduced to a “trickle” of around 5 percent. The duration was also reported to have decreased down from roughly nine months to two months. While these successes may be testimony to the outstanding performance of the NGO, there may also be exceptional circumstances as in the case of Ralegaon Sidhi (Maharasthra) where heavy expenditure and the importing of water from other areas made it possible (Sastry *et al.,* 2003). Shah’s (2001) work in Gujarat also shows that a significant reduction in migration was achieved only in the case of households, which had benefited from a substantial increase in irrigation. She also notes that employment gains during the project implementation phase may not be sustained afterwards.

On the whole, the impacts of WSD on long-term migration appear to be disappointing; Shah and Memon’s (1999) (quoted in Hanumantha Rao, 2000) study of WS programmes being implemented in Gujarat since 1995-96 observed that although employment opportunities had increased, migration rates had not come down. Similarly, a recent review of several watershed programmes in Karnataka and Maharashtra conducted by the Centre for Interdisciplinary Studies in Environment and Development (CISED) and the Society for Promoting Participatory Ecosystem Management (SOPPECOM)[2], has concluded that the impact of WSD on livelihoods, and migration and employment patterns has not been as significant as the impact on soil conservation.

If viewed against the stated objective of controlling or reversing migration[3], this could be perceived as a widespread failure of WSD programmes. But given the state of flux in Indian agriculture and urban areas, it is not surprising that migration has continued or even increased. It is important to understand these trends in the overall development context where strong new 'pushes' and 'pulls' have emerged.

Migration Trends

In addition to village studies there are plenty of other examples, many of which continue to be regarded as 'anecdotal' and remain undocumented. Project staff and local government officials who are involved in rural livelihood programmes frequently mention the growing incidence of seasonal migration. For example staff of the DFID funded Western Orissa Livelihoods Project estimate that around 300,000 labourers migrate from Bolangir every year. Bolangir is one of the poorest and drought prone districts in the state. Similar numbers have been reported by staff on the Andhra Pradesh Rural Livelihoods Project from Mahbubnagar, a poor and dry district in Andhra Pradesh.

In sharp contrast to the narrative that is developing through micro-studies, macro level data sets and studies based on these tend to underemphasize the importance of migration and may even draw the conclusion that population mobility is decreasing. For instance, the 2001 National Census and 1999-2000 National Sample Survey data show a slow down in permanent or long-term rural-urban migration rates despite increasing inter-regional inequalities. Kundu (pers. comm.) calculates that rural-urban migration has declined by 1.5 percentage points, even allowing for a decline in the fertility rate, increases in urban boundaries and the emergence of new towns.

The main problem with conventional surveys is that they are unable to capture information related to temporary movement and part-time occupations. This is illustrated very nicely by the Panchmahals study (Shylendra and Thomas, 1995) where the village was supposedly completely dependent on agriculture according to official statistics (98.4 percent of the households and 97.7 percent of the labour force reported agriculture as their primary occupation in the NSS data of 1993-94), was actually highly diversified. Roughly 90 percent of the households were engaged in non-farm activities and migration rates were very high.

It is very likely that short-term migration will continue to increase due to a variety of new pushes and pulls that have become apparent recently. Apart from the constraints in traditional agriculture are new forces of change such as acute

[2]Report of the workshop is available at http://www.cised.org/research_programmes.htm.

[3]See for example the report of the Working Group on Watershed Development, Rainfed Farming and Natural Resource Management for the Tenth Five-Year Plan.

population pressure, commodity price crashes, improved infrastructure and urbanisation all of which, as we discuss in the following paragraphs, add to the flow of migration.

The 'Push': Declining Opportunities in Agriculture

Situations of surplus labour arising from the scarcity of cultivated land, inequitable land distribution, low agricultural productivity, high population density and the concentration of the rural economy almost exclusively on agriculture have led to a continuous increase in out-migration. Having little access to land in a predominantly agrarian society leaves the landless with few alternatives to migration. In India, 80 percent of the holdings are now small and marginal and per capita net sown area is less than 0.2 ha.

Drought

Drought is the classic push affecting a growing number of people, which exacerbates the problems described earlier. Nearly two-thirds of the arable land in India is rainfed and with low potential, and this is where the effects of drought are most severe. Natural drought is exacerbated by manmade drought. Groundwater exploitation in western and southern India has reached unsustainable limits (see several reports by International Water Management Institute).

A majority of the villages in the dry areas stretching across eastern Maharashtra, eastern Karnatka, western Andhra Pradesh, and southern Madhya Pradesh, have very high rates of migration. A typical case is the drought-prone Mahbubnagar district in Andhra Pradesh, which has had high migration rates for several decades. It is now well known for the legendary *Palamur* labourers who work in construction all over India. The neighbouring district of Ananthapur is also highly drought prone and is one of the poorest districts in India. There, too, seasonal migration has become routine (Rao, 2001). In a study in Madhya Pradesh, Deshingkar and Start (2003) found that more than half the households in four out of six study villages had migrating members. The proportion was as high as 75 percent in the most remote and hilly village with infertile soils. In Andhra Pradesh, while average migration rates were lower, the most remote and unirrigated village had 78 percent of the households with migrating members. Similarly, a study by Mosse *et al.* (1997) of the first phase of the DFID funded Western India Rainfed Farming Project (Madhya Pradesh, Gujarat and Rajasthan) revealed that 65 percent of households included migrants. Another later study in the same area found that in many villages up to 75 percent of the population is absent between November and June (Virgo *et al.*, 2003). The dry areas of Bihar, Orissa, Gujarat and West Bengal are also known for high migration rates. Bolangir a very poor and drought-prone district in Orissa, is a striking example. An estimated 60,000 people migrated out during the 2001 drought (Wandshcneider and Mishra, 2003) alone and as mentioned before current informal estimates are in the region of 300,000. The situation in the arid Panchmahals district of Gujarat (Shylendra and Thomas, 1995) is similar where seasonal migration was so high that 44 percent of the labour force was migrating and the average number of persons migrating from each household was 2.2 including women.

The situation in most of the backward and dry areas of India (nearly two-thirds of the country) increasingly resembles this because of the low levels of diversification and deteriorating access to common property resources.

Poor Mountain and Forest Economies

Outmigration has also been historically high from poor mountainous areas, which suffer similar problems of low agricultural productivity, poor access to credit or other pre-requisites for diversification and high population densities. A recent increase in migration has been reported from Uttaranchal by Mamgain (2003), as the fragile mountain ecosystem cannot support increasing populations. The poor mountainous districts of Nepal also have high rates of out-migration (Bal Kumar, 2003). More or less the same factors create a push from many forested areas where population pressure has increased and CPR-based livelihoods have become unsustainable. A study on linkages between the degradation of common property resources (CPRs), and out-migration in arid and semi-arid regions by Chopra and Gulati (2001) found a significant positive relationship between land degradation[4] and out-migration. The very high rates seen from forested tribal areas of Madhya Pradesh are an example of this.

Other Push Factors

The most recent push factor appears to be a fall in agricultural commodity prices brought about by macro-economic reforms linked with liberalisation and globalisation policies. Fresh evidence of this has emerged across India. For example, recent research by Ghosh and Harriss-White (2002) in Birbhum and Bardhaman districts of West Bengal suggests that paddy producers are facing heavy losses as prices fell sharply by over 50 percent since 1999. This situation was created by the reduction of subsidies as well as the de-restriction of inter-state transport which has allowed cheaper paddy to come in from Bihar, as well as from Jharkhand and Orissa where distress sales were occurring. Another example is that of rubber prices fell to a third of what they used to be five years before because of cheap imports. This has adversely impacted on the 900,000 rubber growers in Kerala of whom 90 percent are small farmers with less than five acres of land[5]. Similar stories are being reported about tea, groundnuts, rice and many other commodities that were previously remunerative. But there are few other academic studies in this area because it has emerged very recently. Press coverage however, has been extensive[6]. More research is urgently needed in this area.

[4]Land degradation was measured through increases in the proportion of sheep and goats in total livestock. Out-migration was measured through increased sex ratio in favour of female. Among other important factors, irrigation was found to have a significant negative impact on out-migration.

[5]India is the fourth largest producer of rubber in the world. http://www.hinduonnet.com/thehindu/thscrip/pgemail.pl?date=2002/05/19.

[6]Several articles have been published in The Hindu a respected English newspaper in India, particularly by P. Sainath, an internationally recognised journalist writing on drought, poverty and migration who is known for his book “Everybody Loves a Good Drought”.

The 'Pull': New Opportunities in Urban-Based Industry and Services

In the 1950s, development economists viewed the demand for labour created by 'growing modern industrial complexes' and the gap in rural and urban wages as the main "pull" factor. There have since been many models and debates on what motivates people to migrate including theories of 'expected' as opposed to actual wage differentials. Other pull factors include the desire to acquire skills or gain new experiences. In the case of voluntary migration of the poor for economic reasons, the wage gap is probably the most important pull and the most important recent determinants of this appear to be urbanisation and the spread of manufacturing.

Urbanisation

Urbanisation has become a major driver of internal migration. Rates of urbanisation influence rural-urban wage differences: an increase in the demand for labour in urban areas can push up urban wages and increase migration. Rural-urban differences in average incomes increased in many south and east Asian countries during the 1990s, especially in China and fell in most African countries (IFAD, 2001; Eastwood and Lipton, 2000). Current ESCAP projections are that urbanisation rates in south and southwest Asia will soon exceed other regions in Asia (Guest, 2003). This is already beginning to be reflected in the growing importance of rural-urban migration. While rural-rural migration[7] still accounted for roughly 62 percent of all movements in 1999-00. According to National Sample Survey data, there has been a sharp increase in rural-urban migration recently (Srivastava and Bhattacharyya, 2003) as more young men travel to work in construction and urban services. For example, studies in areas of Bihar that have experienced a doubling of outmigration rates since the 1970s show that migration is now mainly to urban areas and not to the traditional destinations in irrigated Punjab where work availability has declined (Karan, 2003). In dry parts of Gujarat, it was seen that urban incomes were so lucrative that not even government employment schemes such as the Jawahar Rozgar Yojana (JRY) and irrigation could reduce outmigration.

Will Migration in WSD Areas Continue to Increase?

Given the deteriorating situation in heavily populated rainfed areas of the country, it is quite possible that migration rates will continue to increase despite efforts to create employment locally.

In addition to the pushes and pulls mentioned previously, there could be following reasons for continuing migration.

- The additional employment created through watersheds not keeping pace with population growth (and additional labour availability). For example, an

[7]Workers from backward states like Bihar, Uttar Pradesh, Orissa and Rajasthan routinely travel to the developed green revolution states of Maharashtra, Punjab and Gujarat for the transplant and harvesting season.

estimated one million workers are added to the workforce every year in Andhra Pradesh and it is unlikely that watershed programmes can absorb all of these.

- WSD benefits only richer farmers and excludes the growing population of landless and marginal farmers.
- The labourer/household no longer wishes to pursue a livelihood system based on agriculture.
- Migration has occurred post-WSD because it has improved the asset base of the household and actually enabled it to migrate and explore other more lucrative opportunities beyond the village.

This is starting to become apparent in some areas. For example, Reddy *et al.* (2001) in a study of WSD in Andhra Pradesh found an increase in the extent of migration when before and after scenarios were compared in all the watersheds studied except one. Even though significant employment was generated during the project period, migration increased afterwards. Their explanation is that this occurred because labour participation increased consequent to the increased demand for watershed works which was then released into the labour market after completion of the works. Earlier studies on watershed development in Maharashtra (Deshpande and Reddy, 1991 quoted in Reddy *et al.*, 2001) also found the same.

How Migration can Contribute to Poverty Reduction and Agricultural Development?

Seasonal migration is often linked to debt cycles and the need for money for repaying debts, covering deficits created by losses in agriculture, or meeting expenditures of large magnitude on account of marriages, festivals, ceremonies, etc. Earlier research was very optimistic about remittances being invested in improving agriculture (Oberai and Singh, 1980). Indeed a link between migration money and investment in tubewell irrigation has been suggested – in fact earning additional income for developing irrigation facilities has often been reported as the main reason for migration from the dry land regions.

But it is very difficult to separate spending on 'consumption' and 'production' uses at the household level and the two are very interchangeable. Several studies appear to show that consumption needs take precedence over any investment in productive uses. However, spending on consumption may not be a cause for worry in itself as it can contribute to the overall increase in the well-being of the household for instance better nutrition, education, etc.

On the proportion of remittances in overall household income, it was believed by many scholars for a long time that remittances form an insubstantial part of household income. A major proponent of this theory was Lipton (1988) who based his argument on the widely quoted Indian village studies conducted by the Institute of Development Studies at Sussex in the 1970s (Connell *et al.*, 1976) which estimated remittances at 2-7 percent of village incomes, and less for poor labourers. However, new evidence suggests that this is not necessarily the case. Deshingkar and Start's (2003) research in unirrigated and forested villages of Madhya Pradesh showed that migration earnings accounted for more than half of the annual earnings from labour. In the more prosperous state of Andhra Pradesh, the overall contribution was much lower but in the village that was in the unirrigated and poor north-western corner, migration contributed 51 percent of household earnings. Research by Mosse *et al.* (1997) of the first phase of the DFID funded Western India Rainfed Farming Project (Madhya Pradesh, Gujarat and Rajasthan) notes that 80 percent of cash income in project villages was derived from migration. Even where remittances are irregular and small they may play an important role in reducing vulnerability and improving food security.

Migration as a Survival or Accumulation Strategy

While many studies on migration have tended to emphasise the impoverishing effects of migration they have rarely posed the question of what these households and individuals would have done in the absence of the opportunity to migrate. In Indian writings, the term ***distress*** migration and migration for survival have often been used; explaining migration by the poor as a response to natural calamities and other shocks (Murthy, 1991; Reddy, 1990; Rao, 1994; Mukherjee, 2001 who calls it 'distressed' migration). Distress migration has also been noted in a variety of African contexts by the PPAs though not necessarily using the same terminology.

But there is compelling evidence showing that the returns from migration can improve over time as migrants acquire more knowledge, confidence and skills; when they can cut out exploitative middlemen and contractors. The concept of *accumulative* migration (Deshingkar and Start, 2003) has been gaining acceptance. Rao's (2001) study of Andhra Pradesh distinguishes between migration for survival and migration for additional income. He observes people from Rayadurga district were migrating for survival in the 1970s but changed to migration for additional income in the 1990s. Another example is Bihar where earlier studies described distress migration and more recent ones such as the one by Karan (2003) describe migration in much more positive terms. In the PPAs synthesised in 'Crying out for Change' migration was identified by both men and women as an important factor leading to upward mobility. The importance of migration was greatest in Asia, followed by Latin America and the Caribbean and less so in Africa.

When Migration is Bad for WSD?

A reverse relationship between migration and watershed development has also been shown to exist where migration adversely affects the incentives for community resource management and participation. Concern has also been expressed in the past over the potentially detrimental effects of out-migration on the productivity of sending areas due to the depletion of labour. While some studies have certainly shown a worsening of poverty levels due to the large-scale male dominated migration as in remote areas of Nepal and Africa, more recent research has shown that some of these impacts may be offset in situations where wages in the destination are high and remittance and communication mechanisms are improving as in several parts of India, southeast Asia and China.

An important implication of livelihood diversification is that natural resource-based activities may become part-time and this could have negative consequences, particularly for participatory resource management such as watershed and community forestry programmes. Those who are away for long periods of time may not be able to participate in community activities and decision-making, and their access to resources may be compromised. Adverse effects of migration on watershed development have been documented by Turton (2000) and *Samuha* in Karnataka. Also, in a recent conference on common property resource management[8], a session was devoted to discuss the adverse impacts of migration on the management of common resources such as forests, water and pasture lands (Rahman, 2004; Reyes and Pacheco, 2004; Lopez, 2004).

Policy Implications, Knowledge Gaps and Research Needs

The present review shows that the WSD-migration link has been addressed by only a few researchers and that too indirectly. Not many have examined the relationship in its entirety: the (positive) effect of additional income, the (negative) effect of labour depletion and reduced collective action and the effect of changing preferences and household behaviour.

What the examples and possibilities illustrate is that the relationship between watershed development and migration is complex and by no means straightforward. In fact, any assumptions to that effect are not only inaccurate but could also be damaging by leading to erroneous policy prescriptions. It is, therefore, important to be able to understand exactly what is likely to occur in particular contexts. Given the increase witnessed recently in migration rates, and the associated increase in the proportion of household income derived from migration, this merits some serious study; a need that has also been noted by other researchers in the field (Shah, 2001).

In this, attention needs to be paid to the broader context in which changes are taking place. India is currently going through a transition from an economy that consisted of very large numbers of viable small and marginal farms to one where the structure of agriculture and industry is changing rapidly in response to globalising forces, environmental limits and stresses and population pressure. While new industries and informal sector jobs have emerged in urban areas creating a considerable pull for poor labourers, a stronger push is also being experienced in many rural areas with land fragmentation, drought, groundwater scarcity and falling agricultural commodity prices.

It is very likely therefore that the increases in productivity that are brought about by WSD may not be sufficient alone to stem the tide of migration. A few studies have begun to observe this; for example Reddy *et al.* (2004) document that watershed development alone is not a ***sufficient*** condition for sustaining rural livelihoods (Reddy *et al.* 2004).

Probably the most important implication for policy is to recognise that migration will continue and this does not represent a failure of watershed development programmes. Migration should be viewed as an inevitable part of unequal regional development and although not the perfect way of providing employment to the poor in rainfed farming, it is arguably an important mechanism by which the fruits

[8]The bi-annual conference of the International Association for the Study of Common Property (IASCP), 9-13 August 2004 in Oaxaca, Mexico.

of agricultural development in more prosperous areas are redistributed. There is, therefore, an urgent need to understand how WSD can become a part of efforts to support more diverse livelihood portfolios where a win-win situation can be created say, through improving the resource base which creates a more conducive environment for investing remittances leading to an overall increase in growth, employment and poverty reduction.

Since roughly 60 percent of the arable land area in India is limited to dryland agriculture due to climatic factors, soil erosion, poor water retention capacity, etc. It is in such areas where migration and watershed development appear to overlap heavily. It is time to find a way of creating a win-win situation where migration is viewed as a viable livelihood option and WSD programmes are designed with that in mind. Therefore, plans for participation need to take into account that part of the population will be absent for periods of time. This creates a different requirement in terms of who is represented in local village institutions and who is given what role in local resource management. The gender implications may be greatest especially where male outmigration is high. It also raises the issue of what the goals of WSD should be – creating an improved natural resource base may actually enable more people to migrate.

Mobility and the positive impacts of remittances are being viewed as an important route to poverty reduction and economic development in southeast Asian and east Asian countries such as Indonesia, Vietnam, Cambodia and China (Deshingkar and Grimm, 2004). Temporary migrants represent much untapped potential in India too and the time is ripe to start thinking about ways of mainstreaming migrant support programmes and migrant incomes into rural development programmes such as watershed development.

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Common Property Resources: Managing The Unmanaged

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Abstract

In last two decades the most challenging issue in managing common pool resource (CPRs) in India was that of designing institutions or the process of working rules for collective action in implementation of natural resources development programmes, in general, and watershed development projects, in particular. Some successful cases of rehabilitation of CPRs through watershed approach, using collective management systems have been effectively replicated in different agro-climatic conditions of the country. In the state of Madhya Pradesh and Chhattisgarh (newly formed state of Chhattisgarh was carved out from Madhya Pradesh in November 2002), watershed development approach was adopted in several villages for sustainable management of renewable CPRs. Nartora Watershed Project (NWP) was implemented in 1983-84 in the Nartora village of Mahasamund district of Chhattisgarh, India, with technical supervision and scientific backup from CRIDA, State Departments of Agriculture; and horticulture, forestry and veterinary scientists of the university. The NWP was completed in 1987-88 and the project has received the second National Productivity Award. An institutional analysis of the NWP was carried out within a dynamic framework to assess potentiality of watershed development programme to manage the CPRs. The results of the NWP study indicated that community based management with well defined institutional rules can provide a fascinating option to private and state property regimes for sustainable development of CPRs and offers bright signals that traditionally proven village level authority can evolve mechanism for reforming institutions for self-governance. It has been shown with inter-temporal interpretations of institutional movements that through effective transformation of institutions sustainable development of CPRs can be achieved.

Introduction

A sizable proportion of people in rural India depend directly for their livelihood and welfare on natural resources like forest, soil, water, fisheries and wildlife. These are the flow common pool resources (CPRs) with critical minimum levels below which a decline in flow may have the irreversible outcome. Renewable CPRs have been managed and controlled under different management regimes in India. These resources can be managed sustainably under state or common or private property regimes and also subject to equally capable of being degraded. There are many overlaps and combinations of state (public), community and private management systems or governance structures in managing resources or eco-system. In other words often resources are managed at the interface of different property regimes. Enough evidences are available in India when resources managed under common property regime degraded into open access due to weak property rights regimes, inadequate institutional arrangements and breakdown of authority system. Examples are also available when renewable resources degraded under open access system brought under a state or private or community management regime through appropriate changes in institutional arrangements (Arnold and Stewart, 1991; Marothia, 1989, 1992a,b, 1993, 1997a,b,c, 2002). Many researchers and policy makers have suggested privatization or state control of resources as a solution to arrest degradation of these resources and the ecosystem. However, it has been widely experienced that government or state control over natural resources accumulated a relatively weak record (Marothia, 1993, 1997a). In turn, resource management under common and private property regimes appears to offer better alternatives to state management regime. In recent years, particularly in eighties, several developmental programmes for water, forestry, fisheries and rehabilitation of waste and wetlands resources have been introduced and few of them were managed under distributed governance or shared management system. In these projects local communities/resource users groups and the state or local government shared the responsibility of managing CPRs by combining appropriate institutional skills of local resource users/local committees and technical, administration and financial resources available with the states, research organisations, and NGOs. In the state of Madhya Pradesh and Chhattisgarh of India watershed management approach was adopted in several villages on degraded common lands for sustainable development of renewable CPRs. Nartora Watershed Project (NWP) was introduced in the Nartora village of Mahasamund district of Chhattisgarh for sustainable development of common degraded land and other CPRs. The main objectives of NWP were to optimize land use pattern to conserve soil and water resources through controlling erosion, to manage land and other biological resources so as to control land degradation, recycling of the run-off water to boost up the production of food, fodder, fuel and timber and to improve the economic conditions of the resources user and village communities. The NWP was started in 1983-84 and completed in 1987-88 and the project has received the second National Productivity Award. The experience of rehabilitation of CPRs through watershed approach, using collective management systems can be replicated in the other parts of the country for sustainable development of CPRs. To draw lessons from NWP, it is important to analyze the collective management systems adopted under NWP for sustainable use of CPRs. This paper is a modest attempt in this direction. An attempt has been made to discuss the outcomes of the watershed approach used as the basic unit for planning and management of CPRs for the upliftment of rural poor in a village of Chhattisgarh. This paper argues in favour of distributed governance for managing CPRs through watershed approach in the initial phase of the project and designing components of exit policy during the project period itself for sustainable community based management using Nartora Watershed Project (NWP) as an illustration.

CPRs in India: Contributions, Status and Causes of Depletion

CPRs of land, water, forest, fisheries, wildlife and agriculture constitute an important component of community assets in India and significantly contribute towards the people's livelihood despite the decline in their area and physical productivity. All protected forests, unclassified forests and degraded forest lands, surface water resources, marine fish, and all inland fisheries in rivers, canals, irrigation channels, reservoirs, and lakes, and quite a significant proportion of the total endowment of non-forest lands (38 percent), groundwater (44 percent), and fresh water ponds and tank fisheries (80 percent) in India are CPRs. Besides, most of the 143 m ha of net sown area in the country also becomes a CPR after the harvest of a crop until the next crops is sown, and to the extent that local people have rights to collect specified forest product from them, the reserved forests also serve as partial CPRs. This indicates the prime importance of common pool resources in rural livelihood system and India's rural economy and hence greater attention is urgently required to their restoration, development, and management (Singh, 1994).

In India, nearly 40 percent rural poor are suffering with poverty and largely depend on CPRs. One of the major causes of the rural poverty in India is the inequal access and control of poor to CPRs (Jodha, 1986; Singh, 1994). Depletion of CPRs has also been major cause for replacing a large number of rural people and reducing their status to environmental refugees. In a substantive work involving 82 villages spread over 21 districts of the dry regions of India, Jodha (2002) has documented the factors which led to the decline of CPRs in terms of area, physical degradation and management system, and related them to the disintegration of social and institutional arrangements evolved and enforced by the rural community to protect and manage CPRs. Jodha (2002) identified the role of different driving forces behind the demographic changes and emphasized that population pressure could be necessary but not the sufficient condition to accelerate shrinkage of CPRs area (*see also* earlier work of Jodha, 1986, 1992, 1995, 1996 for contribution and status of CPRs in India). A large number of studies conducted in different parts of India also documented monetary and non-monetary contribution of CPRs (*see* Arnold and Stewart, 1991; Singh, 1994; Marothia, 2002).

During the last two decades, scholars from various fields have documented the factors leading to the decline of CPRs in India in terms of area, physical degradation and ineffective management systems. The important factors responsible for the decline are demographic changes, encroachments, fragmented land holdings, land holdings in the vicinity of forests, tiny farm size, acquisition of common lands by developmental agencies, increased pressure of outsiders on common lands, and disintegration of social and institutional arrangements evolved and enforced by rural communities to protect and manage CPRs. Economic development with greater reliance on market forces and commercial interests, commoditization of CPRs and unfavourable public policies have also resulted into the decline of CPRs (for case studies, *see* Marothia, 2002).

A number of studies conducted in different parts of the country clearly indicate that erosion or collapse of the 'social capital' leads to decline of CPRs. Once the 'social capital' depletes, CPRs become an open access resource and the process of their depletion begins (Jodha, 2002). Local social groups and their customs have played an important role in designing informal institutional arrangements for managing CPRs collectively. Over time, however, these informal binders seem to loose their effectiveness and, as a result, voluntary participation in resource managements starts declining. Also, due to the introduction of elected village councils (*panchayats)* and de-recognition of traditional social arrangements and customs (social capital), the community lost collective stake and control over the CPRs, and the culture of group action got replaced by individualistic tendencies. All these led to disintegration of village community and depletion of social capital (Gupta, 1987; Jodha, 2002; Negi, 2002). Further, most of the development programs undertaken by the government to restore and conserve CPRs largely focussed on financial and technical support without recognition of local perceptions and traditional knowledge systems (Jodha, 2002). Understanding of the traditional institutional arrangements may serve as an important step towards rehabilitation of CPRs as well as rebuilding of social capital.

Institutional Mechanism to Manage CPRs

In last three decades, various structures of institutional mechanism for coordination and integration of the CPR management plan incorporating concepts of equity and sustainability with the plans of various departments engaged in agriculture and rural development at national, state and field planning officer levels have been evolved in India (Gupta, 1995; Agarwal and Narain, 2002). In most of the institutional innovations (right from joint forest management to rain water harvesting and watershed management) either external institutional arrangements or internal or combination of both institutional arrangements (distributed or shared governance) have been adopted for collective action in terms of positive interactions among resource users, between local management body and project sponsoring authority. An external governance structure has essentially three alternatives of management systems (Townsend and Polley, 1995), namely, rights-based management (the government grant usufruct rights to individual resource users/party under well-specified constraint conditions and assumes the role of monopoly over the resource base and retains all responsibility/authority for conservation decision), co-management (the government and local communities share ongoing responsibility for decision-making overall or most of the resource management decisions) and contracted management (to transfer a large part of the decision-making process to local bodies). These systems have been functional in various parts of India to manage CPRs (Marothia, 2002, 2003)

Three alternative internal institutional arrangements (Townsend and Polley, 1995) have closely been associated with the concept of distributed governance – self-organizing institutions (institutional and organizational decisions remain with the local communities and the government may use the institutional building capacity to support and gain strength from self-organization), communal management (to reduce the existing authority of state and vest more localized interest), cooperative management (membership is limited with well-defined working rules for collective governance) and corporate (under the corporate governance the owners and shareholders of the corporation would operate under governance rules typical of private corporations (Townsend and Polley, 1995). The degree of authority that the government could grant to local organization varies with the internal governance structure (Marothia, 1993, 1997a). If management is to be most effective and efficient, two features should be characterized. Firstly, institutional arrangements for local community and government are clearly defined and the potential for prolonged and costly disagreements among resource user groups and government administration be minimized. Second, the decision-making structure should be shared at different levels of administration so that costs and benefits of any decision are internalized within some cohesive decision making unit (Townsend and Polley, 1995; Marothia and Phillips, 1995).

CPRs Management in NWP: A Case Study

The watershed as a unit for land and water management has had considerable attraction for policy makers and scientists in India for over forty years now. As the area of land over which hydrological processes are integrated, it is in some sense a natural unit for such planning. Any attempt at soil and water conservation within smaller privately owned units accounts in a less complete way for externalities. The earliest experiment in watershed management in India was conducted in the semi-arid tropics under the 'aegis' of International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The Indian Council of Agricultural Research took up forty-six model watersheds in the dryland areas of the country in 1982. A few pilot projects were also launched with World Bank assistance in 1984. In 1986-87, the National Watershed Development Programme for Rainfed Agriculture (NWDPRA) was launched. Around 2,328 watersheds received treatment under this programme.

For sustainable use of degraded common lands and other CPR, NWP was implemented in Chhattisgarh for the implementation of model watershed development project alongwith others in dryland farming areas in different parts of the country in 1982. NWP was among 30 projects, which were provided with technical supervision and scientific backup from Central Research Institute for Dryland Agriculture (CRIDA) and scientists of State Agricultural Universities.

NWP has a total watershed area of 704 ha and is situated at $21^{o}8'$ to $21^{o}10'$ N latitude and $82^{o}\,21'$ to $82^{0}22'$ E longitude. The area lies 300 to 330 m above MSL. NWP is the catchments of Kodar nala and it covers three villages, namely, Nartora, Kulharia and Saraipali. A sub-watershed represents each village. In the first phase of the project, Nartora and Kulharia villages were considered for the watershed management. However, most of the development activities have largely been confined to the village Nartora and hence this study was carried out in Nartora village. A brief profile of the study area is given in Table 1. The details of the activities undertaken are given in Table 2.

Organizational and Administrative Structure

Organizational and administrative structure of the NWP was formed at three-tier levels, namely, coordination committee at the state level, project implementation committee at the district level and village resource development committee (VRDC)

Table 1. Profile of Nartora village

Sl. No.	Particulars	1982-83	2001-02
1.	Total geographical area (ha)	513	508
2.	Village forest (ha)	63	5
3.	Grazing land		
	(a) Open (ha)	9	5
	(b) Private (ha)	4	4
4.	Fallow land		
	(a) Government (ha)	25	5
	(b) Private (ha)	37	37
5.	Land owned by panchayat (ha)	0.02	0.02
6.	Common property resource land per person (ha)	0.12	0.12
7.	Area under fruits (ha)	5	5
8.	Area under cultivation (ha)	360	377.29
9.	Cropping intensity (%)	103.38	120.28
10.	Total population (No.)	1286	1346
11.	Population density (person/ha)	2.51	2.65
12.	Literacy (%)	27.06	56.02
13.	Livestock population (No.)	712	755
14.	Livestock population Density (livestock/ha.) of cropped area.	1.98	2.00
15.	Human livestock ratio	1.81	1.78
16.	Landless farmers (No.)	7	12
17.	Marginal farmers (No.)	139	98
18.	Small farmers (No.)	57	55
19.	Medium farmers (No.)	34	33
20.	Large farmers (No.)	24	20
21.	Total farmers (No.)	261	206
22.	Percent of total agricultral labourers	96	
23.	Irrigated area (ha)		
	a) Well	2	-
	b) Tank	19	30
	c) Tubewell	25	113
	(d) Stream	-	1
	(e) Total	46	144
24.	Slope gradient (%)	1-3 (with upper and lower pediment)	
24.	Soil formation	Lateritic with sand and lime stones (red lateritic to clay)	
26.	Drainage pattern	Uneven	
27.	Climate	Sub-humid	
28.	Temperature (°C)	21.2 – 36.6	
29.	Average rainfall (mm) (92% rains received from mid June to end of September)	865	

Table 2. Details of various activities undertaken in Nartora Watershed Project

Sl. No.	Particulars	Units	1983-84	1984-85	1985-86	1986-87	1987-88	Total
A.	Land Treatment Works							
1.	Terrace and inter-terrace treatment	ha.	-	8.00	20.72	-	-	28.72
2.	Pasture development	ha.	-	4.00	-	-	-	4.00
3.	Social forestry	ha.	15.00	10.00	10.00	-	5.00	40.00
4.	Horticultural plantation	ha.	5.00	-	-	-	-	5.00
5.	Total land area under treatment	ha.	20.00	22.00	30.72	-	5.00	77.72
B.	Water Harvesting Structures							
1.	Farm Pond/percolation tanks	No.	-	-	-	-	1.00	1.00
2.	New tanks	No.	1.00	-	-	-	-	1.00
3.	Remolding of tanks		-	2.00	1.00	1.00	-	4.00
4.	Utilization of 1, 2 and 3, ha. for irrigation	No.	-	40.00	57.00	77.00	95.00	269.00
5.	Construction of channel	No.	530.00	500.00	-	-	-	1030.00
6.	Tubewells	No.	2.00	1.00	-	1.00	4.00	8.00
7.	Fish ponds	No.	-	-	-	-	2.00	2.00
C.	Distribution of Crop Production Technology							
1.	HYV/improved seeds							
	a. Paddy	kg	1800	8500	22800	4600	4600	42300
	b. Wheat	kg	-	-	600	-	-	600
	c. Groundnut	kg	-	-	0.28	700	-	728
2.	Fertilizers NPK	ton	28.40	50.10	45.90	29.70	37.60	191.70
3.	Pesticides	kg	14	-	-	-	-	14
4.	Crop-loan to beneficiaries	No.	122	123	189	129	157	720
5.	Plant protection equipment	No.	-	3	17	36	19	75
D.	Extension Activities							
1.	Adaptive trails	ha.	-	-	-	-	4	4
2.	Training camps	No.	-	2/100*	1/350	4/900	1/150	-
3.	Exhibitions/ Krishi melas	No.	1	1	1	1	1	5
4.	Film shows	No.	1	1	-	-	-	2
5.	Input subsidy	No.	-	67	306	29	-	402
6.	Minikit seed	No.	30	212	187	185	16	634
7.	Farmers on study tour out of state	No.	-	-	-	25	54	79
E.	Infrastructural Facilities							
1.	Punjab National Bank	No.	-	-	-	1	-	1
2.	Veterinary Hospital	No.	-	1	-	-	-	1
3.	Milk Collection Centre	No.	-	-	-	1	-	1
4.	Cattle breeding bulls	No.	-	-	1	1	-	2

Source: Soil Conservation. Mahasamund; * Number of participants.

at the project level to undertake various activities for sustainable development of degraded common lands and other CPRs in Nartora village.

Coordination Committee

The Production Commissioner of State Government was the Chairman of the coordination committee, its members being the Director of Extension/Research Services of the State Agricultural University, Director of Agriculture and Additional Director (Soil Conservation); Secretary (Agriculture/Veterinary) was the member secretary of the committee. The Coordination Committee was the apex committee for project monitoring and controlling. This committee was formed to scrutinize the project proposals, find out the problems and remove the deficiencies of the project proposals. The coordination committee was assisted by a scientific consortium in technical matters like improved seeds, fertilizers, plant protection measures, etc. The Chairman of the Coordination Committee played key role in coordinating the activities of the State Departments of Forest (SDF), Veterinary (SVD), Soil Conservation (SCD), Agriculture (SDA) and Horticulture (SDH).

Project Implementation Committee

The Project Implementation Committee was formed at the district level. The district collector headed the committee. Its other members were from Agriculture, Horticulture, Veterinary and Forest Departments. The committee met quarterly to analyze the progress report of the project. A team of university scientists consisting of one scientist (soil and water engineering) and three junior scientists, one each from Agronomy, Soil-Science and Economics Departments, IGAU, Raipur, helped the committee in diffusion of new technology and formulation of the training programme for the farmers as well as the staff members. Implementation of various development activities was the main responsibility of the committee.

Village Resource Development Committee (VRDC)

VRDC was formed at the village level. Village Head (Sarpanch) was the chairman of the committee. Other elected members of the village council and Rural Agricultural Extension Officer (RAEO) of Nartora village were the members of this committee. The committee worked under the guidance of the Project Officer of the Soil Conservation Department. He being in direct contact with the farmers, main responsibility of the VRDC was to transfer improved technology to the farmers as well as to assure farmers' cooperation to take care of various activities of the project. Under the guidance of the Project Officer, VRDC got success in deriving people's participation through providing short-term benefits to the farmers in the form of intercropping on 0.04 ha plots in the orchard plots, and fodder grass from the farm forestry activity. Besides it, the Committee collected the water charges for irrigation, rent for intercropping in the orchard activity, charges for fodder grass from the forestry activities and penalties from free riding farmers. The fund thus collected was further utilized to pay electricity charges of the tubewell and maintain the various other activities. Soil Conservation Department was responsible to take care of various activities upto their full establishment and then handover to the VRDC. Grazing was strictly prohibited in the forest and orchard land. The farmers in the project area were allowed to cut natural vegetation in the forestland. But in a single day they could take one quintal of grass only at the payment of Rs. 0.50 to the committee. In the orchard land, 0.04 ha of land per farm household was distributed to the farmers through lottery system. Besides using these plots for intercropping purposes, they had to take care of three fruit trees plots, failing which could cause them to pay Rs. 70 per annum to the committee for the intercropping. The use of bullocks in these plots was prohibited and could attract a penalty of Rs 500 for violation.

Major Interventions in NWP

The major activities undertaken in the NWP aimed to restore common property land and water resources for technological interventions in the crop, horticulture, pasture and fuel and small timber production to meet the local requirement and enhance the livelihood levels of the people of Nartora village. The technical and institutional arrangements for promoting adoption of various components of crop technologies, farm-forestry, livestock, poultry and fisheries were designed by the coordination and project implementation committee with local knowledge provided by members of the village resource development committee. The institutional and technical interventions were further supported by the well-designed extension activities and infrastructural facilities during the project period. Extent of development of common property degraded land through farm forestry during the project period (1983-84 to 1987-88) is given in Table 3. Share of common property wasteland resource development in the total investment is provided in Table 4. During the project period total common pool wastelands of 77.72 ha were treated with the investment of Rs.6.37 lakhs which in turn accounts for 17.27 percent of the total investment made on all the development activities of the project (Table 4).

Table 3. Extent of development of wastelands through farm forestry

Particulars	1983-84	1984-85	1985-86	1986-87	1987-88	Total
A. Percent of total wasteland developed through						
(i) Silvi-pasture	15.00 (75.00)	10.00 (45.45)	10.00 (32.55)		5.00 (100.00)	40.00 51.47
(ii) Agro-horticulture	—	5.00	—		—	5.00 (6.43)
(iii) Pasture	—	4.00 (18.18)	—		—	4.00 (5.15)
(iv) Terracing	—	8.00 (36.36)	20.72 (67.45)		—	28.72 (36.95)
B. Total wasteland treated (ha.)	20.00 (100.00)	22.00 (100.00)	32.72 (100.00)		5.00 (100.00)	77.72 (100.00)

Note: Figures in parenthesis indicate percent of total wastelands treated.

Mechanism for Continuity and Adjustment in Institutional Arrangements

The physical and technical attributes of common property land and water resources alongwith interventions related to fuel, fodder and timber (FFT) plantation,

Table 4. Extent of development of wastelands and its share in the total investment (Thousand Rupees).

Particulars	1983-84	1984-85	1985-86	1986-87	1987-88	Total
(i) Silvi-pastrure	100.00 (14.35)	100.00 (12.78)	125.00 (12.14)	—	50.00 (9.02)	375.00 (10.17)
(ii) Ago-horticulture	30.00 (4.30)	80.00 (10.22)	—	10.00 (1.00)	120.00 (3.25)	240.00 (6.51)
(iii) Pasture	—	32.00 (4.09)	10.00 (0.97)	8.00 (1.28)	—	50.00 (1.35)
(iv) Terracing	—	9.00 (1.15)	83.00 (8.06)	—	—	82.00 (2.22)
Investment made on land development	130.00 (18.65)	221.00 (28.24)	218.00 (21.16)	8.00 (1.28)	60.00 (10.83)	637.00 (17.27)
Total investment made on all development activities (Rs.000)	697.00 (100.00)	782.50 (100.00)	1029.84 (100.00)	624.80 (100.00)	554.00 (100.00)	3688.14 (100.00)

Note: Figure in parenthesis indicate percentage of total investment made on all development activities.
B: Investment on other activities involves water conservation, cropping technology, extension and infrastructural services.
Source: Estimates derived from the NWP Report 1989.

fruit plantation and surface irrigation (tank irrigation) are given in Table 5. The institutional arrangements designed by the project organizational committee for efficient, equitable and sustainable development of CPRs through collective action are also presented in the same table. The decision making arrangements for managing village degraded common lands for fuel, fodder and timber (FFT), fruit plantation and community tanks for irrigation and fish culture were designed for effective implementation and positive interaction among the members by the organization committee. The outcome and impacts in terms of economic gains, distributive gains and sustainability due to effective implementation of institutional arrangements is listed in Table 5 (Oakerson, 1992; Bromley, 1992; Singh and Ballabh, 1996; Marothia, 2002).

It is important to note here that after the withdrawal of financial, technical and organizational support from project sponsoring authority, after the completion of the project period, to Village Resource Development Committee (VRDC) still the institutional arrangements designed during the project implementation period are functional. The management of NWP has totally been under the control of VRDC after the exit of project authority. The organizational setup of VRDC is now composed of President, Vice-president, Secretary, Treasurer and 19 members of the working committee. One member from each household of the village is also member of the VRDC. In the orchard plantation area, 0.04 ha of land per farm household was allotted under the usufructury property rights regime by the project authority during project period. Due to this intervention the villagers had adequate availability of vegetables and fruits. After 2002 due to frequent power interruptions the inter-cropping activity in the orchard plots was discontinued. The power fluctuations/low voltage resulted in inadequate water supply, particularly in summer. VRDC has been auctioning picking of fruits from the fruit plantation sites. The auction money has been deposited for the watershed fund created by

Table 5. Characteristics and institutional arrangements of collective management system

Characteristics	Fuel, fodder, timber (FFT) plantation	Fruit plantation	Tank irrigation
A. Resource Attributes			
Original ecological status	Catchment of natural *nala*	Catchment of natural *nala*	Old silted tank
Original land tenure	Village degraded wasteland	Village degraded wasteland	Community tank
Current property rights regimes	Common property managed by VRDC	Common property managed by VRDC	Common property managed by VRDC
Year of initiation	1983-84	1983-84	1983-84 (new tank) 1984-85 (rehabilitation old tank)
Area covered (ha)	15	5	270
Main products	Green fodder, fuel and small timber from bamboo, subabul, acacia and sisal (fibre crop for rope making)	Jackfruit, mango, guava, lime and vegetables	Crops and fish
B. Decision Making Arrangements			
Legal and administrative relations	State Department of Forest (SDF)	State Department of Horticulture	State Departments of Agricultural (Soil Conservation Divisions) Irrigation & Fisheries Department
Ability to raise funds	Sale of green fodder, and fuelwood, auction of bamboo, small timber	Sale of fruits and land lease rents	Sale of water for crop production and fish rearing
Ability to influence other government activities	Influenced dairy cooperative societies, social and agro-forestry	Influenced fruits plantation programme of Horticulture Department	Influenced micro/minor irrigation of Soil Conservation Division for effective irrigation, rehabilitation of old tank and construction of new tanks, composite culture fisheries programme
External organizational and technical assistance	Financial and technical support from ICAR, State Department of Forest, Agriculture and Ag. University	Financial and technical support from ICAR, State Departments of Horticulture, Agriculture, and Agricultural University	Financial and technical support from ICAR, State Departments of Agriculture, Fisheries and Irrigation
C. Patterns of Interactions			
Membership, legitimacy and outsiders	VRDC consist of village *surpunch*, *panch* and member secretary (RAEO), strong rules against free riding	VRDC consist of village *surpanch*, *panch* and member secretary (RAEO) strong rules against free riding	VRDC consist of village *surpanch, panch* and member secretary (RAEO) strong rules against free riding

(*Contd.*)

Table 5. (*Contd.*)

Characteristics	FFT plantation	Fruit plantation	Tank irrigation
Protection	Watchman guards FFT plantation, fenced	Beneficiaries protects fruit trees under the lease agreement for intercropping	Water distribution is regulated by waterman
Use and regulation	No open grazing. Only hand cutting grass is allowed on nominal charges. Cutting trees bushes forbidden. Fallen twigs and branches are sold by the VRDC to the villagers. Local people get preference in auction of bamboo and small timber	Beneficiaries using plots in the fruits plantation area must take care of fruit trees, Bullocks driven operation are prohibited Rs.500 penalty for violation.	VRDC changes Rs. 50 per ha. as irrigation fees. Field to field irrigation. Strong sanctions for non-payment of fee. VRDC ensures adequate water in the tanks for fish cultivation
Pay-off	FFT sold and distributed first in the village. Financial benefit go to VRDC,	VRDC sells fruits to the villagers first, surplus outside. Financial benefit go to VRDC	Fishes sold in village, first surplus sold outside. VRDC gets financial benefit for fisheries.
Development	Funds for reinvestment kept aside	Funds for reinvestment kept aside	Some portion of the funds is being utilized for maintenance of tanks and water channels
Broader agenda	Developed continuous supply of FFT for and induced stall feeding for cattle, dairy cooperatives have been developed and improved cattle breeding programme initiated	Improved nutritive diet intake due to fruit and vegetable availability Established linkages with the weekly markets	Adoption of composite fish culture, HYVs and growth promoting inputs in crop production. Established linkages with financial institutions for agril. loan
Equity rules	Equal rights for all villagers	Beneficiaries are selected through lottery system for leasing out plots for intercropping	Equal rights to tank irrigation water lease of tanks for fisheries is open to each villager

D. Outcome and Impacts

(a) Economic gain: Shift in cropping pattern in favour of high value crops. Diversification of farming system.

(b) Distributive gains: Every resource user gained almost equally from various activities undertaken in the M.P area due to effective enforcement of institutional rules by village resource development committee.

(c) Sustainability: Resource use is sustainable due to effective VRDC role.

*Fuel, Fodder and Timber.

VRDC. Similarly, the committee has fixed prices for bamboo, leucenea, acacia and eucalyptus poles for villagers and outsiders. Naturally grown grasses in the orchard and social forestry area have also been auctioned to the villagers. Still free grazing is not permitted in the village and strong financial and social sanctions are in operation. The water for irrigation has been provided by the common irrigation tanks, constructed during project period, to the farmers located in the command area through field to field irrigation system with well designed scheduling. The water charges during the project period were fixed at Rs. 50 per ha. In recent years financially and politically powerful farmers have not been paying irrigation fees regularly. As a result the tanks and canals are in bad shape and erosion of the tank bunds is quite visible. The VRDC is in the process of negotiation with the defaulters and during our recent visit they were hopeful to resolve the issue. Despite the fact that VRDC has adequate working capital the members are reluctant to invest in maintenance of the tanks and canal on the pretext that unless we recover the irrigation fees from the defaulters it will not be maintained. The poor maintenance of the tanks have also affected the fisheries production and significantly lowered down the lease rents from Rs 4000 to Rs. 700. During project period three tubewells were installed to increase the irrigated area for improving the cropping intensity. One tubewell located near orchard was exclusively used for irrigating fruit plants and providing water to the farmers cultivating plots in the orchard area. Currently from this tubewell water is being provided to the newly planted (nearly 6000 guava and citrus plants) trees in the old plantation area. From other two tubewells irrigation was provided during the project period to the farmers located in the periphery of these tubewells at the rate of Rs. 250-375 per ha per season. This system of water distribution and maintenance of tubewell continued till 1999-2000. VRDC has decided to assign responsibility of maintenance and operation of these two tubewells by the farmers who were willing to maintain and distribute the water to the nearby farmers. The farmer who has been assigned usufrutury rights to use tubewell with certain conditions can sell the water to the other farmers on the mutual agreed conditions. The bamboo plantation was fenced with dense agave plants for providing employment to the landless people through rope making. VRDC could not install the processing machine and as a result the agave plant material is unutilized. The VRDC has been very particular in maintaining the biomass in orchard plots and agro-forestry area. Before harvesting any species of the plants, similar species were replanted by the members of the VRDC. The dairy activities are still functioning satisfactorily due to adequate number of cross-bred animals and stall-feeding. However, the cost of producing milk is quite high in comparison to sale price of the milk. The commercial poultry has been reduced to backyard poultry activity.

Impact of NWP

The impact of NWP is assessed using tangible and non-tangible impact indicators. The impact is further evaluated at two points of time (1989-90 and 2003-04). The extent of change in the tangible indicators is given in Table 6. It is clear from the data that gross cultivated area, irrigated area, cropping intensity, area under high yielding varities and use of manure and chemical fertilizers have increased manifold. This in turn has also increased net income from the crops and allied activities. The intangible benefits in terms of improvement in soil structure, reduction in soil and water erosion, increase in groundwater level and biomass and improvement in microclimate are quite visible. Distress migration has completely

Table 6. Changes in impact indicators of Nartora Watershed Project
(in percentages over the base year)

Sl.No.	Impact indicators	1989-90	2003-04
1.	Operational area per farm	13.51	13.81
2.	Gross cultivated area per farm	16.74	18.01
3.	Cropping intensity	4.47	21.24
4.	Labour utilization per ha	20.62	25.12
5.	Fertilizer consumption per ha		
	a) *Kharif*	22.94	27.02
	b) *Rabi*	8.94	68.08
6.	Irrigated area per farm		
	a) *Kharif*	215.50	826.00
	b) *Rabi*	960.00	980.00
	c) Summer	203.70	915.00
7.	Net income from crops per ha	57.00	957.00
8.	Net income per farm through dairy, poultry Goatry, wage earning and crop sector	88.00	897.00
9.	HYV area	16.00	68.80

ceased, which was a part of life before NWP. The spillover impact of rainwater harvesting can also be seen in the small water ponds owned by the private farmers and panchayat. During 1999-2004, nearly 100 tubewells were developed in the command area of NWP. This has significantly reduced water level in open dug wells and increased water markets in farm sector.

Income and expenditure details of VRDC are given in Table 7. VRDC over the years has consolidated its financial position. The main sources of income includes sale of bamboo, fuel wood, timber, fruits, grass, leasing out tanks for culture of fisheries, and recovery of water fees. The major expenditure includes electricity charges, labour wages, watchman salary, payments to the school teachers and social and cultural activities. Besides, having Rs.3.39 lakh savings the approximate value of stock capital (in form of bamboo and farm forestry plantation) is

Table 7. Yearwise income and expenditure of Nartora Watershed Project

Year	Income (Rs.)	Expenditure (Rs.)	Profit/loss
1996	15004.00	10904.00	4100.00
1997	42585.00	19211.00	23374.00
1998	84497.00	49337.00	35160.00
1999	50993.00	11968.00	39025.00
2000	102144.00	61940.00	40204.00
2001	85002.00	88574.00	(-) 3572.00
2002	78381.00	34829.00	43552.00
2003	111317.00	36836.00	74481.00
2004(Upto 18-8-2004)	112928.00	29873.00	83055.00
Overall(1996 to 2004)	682851.00	343472.00	339379.00

Income from sale of bamboo, fuel wood, timber, fruits, fisheries, water tariffs, grass, etc.
Expenditure on wages, electricity charges, watchman salary, educational and social work etc.

approximately Rs. 15 lakhs. The standing biomass has significant ecological and environmental value for the village of Nartora. The members of the VRDC have tremendous impact in the social life of the village. Liquor consumption is completely banned and there are no crimes against women in the village. The VRDC has been in a comfortable position to influence even the panchayat decisions for the rural development, in general, and CPR management, in particular. The panchayat body invariably consults VRDC for any new initiative to be introduced in the village.

Conclusion and Policy Implications

The foregoing analysis has obvious policy implications for the governance of CPRs and welfare of the rural poor but the analysis also suggests a general approach for policy designing in CPRs management. Institutional arrangements (both external and internal) are important factors in CPRs management under different property rights regimes. Institutional movements have redefined property rights structure in number of CPRs in NWP aimed at reducing rural poverty. This transition of institutional arrangements became major source of CPRs restoration. It can be inferred from the findings that due to well designed institutional rules and their effective implementation by VRDC the management of community based resource lead towards self-governing system and improved efficiency, equity and sustainability. The basic requirement for effective management of community-based resource is an authority system that can guarantee the security of expectations to the resource users. In case of NWP the VRDC has been playing effective role in upholding the users rights. The paper analyses that institutional designing is a vital procedure, which facilitates and enhances community based resource management systems. Nartora model of watershed seems to hold high promise as an appropriate approach for the management of common pool resources and it can be replicated in other parts of the country where the community manages resources based organizations. NWP experience suggests that common pool resources under common property regime with well defined institutional rules could provide a fascinating option to private and state property regimes and offer bright signals that traditionally proven village level authority can direct the designing of new institutions for self-governance. Distributed governance seems to be most appropriate for designing CPRs management programmes in the initial phase of implementation before withdrawal of technical, financial and organizational support and the project authority may design various components of exit policy for self governing system. The outcomes of this case study suggest that the policy designers of institutional arrangements for CPRs development programmes in rural areas should have an in-depth understanding of the strength and weakness of alternative property rights regimes, social economy, ecological linkages, and users participation.

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Upstream-Downstream Complementarities and Tradeoffs: Opportunities and Constraints in Watershed Development in Water Scarce Regions

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Abstract

In India watershed management is largely focused on local level micro-watershed (typical watershed area between 500-1000 ha) for improved soil and water management. The key underlying assumption in many watershed development programmes is that good land management will lead to increased availability of water resources, especially groundwater resources for productive and domestic uses.

Watershed development projects implemented over the last two decades have some important positive and negative aspects. On the positive side, it has increased net agricultural production on arable and non-arable land. There is development of village level institutions and substantial improvement in the livelihood of some social groups. The less positive aspects of the programme include emphasis on development of land and to a lesser extent on water resources (i.e., emphasis is on increasing water supplies by constructing check dams, rehabilitating tanks, etc). As the planning takes place at the village level, a whole range of wider issues, such as upstream-downstream equity, allocation of water among and within watersheds, flood protection, drought preparedness, pollution of water courses, biodiversity and protection of rare habitats are not considered in the planning process and not included in the development proposals.

This paper presents a conceptual framework wherein it argues that water resources management should play a vital role to improve the sustainable productivity of the watershed. The paper looks at the upstream-downstream conflict created at basin scale due to micro-level planning and implementation of watershed programme through a case study. The paper also presents some research results of an on-going collaborative project of IWMI with Catholic Relief Services (CRS) on four pilot watersheds in the tribal belt of central India. The importance of hydrologic analysis of watershed is brought out for ameliorating upstream-downstream conflicts.

Introduction

There is a great deal of hope bestowed on watershed management and development to meet a variety of needs in regions like south Asia and Africa. Following the recognition that Green Revolution advances were limited to a handful of its better resource-endowed districts, India has made significant investments in 'watersheds' (estimated at Rs. 14,000 crore and Rs. 18,000 crore in the 1996-2001, 9th Plan and 2002-07, 10th Plan periods, or US$ 2.9 and 3.7 billion, respectively)[1]. The most important lessons from the Indian experience is that greater water availability made through watershed development is quickly nullified by the increased use of water by conventional inefficient methods for irrigation and other purposes. The implication is that watershed management as practised now alone cannot satisfy increasing needs and that at some point allocation and demand management of water must be dealt with as well. In this regard, an issue that needs immediate attention is in water allocation and water rights to stakeholders. For example, while successful capture of rainfall in one part of the watershed can lead to improved local availability, this can also lead to problems further downstream if proper water rights are not stipulated. Even at the scale of small watershed itself, there are problems linked to capture by land holders in the valley bottom of improved water resources created by investments in good land management on the hill slopes.

In countries around the world including India, 'watersheds' are seen as the silver bullet of environmental management, water resources improvement, poverty alleviation and a long wish list of rural development of governments and NGOs. By contrast, we support the notion that watersheds are water and land resource assessment and management units. Physical watershed development alone is not sufficient. This must be followed with the critical phase of management practices by the stakeholders for sustainability of the developed system. Special focus is given in this paper and the case studies it summarizes to the spatial and temporal distributions— shortage and abundance—of water. When linked with land resource parameters (soil quality, slope, holding size, etc.), management by users at different scales generates watershed outputs and benefits. There are no doubt that these outputs and benefits have considerable linkages with other aspects of the rural development enterprise—health care, education, markets, etc.; however, we insist that water (and land) management need to be positioned at the centre of watershed management. Water allocation and demand management alongwith water conservation should play the central role in watershed development and management paradigm.

A brief recap of water management in India may provide a useful context in which to consider the growing importance of the watershed approach. India's massive investments in irrigation infrastructure in the post-independence and Green Revolution periods are getting plataeuing and reducing year by year. The heyday of big dams and river valley projects has been replaced by a quiet but highly dynamic and equitable groundwater revolution (Shah, 2001). The groundwater boom since the early 1970s parallels another political trend in the country towards decentralization of services and investment, but has largely been driven by farmers' own investments and sheer determination. Yet there are signs that groundwater too will plateau, constrained by aquifer depletion, water quality problems, and competition with rural and urban water needs. This leaves watersheds and upper catchments as the 'ultimate frontier' for development and the closest

[1]Watersheds are operationally considered to be village-level catchments, roughly 500 ha in size. An estimated 10,000 'micro-watersheds' in India have received some form of external assistance for soil and water conservation, agricultural land improvement, etc. This does not include untold numbers of watersheds managed and improved through farmers and land users' own interventions and investments.

point on land to where the water falls as rain. It is not without its tradeoffs, particularly in semi-arid and arid watersheds, where watershed development has resulted in decreased inflows to important reservoirs, many increasingly used for urban water supplies. The case study presented illustrates the impact of upstream development on downstream reservoir inflow and inequity in water use within villages where development of watershed work was undertaken.

Impact of Upstream Watershed Development on Downstream Reservoir Inflow

Aji 1 reservoir is a water supply reservoir to the city of Rajkot in Saurashtra, Gujarat, and is located at the downstream end of Aji 1 catchment. Of late, the flow to the reservoir was on decline although the rainfall was not. There has been large-scale development of small water harvesting structures within the watershed for artificial groundwater recharging.

Aji 1 inflow during 1968-1999 was considered for the analysis. The flow to the reservoir is hypothesized to be governed by two factors: one is rainfall and the other is upstream development with massive implementation of water conservation structures resulting in abstraction of large quantity of water by water harvesting structures. To separate these two effects, a linear regression between rainfall and reservoir inflow was attempted (Fig. 1).

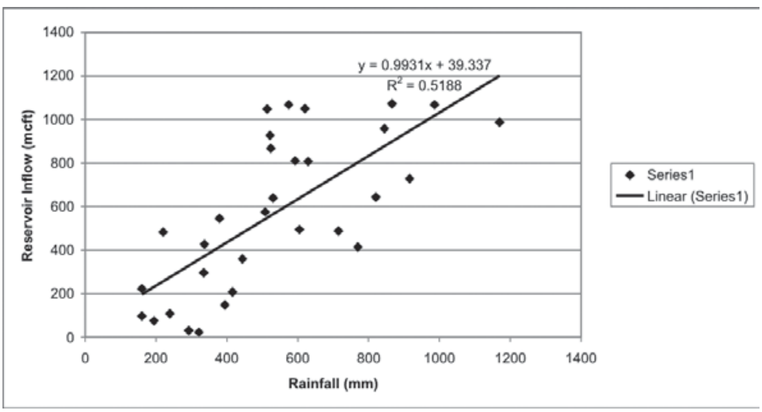


Figure 1. Linear regression between rainfall and reservoir inflow

From the regression equation, the contribution by rainfall is determined and subtracted from the annual inflow to Aji 1 reservoir to get the impact on downstream flow due to upstream development and retention by water harvesting structures. This component is plotted in Fig. 2.

As seen in Fig. 2, the contribution to the reservoir storage was significantly reduced after 1985. During this time an estimated 100 check dams started to come up within the catchment. Definitely there is a downstream impact on reservoir inflow due to upstream development of water harvesting structures. This can also be seen in run-off coefficient variation along with rainfall variation from 1968 to

1999 (Fig. 3). As can be seen that run-off coefficient was fairly high up to 1985 and thereafter it has reduced considerably although the rainfall remained more or less the same during the two periods. The average reduction in run-off coefficient is almost 100 percent indicating the impact of upstream water harvesting structures on downstream flow. The Rajkot city has to now look for another source for its water supply.

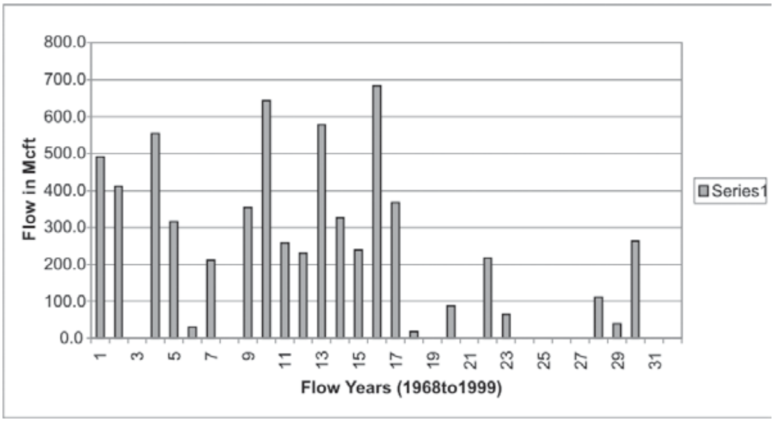


Figure 2. AJI 1 Inflow after accounting for rainfall

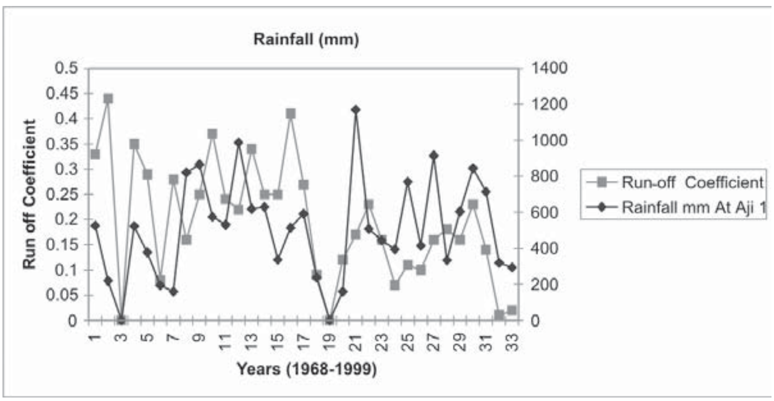
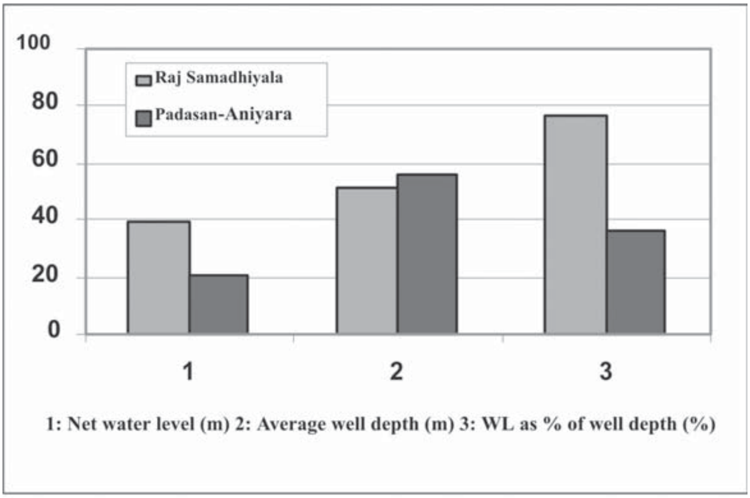


Figure 3. Run-off coefficient and rainfall in Aji 1 catchment

Impact of Watershed Development Within and Without Water Recharge Structures

Raj Samadhiyala (RS) and Padasen (PA) are two neighbuoring villages located within Aji 1 catchment with one difference. Raj Samadhiyala has more than 12 water harvesting structures such as percolation ponds, and check dams which holds not only run-off generated from its own catchment but also a part of run-off generated from upper catchment flowing through Aji river whereas Padasen gets only natural recharge from rainfall. The artificial recharge through watershed development has made the following differences to the two villages as shown in Fig. 4.



Pumping hours	RS	PA
Average (till Dec)	477	81
Till September	153	81
Till Sept as %of total	31	100

Figure 4. Water level in sample wells - 30th September 2001

Present Status of Watershed Management

It appears that in India the art and science of watershed development and management has gone through major change. Initially, in certain water-scarce regions, the 'anarchy model' of watershed development-indiscriminate management of scarce water and land resources-has come to the fore. Institutional and physical (spatial) scale linkages, which are critical to ensure equity and minimize conflicts, have largely been ignored. It has long been acknowledged that technological innovation alone is insufficient to address environmental sustainability concerns. Best watershed practices must be integrated with sound management and governance in order to be viable over the medium to long term. The goals and objectives vary considerably by project and region as well. However, it has been difficult to assess the real outcomes of watershed development of the past decade's massive efforts (Kerr *et al.,* 2002). And land degradation driven by mounting population and other pressures on resources continues apace, suggesting that at best a 'holding pattern' has been reached. In other, more critical conditions, the battle is being lost, resulting in irreversible resource exploitation, abject poverty, out-migration to cities and better endowed regions, and ultimately, collapse of the environmental underpinnings of agrarian societies.

This reads like a doomsday litany of unbridled resource appropriation and exploitation but does it has to be so? There is evidence to suggest that in India over the past decade and a half, since the 1987 drought, a subtle shift has been occurring in natural resource use centered on watershed management. The equity implications of intensification on agricultural and non-agricultural lands alike are important and looked into. Institutional strengthening of community during pre-watershed development phase is given due recognition (Bhattacharya, 2002). What are the key elements of success or failure of these decentralized approaches envisaged to natural resource management? What are the management principles on which future development should take place? Finally, what is the appropriate mix of initiative and investment on the part of government, non-governmental organizations, community groups, and individual users?

This paper seeks to address some of these concerns through the presentation and assessment of a series of case studies[2] on watershed-based land and water management primarily in central India. We develop a conceptual approach that static, historical levels of watershed resource productivity are inadequate to confront today and tomorrow's realities, and that management is the critical variable in ensuring sustainability at various levels including biophysical resource use, local social and economic relations, and the macro institutional and policy contexts. We propose (the outlines of) a series of watershed indicators that will continue to be developed, but which have the aim of establishing reliable assessments of the interactions between management approaches, resource use and livelihoods. An explicit attempt is made to address scale issues - physical, spatial, institutional, social and economic. There is growing agreement that "scale out" means to replicate, i.e., adopt the village-level watershed approach in x number of villages in a state or region, etc. but without explicit attempts to capture the benefits, tradeoffs, or negative outcomes of one watershed project on another particularly in an upstream-downstream relationship. On the other hand, "scale up" means to implement multiple watershed projects in nested scales, particularly village or micro watershed projects concentrated from upstream to downstream in the larger basin of a river or (or large tributary) with explicit recognition that omitting one or more contiguous (sub-) watersheds will not allow the full impacts of scaling-up to be achieved.

The central premise of the paper is that with growing livelihood dependence on water and land resources in a watershed context, there is a need to rise above the individual, household and even village community levels in order to address equity, productivity, and competition for resources. Institutions that function quite well at subsidiary levels are not easily scaled up. Part of the constraint is the policy environment in which line agencies and investments are stove-piped and not integrated to the same degree to which their outcomes are felt by resource users.

Conceptual Framework for Watershed Development

A conceptual framework for watershed development over a period of time is presented in Fig. 5. Initially when the population in the watershed is less than its carrying capacity, the actual production in the watershed is less than its potential

[2]Catholic Relief Services and the International Water Management Institute have developed collaboration in India in 2002 at four watershed sites across a transect of resource endowment and tradition of water harvesting, stretching from Ajmer (Rajasthan) in the west to Dundlu (West Bengal) in the east. This paper draws heavily on the lessons learnt during the process and also brings in and incorporates relevant material from both CRS and IWMI's own institutional experience.

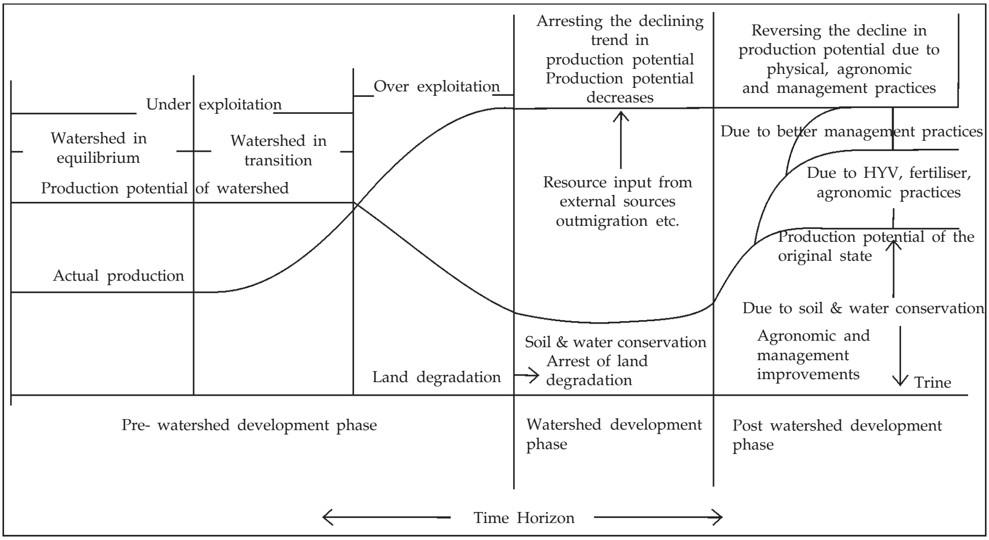


Figure 5. A conceptual framework for watershed development

production and the watershed is said to be in equilibrium condition from the point of bio-mass and sustainability considerations. In other words, the watershed is in its virgin condition. As the population increases and agricultural production takes place, actual production goes on increasing to reach the potential level of production. This is what we call as transition phase. Soon, the actual production level surpasses the potential production, which happens at the expense of over-exploitation and degradation of vital natural resources such as land, forest and water. This over-exploitation and degradation of watershed leads to progressive reduction in potential production of a watershed. At this juncture, the watershed development focuses primarily to arrest and reverse watershed degradation through land and water conservation. During this stage, very little management factors form part of watershed development project. This stage is called watershed development phase. In the post-watershed development phase, it is not only sufficient to raise the production level to its original production but also we need to go beyond that to the existing level of actual production so that sustainability of developed watershed can be maintained. Herein comes the need for improved agricultural practices such as introduction of high yielding varieties and application of chemical fertilizers etc; and land and water management practices to increase agricultural productivity through farming system approaches. Therefore, in the post-development phase attention has to be shifted to the efficient use of natural resource and increasing production potential by: (a) proper estimation and augmentation of available and sustainable natural resource base, (b) improving agronomic practices by farming system approaches, and (c) demand management of water.

Indicators

The following are the broad areas in which we develop indicators to monitor the process and outcome of the watershed development projects:

- Baseline
  - (b) Biophysical
  - (c) Livestock
  - (d) Social, and
  - (e) Economic
- Process
  - (g) Implementation
  - (h) Equity
  - (i) Productivity, and
  - (j) Watershed potential
- Outcome/Impact
  - (l) Livelihoods
  - (m) Environmental quality, and
  - (n) Sustainability
- Scale Linkages
  - (p) Water resources (conjunctive surface-groundwater, upstream-downstream, rainfed irrigated, domestic agriculture…), and
  - (q) Multipliers (the up-spiral).

Scales

There are multiple scales at which watershed interventions are implemented and their benefits are derived. Retaining the focus on water and land-based resources in a watershed context, the scales of management are:

- Household (including intra-household gender concerns, particularly important in the context of migration).
- Community (in large villages, there may be differential approaches by hamlets or caste-based groupings).
- Watershed (this usually brings in government resources, e.g., forest lands, in addition to private and village resources).
- Meso-watershed (groupings of watersheds).
- River basin.

Among the five scales of analysis and development, focus is now on the first three aspects of Indian watershed development projects with limited emphasis on the remaining two aspects. It is hypothesized that the last two aspects are equally important for equitable and sustainable water resources development, use and management in the long run especially when the basin turns from open to closing and closed basins.

Case study

The Catholic Relief Services (CRS), a non-governmental organization is implementing about 200 watershed project in the central Indian tribal belt. Among the 200 and odd projects to be implemented by Catholic Relief Services (CRS), four pilot watershed projects (Nakna in Chhattisgarh, Nayagaon in Rajasthan, Karaighat in UP and Dundlu in West Bengal) were selected in association with International

Water Management Institute (IWMI), Colombo for learning watershed development process and forming guidelines relating to institutional arrangement and technical requirement with needed information base for sustainable watershed development. In selecting these pilot projects, considerable time and energy were spent to select those projects representing the geographic, agro-climatic and socio-economic situation of the watershed projects being implemented by the CRS. The pilot projects started in 2002 are in different stages of planning, development, and implementation. This paper summarizes the process adopted and lessons learnt so far in implementing these pilot projects. The process adopted and the lessons learned will be valuable not only for implementing CRS projects but for similar projects being implemented in the Asian region.

Presently, the whole exercise of watershed development is being undertaken without really estimating how much water that we receive in the watershed, how much of it is stored where and how much of it can be used in a drought year, in a normal and in a surplus year. What we really do not know is the flow paths taken by the various components of the hydrological cycle both spatially and temporally. We would like to know these flow paths before and after the watershed development to match the supply and demand situation. A hypothetical situation of flow paths before and after the watershed development is depicted in Fig. 6a and 6b by taking watershed as a unit of analysis for a time period of one year. This figure is called a finger diagram since it is similar to a hand with five fingers. The width of the finger is an indication of how much water is stored or used in different components of the hydrological cycle. For example, after the watershed development, one would expect that evapo-transpiration will go up and run-off from the watershed will decrease compared to what it were before watershed development. There is a need to continuously monitor the magnitude of the flow paths in the finger diagram to know how much water we are utilizing now in this watershed; how much water we will be using when it is fully developed and what will be the impact of such development on the downstream cluster of watersheds? In the pilot watersheds, arrangements have been made to collect requisite hydro-meteorological and other relevant data to track down the flow paths of watershed water.

River basin in essence will consist of a number of watersheds, the management of which will have impact on the basin management and vice versa. Similarly, the alteration of flow paths in a particular watershed will not only affect the neighbouring downstream watersheds but it will also have impact on the whole basin. Both institutions and hydrological variables, particularly quantity and quality of flow are inter-related as one moves from watershed level to basin level.

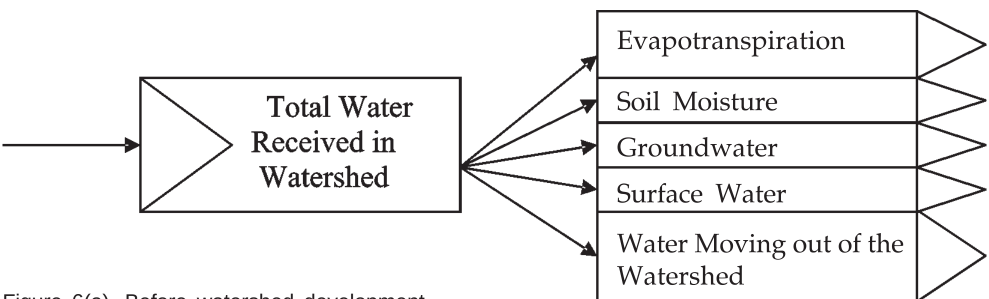


Figure 6(a). Before watershed development

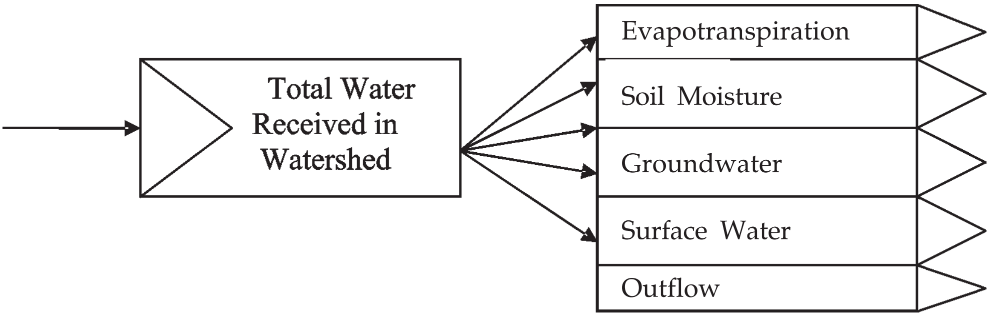


Figure 6(b). After watershed development

Hydrological analysis for managing natural resource base especially water become complex as one moves from watershed to basin scale. The basic problem encountered in watershed management is the complexity of institutional arrangement needed to manage a large watershed such as a river basin which consists of large number of small micro watersheds. Since watershed institutions are hierarchical and embedded within one another, crafting of smooth and co-operating institutional arrangements with forward and backward linkages assumes greater significance. There are attempts to develop institutional mechanisms to manage the river basin in a top down approach. There are also attempts to develop institutions at micro level. However, there are not very many studies to connect these two approaches for managing a large watershed with a number of clustered micro watersheds. This type of study would allow us to test a set of hypotheses on institutional arrangements from which to select the one that would be easy to implement and effective in managing upscaled watersheds.

The bigger problem in managing clustered watersheds will come not from hydrological issues (although they are important) but from institutional issues due to inclusion of extended administrative boundaries. If the institutional interface is not smooth and co-operative, managing the watershed becomes difficult. Therefore, crafting institutions for collective choice decision making and institutional arrangement needed for effective management are the areas for action and adaptive research. As a result of understanding and commitment to institutional issues, IWMI and CRS can play a crucial role in taking forward the clustered watershed approach to upscaling.

Lessons learnt from the On-going Study

The four pilot project studies undertaken by IWMI-CRS collaboration are under different stages of development. Two of the pilot studies are progressing well while the other two are not doing so well. In those that are progressing well the following processes were adopted.

For setting the stage for participatory planning during the pre-watershed phase, the following activities were carried out in an intensive and systematic way.

- Awareness creation (meetings, street play, video presentation, etc.).
- Rapport building through entry point activities.
- Creating program for women and landless.

- Creation of SHGs and mobilizing community for watershed development works.
- Formation of village institutions (Watershed Committee; Core Committee; Hamlet Committee).
- Understanding the existing:
  - indigenous knowledge use,
  - ability for community to make decisions,
  - willingness to share cost of watershed development,
  - status of managing common property resource,
  - equity among all (poor, women, landless), and
  - mechanism for conflict management.
- Identifying the core problems faced by the community through brain storming and prioritizing.
- Hydrologic and socio-economic data collection.
- Preparation of watershed maps.
- Identifying livelihood coping mechanisms.
- Preparation of detailed watershed development proposal and getting it approved by the village institutions and CRS.
- Developing skills and knowledge of PIAs to promote participatory planning.
- Capacity building of village institutions for taking up implementation programme.
- Implementation and monitoring.

From the results of this study, it is seen that for efficient watershed development, the following are important factors.

Community Participation: It is necessary to bring all the communities within a watershed under one fold and make them feel that they all will get benefitted both in the short–term as well as in the long–term; this activity may need a flexible time period (not fixed period as envisaged now) to create awareness, convince all the community to work together and show the benefit through entry point activities. In addition, the Project Management Team should be recruited mostly from the locals within watershed hamlets and implemented through village institutions. They must speak the same language as the locals and must be well versed with their local customs and norms.

Institution Building: A systematic procedure in creating hamlet and watershed committees should be followed using grassroot organization such as SHGs to select committee members giving representation to all. This broad based representation in the committee will have a good impact in bringing the community together. Great care should be bestowed in establishing smooth and cooperative institutions for collective choice decision-making. It is also necessary to rope up the government and other institutions working within the watershed to be part and parcel of this activity.

Data/Information Collection and Collation: Socio-economic, physical and hydrologic information base needs to be developed to the extent possible by the stakeholders and presented in the easily readable forms of charts and maps to the watershed community to make rational decisions. Water should play the centre stage in all development process. Hydrologic measurement of important parameters such as rainfall, groundwater level and outflow hydrograph of flow from the watershed should start simultaneously or even before the start of the watershed project.

Watershed Development Plan: Preparation of a detailed watershed development proposal through intense community involvement is a must detailing the activities envisaged, resources required, present status of that activity and expected benefits. While preparing such plan upstream-downstream impact of developing the watershed and demand management of the water conserved must be given due consideration. Preparation of such a detailed proposal makes implementation of the project much more simpler, monitoring easy and allow corrective steps to be taken in time.

Transparency: Displaying through pasting on each hamlet notice board (wall), the sanctioned work, the cost estimate and expected contribution from the community has a marked effect on the community on the transparency of the project implementation. This has to be followed.

Allocation and Accountability: For each intervention such as nursery raising, pond construction, a user group is identified and they are involved from the very beginning of the project. They maintain and manage the whole activity and share the benefits with Watershed Committee.

Communication: During the implementation phase, it is very essential that the community and others involved in implementation be kept informed of the progress. Achievement and the work that lie ahead for which what should be the community contribution. For this, conduct of Annual General Body meeting with accounts and achievements is a must.

Capacity Building: Capacity building of the village institutions is an important activity for sustaining the assets created and to get the benefit out of it. Presently, this component is not given due importance either in allocation of funds or in the time allocated by the Project Management Committee. This aspect needs to be given utmost importance while formulating the detailed watershed development proposal.

Monitoring: Monitoring the changes in hydrological flow paths and livelihood changes of the communities during and post-implementation phases is important.

Scaling up: Institutional analysis becomes complex as watersheds are scaled up. It is time that we take up a few studies on clustering of watersheds with different institutional arrangement to learn lessons and to arrive at certain guidelines for scaling up of watersheds.

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Watershed Management for Drought Proofing

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Abstract

Indian economy is largely based on agriculture. However, this is a gamble of the vagaries of monsoon as large parts of country's lands are still un-irrigated. Drought is a common phenomena in one or other part of India. Arid and semi-arid regions, practising largely rainfed agriculture are more prone to drought than the other climatic zones, the probability of drought being more than 20 % of the years. Under such situations, resource conservation for drought proofing can be achieved through successful implementation of watershed management programmes. Watershed management approach accommodates the interest of the widest possible number of people. The approach examines the benefit obtained by optimizing production and maintaining environmental integrity. Watershed management serves to conserve and sustain water availability for conjunctive use, food, fodder, fuel and livestock production to bring sustainability in livelihood and to improve socio-economic condition of local population. Central Arid Zone Research Institute, Jodhpur under its R & D programme has developed model watersheds in different agro-ecological zones within arid eco-system. An overview of watershed management programmes for drought proofing and experiences in selected case studies is the focus of this paper. Institutional and policy considerations are discussed to place watershed management in a proper perceptive.

Introduction

India is home to about 18 % of the world's human population and 15 % of the livestock population, but it has only 2 % of the world's geographical area and 0.5 % of pasturelands. The per capita availability of forests in India is about one-tenth of the world average. In India, out of 329 million hectares of geographical area, nearly 50 % land is said to be either waste or degraded. Clearly, the land, water, and natural vegetation resources of the country are under tremendous pressure. Droughts, floods and other climatological extremes are common phenomena in one or other parts of the country. These extremes cause widespread damage and setback to economic development of the country. Drought occurs over an extended period of time and space, making it unpredictable, and losses are not quantifiable easily (Samra, 2002). Therefore, the impact of drought on the techno-economic and socio-economic aspects of agricultural development and growth of nation is severe and results slowly in huge losses. In last 125 years the country has experienced 25 drought years; 1916 was one of the worst drought year when more than 70 percent area was affected. During the last 50 years, India experienced more than 14 droughts, of which 1987 drought was the worst, affecting almost half of the land of country (Anonymous, 2000).

Arid and semi-arid regions of India are more prone to drought than the other climatic zones, the probability of drought being 20 percent of the years. The hot arid regions, covering 32.7 million ha of western Rajasthan, Gujarat, Haryana and part of Karnataka and Andhra Pradesh, are chronically drought-prone with probability of drought being 30 to 40 percent of the recorded years (Narain and Singh, 2002). Often the drought persists continuously for 3 to 6 years at different intensities, as was experienced during 1903-05, 1957-60, 1966-1971, 1984-87 and 1998-2002, causing multiple negative effects on availability of water resources for drinking to human and livestock, and crop and fodder production (Khan, 2002; Khan and Narain, 2003). During severe droughts, a large population of the region migrates with their livestock to far off places with better resource availability. In process, people have to suffer lot of climatic and economic hardships. Under such situation the ecological balance, increase and sustenance in crop production and drinking water availability for drought proofing can be achieved through successful management of land and water resources with simultaneous enhancement in the quality of environment on watershed basis.

Watershed Management Approach

Watershed management is an approach of area planning of natural resources to sub-serve the socio-economic needs of the human society or community concerned. Watershed management programme would permit maximum possible stability through the process of production, consumption and regeneration. This approach has become the key for improvement of water resources and productivity of rainfed areas and ecological restoration. Watershed management is also the process of organizing the use of land, water, and other natural resources to provide necessary goods and services to people, and mitigates droughts (Sheng, 1996 and 1998; Khan, 2002). This approach recognizes the intrinsic inter-relationships among soil, water and land use, and the connections between upland and downstream watersheds. It incorporates soil and water conservation and land-use planning into a holistic and logical framework. This more encompassing approach is achieved by recognizing the positive and negative impacts on people that are caused by planned or unplanned interactions of water with other watershed resources. It is also necessary to appreciate that the nature and severity of these interactions are influenced by how people use these resources and the quantities of resources that they use. The effects of these interactions follow watershed boundaries and, not political administrative boundaries. Watershed management activities on the uplands of one political unit can significantly impact the people on a downstream political unit regardless of the respective land ownership, often resulting in unacceptable downstream or off-site effects.

A watershed management approach to land stewardship accommodates the interests of the widest possible number of people. The approach examines the benefits obtained from land stewardship by optimizing production and maintaining environmental integrity. It also facilitates to ignore effective conflict resolution from a sustainability perspective (Khan, 2002).

Watershed Planning

Planning is the process by which the society directs its activities to achieve goals it regards as important (Weiss and Beard, 1971). A sound planning is a pre-requisite for optimal use of available resources. It involves estimation of short-term and long-term needs and ways to meet these needs, and then a comparative evaluation of alternative solutions with respect to their technical, economic and social merits.

Watershed planning requires a compatible team who can draw a plan that is acceptable to the decision-maker and the public. However, future trends in demography and economy are difficult to predict and hence, elements of uncertainty enter the process. The other noteworthy aspect is that many decisions are more or less irreversible. Participatory rural appraisal (PRA) plays an important role in planning watershed management programme. Because of wide variations in distribution of resources and diversity of issues, watershed planning is always broad in scope. Such planning is needed at different levels and for different purposes (Honore, 1999; Khan *et. al*., 2001).

An intelligent exploitation of watershed resources calls for integrated planning, which is the planning for water, land and other associated resources with coordination among geographical, functional and procedural aspects. It is important to note that unplanned use of resources is likely to lead to an imbalance because the availability of one resource in natural ecology is closely related to the use of another. The two basic requirements that must be met in basin-wide integrated planning are improved coordination of a diverse variety of human activities, and integration and utilization of large amount of information. In watershed planning the following points need consideration.

Creation and Management of Data Base

A sound planning requires a broad database and this should include topographic maps, demographic data, hydrogeological maps, soil properties, data about precipitation, related meteorological variables, water availability and demands, water use and the quality of sources of water. The agriculture related data include cropped areas, cropping patterns, water requirements and yields. This information would be most suitable if it is available for each planning unit, say at sub-watershed level. Besides the magnitude, the variation of demands is equally important to examine how far the various uses are compatible with each other.

Institutional and Policy Consideration

Policymaking and research and development institutions are the key players in planning and implementation of watershed programmes. Organizational participation is often needed to facilitate the cooperation and coordination in natural resources management. The goals and objectives of management and regulatory agencies and the diverse interests of local people need to be integrated to achieve this purpose. To help in attaining this integration, a variety of watershed partnerships, watershed councils, watershed corporations, and other locally-led initiatives have emerged worldwide in recent years (Lant, 1999). Interactions among the social, political, and economic forces of land stewardship with the technical aspects of watershed management are effectively fostered through the activities of these organizations. Some of the organizations are forums for exchanging ideas, views, concerns, and management recommendations, while others are actively responsible for watershed management programmes. The basic idea of these organizations is that all members of society have equal decision-making power and have equity in benefit sharing.

Social, Political and Cultural Considerations

Watershed management schemes influence social, political and cultural life of the area, and it is important to consider these at the planning stage. Watershed management activities that affect social life include building means of communication. The political involvement in watershed management can work for its betterment as well as detriment. If right support is available, it can help in mobilizing funds and facilities. If the political support is not of 'right' kind, it may lead to mutual conflicts, differences, and various other problems. In the process of watershed management, there will be beneficiaries as well as adversely affected people. The challenge is to strike a balance and maintain effective harmony amongst various interest groups.

Administrative, Legal and other Considerations

Since watershed management activities frequently involve work on land, therefore administrative complications due to ownership of land and other related issues are some of the constraints to be resolved. While government continues to be major fund provider, private trusts are known to have funded many public welfare programmes. There are numerous examples where projects were completed by funds collected through donation, arranged labour and through public participation.

Water Rights

Water and land resources in a watershed are owned by various categories of people and institutions. According to the riparian doctrine, water rights are a component of the property interest that arise from the ownership of the land bordering a natural watercourse and include the right to make a reasonable use of water on the riparian land. If the rights are appropriately determined and allocated, the aggregate level of consumption will gradually reach an optimal level. For the rights to be acceptable, it is essential that the historical pattern of appropriation is taken into account. Rights are one of the management tools and rights alone do not ensure an efficient use of water resources. In developing countries with a high density of population, such as in India, most of the farmers have small landholdings. The concept of water banks may suitably be adopted to benefit small and marginal farmers, and landless labourers.

Watershed Management Practices

Watershed management practices are planned changes in land use and vegetative cover and other non-structural and structural actions that are made on a watershed to achieve ecosystem-based, multiple-use management objectives. Watershed management practices implemented in rainfed regions are oriented largely toward rehabilitating degraded lands; protecting soil, water, and other natural resources to produce food, forage, fibre, and other products; enhancing the flows of high-quality water from upland watersheds to downstream places of use (FAO, 1986; Khan, 2002). While many land uses can occur on watersheds, natural resources production and environmental protection are equally important managerial objectives.

Conservation and Management of Natural Resources

Watersheds provide a diversity of benefits to local inhabitants and to a greater number of people through the flow of water and other natural resources off the watersheds. Inhabitants of watersheds manage their land for the production of forage, food, and fibre that they require to survive and generate income. Therefore, water, timber, forage, and other natural resources on the watersheds should be managed in the most economically efficient and environmentally sound combinations possible to obtain the products, commodities, and amenities that people need. Importantly, the consumption or otherwise use of the natural resources on upland watersheds must also be balanced with the needs of people living downstream and in the larger river basin. As a consequence, the proper management of watersheds is pre-requisite to sustaining the flow of water that is necessary to maintain large-scale agricultural production within watersheds. How these watersheds are managed is also crucial to sustaining the flows of other commodities and amenities that are necessary to the livelihood of the people living on the watersheds and to downstream.

Components of Watershed Management

Watershed management involves water and crop management, afforestation, rehabilitation of degraded grazing lands, livestock management, rural energy management and other on-farm and non-farm activities, and development of community skills and resources. Among all these components soil and water are basic resources. Since the shortfall in rainfall leads to drought, therefore, effective rainwater harvesting, conservation and utilization is crucial and critical for success of watershed programmes. In case of drought prone rainfed areas, it is important to identify and execute the location specific water conservation measures so that almost all rainwater during normal and drought years and part of excess water during wet years is conserved, stored and utilized for getting assured crop production and other beneficial uses.

Drought Proofing Measures

Drought proofing measures may be short-term and long-term. Short-term measures are focussed towards providing relief during crises, whereas the long-term measures lead to advance preparedness for drought proofing (Khan, 2002).

Short-term Measures

- Relief work.
- Food for work programme.
- Provide safe drinking water and food grains.
- Opening of fodder depots.
- Cattle camps.

Long-term Measures

- Harvesting, conservation and judicious use of rainwater.
- Rejuvenation of depleted aquifers by adopting suitable artificial groundwater recharge technologies.
- Crop planning for rainfed areas.
- Developing water, fodder and seed banks.
- Rehabilitation and management of degraded grazing lands.
- Launching afforestation programme in a big way.
- Crop diversification and adaptation of horticulture and medicinal plants based landuse models.
- Adaptation of improved cattle breeds and their health management.
- Creation of technological awareness among watershed farmers.
- Providing financial support and credit facilities to watershed farmers for programme implementation.

Watershed Management in India

Watershed, Index catchment and Land Resources Development Area (LRDA) are the approaches for adoption of land resources development programmes. In India, watershed management has conventionally aimed at treating degraded lands with the help of locally available low-cost technologies and through a participatory approach by close involvement of user-communities.

The broad objectives of these programmes are resource conservation for drought proofing, promotion of overall economic development, and improvement of the socio-economic conditions of the local rural population. A large number of programmes were formulated by the Govt. of India as well as the state governments. The Drought Prone Areas Programme (DPAP), the Desert Development Programme (DDP), and the Integrated Wasteland Development Programme (IWDP) were converted into the watershed mode in the late 1980s and 1990s. Several other programmes of various ministries are now being implemented with a watershed as the basic unit because the common theme has been the natural resource management for sustainable development and community empowerment.

Based on a number of studies and discussion in various fora, a set of guidelines has been formulated to develop and execute watershed development projects. These have been updated from time to time. According to these guidelines, the broad aim of watershed development is drought proofing and to ensure:

- Programme-specific and focussed project approach;
- Greater flexibility in implementation;
- Well-defined role for state, district and village level institutions;
- Seeking a combination of GO/NGO as project implementing agencies;
- Removal of overlaps;
- A "twin track" approach to the implementation of projects;
- A greater role for women (women empowerment);
- An effective role for the Panchayati Raj institutions (village level institutions);
- Bringing to centre-stage self-help groups, comprising rural poor, especially those belonging to scheduled caste and scheduled tribe categories;
- Establishing a credit facility from financial institutions (micro-financing); and
- Transparency in implementation.

Case Studies

Under research and development programmes and based on research output, the Central Arid Zone Research Institute, Jodhpur has developed model watersheds in different agro-ecological zones within Indian arid-ecosystem. The basic features and success made in Baorli-Bambore and Sar watershed are presented here.

Baorli-Bambore Watershed

Baorli-Bambore watershed is a classical example of resource conservation for drought proofing in hostile arid ecosystem. This watershed has attracted attention of several organizations in understanding and disseminating the success of resource conservation and sustainable utilization in an arid environment. The watershed covering an area of 870 ha is located at a distance of 39 km from Jodhpur on Jodhpur-Jaisalmer highway (Fig. 1). It includes 673.7 ha of village Ajeetnagar in Baorli Panchyat Samiti, 193.9 ha of Bambore and 2.4 ha of Tulesar villages. Out of total area, 273 ha is under hills and uplands, and cultivated lands occupy 597 ha. The slope of watershed in hilly terrain is 18-26%, in pediment 5-8% whereas, in flood plains it is between 0.1 to 0.5%. In general, soils of the watershed are sandy. Two major streams originate from the upper hilly region and pass through the watershed area. Streams originating in hills drain at a common point i.e. at outlet of the watershed. One of the stream which follows the eastern boundary of the watershed provides input to two *nadis* (ponds) at upper reach and a *khadins* (run-off farming system) at lower reach. The main stream with its minors at upper reach dissects the pediment and alluvial zones before being fully utilized in agricultural fields and re-appearing near the outlet. Except in patches, agricultural fields have flat topography with 0.2-0.5 % slope. The pediments have rolling topography with 2.0-5.0 % slope.

The total number of families in the watershed are 92 with a human population of 540 and average size of family is 5.86 members. The average size of land

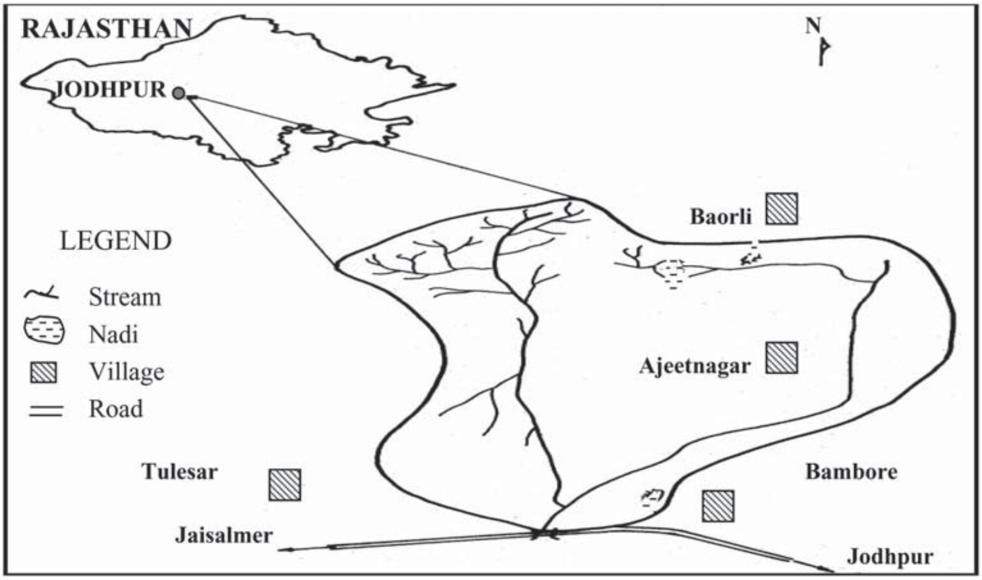

Figure 1. Baorli-Bambore watershed in Jodhpur district, India

holdings in different size group are 1.55 ha (small), 3.16 ha (medium) and 8.34 ha (large) with an overall average of 4.86 ha. The total cattle population is 1142. Rainfed agriculture is a dominant land use in the watershed. Pearlmillet, moth bean, mung bean, cluster bean and sesame are major monsoon (*kharif*) crops. In winter season chickpea and mustard are grown on stored profile moisture.

Achievements

Based on natural resources and inputs from Participatory Rural Appraisal, a master plan for adopting developmental activities and suitable land use models was prepared. The following watershed management activities were taken up.

Soil and Water Conservation Measures: As envisaged in the master plan, soil and water conservation measures was given priority for implementation, 2270 m long contour bunds were constructed in 15 ha arable lands. Three check dams with stream gauging structures on main stream and several earthen and sand bags gully plugs were constructed to protect lands from erosion, protection of arable lands from sand and gravel casting, conservation of run-off and safe disposal of excess water.

With the adoption of soil and water conservation programmes the highly degraded lands which were untilled before initiation of watershed management programme have been brought under crop cultivation. With the construction of gully control structures, gullies have been reclaimed, soil moisture regime has been improved, and groundwater reserve has been enhanced through recharge processes.

Khadin: Three *khadins* (run-off water based farming system) in sequence covering 3 ha, 6 ha and 10 ha have been constructed on farmer's fields. The input to *khadins* are uplands with catchment to command area ratio of 12:1. With the construction of *khadins* the land productivity has improved significantly. The farmers of *khadins* are taking chickpea and mustard on stored profile moisture. In the year 2001 farmers could get Rs. 20,000-25,000/ ha net return out of sale of chickpea. Even during the severe drought of 2002 when nothing could be grown due to moisture limitation, farmers of *khadins* were able to grow sorghum for fodder and earned Rs. 28,500/ ha as gross income. The year 2003 was a good rainfall year and all the *khadins* received rainwater in excess (20-45%) to their capacities. In *rabi* (winter) season 2003 chickpea and mustard were taken on stored soil profile moisture in 19 ha *khadin* farms as well as in 24 ha outside with pre-sowing irrigation from *khadins*. *Khadins* have appreciably changed the hydromorphology of the watershed.

Tanka and Nadi: Five *tankas* (underground reservoir) of 20,000 litres capacity each and one *tanka* of 100,000 litres capacity were constructed for raising nurseries, forest plants on field boundaries and developing fruit orchards. The stored water in bigger *tanka* is used for developing *Zizyphus* (ber) orchard using drip irrigation. In order to improve drinking water availability, both for human and livestock in the watershed the existing *nadis* (surface ponds) have been renovated and structured to store 87000 m^3 rainwater. This has helped the local population to save their time and energy used in transporting water from long distances.

Crop Production and Productivity: Several conservation agronomic measures have been undertaken to increase the land productivity and to reduce the erosion in the watershed. Beside conservation measures, crop demonstrations were conducted on farmers fields with improved packages and practices which included certified improved varieties of seeds, balanced fertilizers, maintaining optimum plant population, soil working, and control of pests and pathogens. Adoption of agronomic practices resulted in better performance of crops due to increase in soil moisture and enrichment of soil fertility. By the year 2003, improved variety of major crops had covered over 80% arable lands. Impact of technology on productivity of monsoon (*kharif*) crops is presented in Table 1.

Table 1. Impact of improved technology on productivity of monsoon crops

Crop	Grain yield (kg ha^{-1})			Reasons
	1999*	2003	Increase (%)	
Pearl millet	380	1224	226	Introduction of hybrid varieties (HHB-67, MH-169 and Raj-170) and improved management practices
Mung bean	340	850	150	Introduction of hybrid variety (K-851) and improved management practices
Moth bean	210	580	171	Introduction of hybrid varieties (RMO-40) and improved management practices
Cluster bean	350	850	140	Introduction of hybrid varieties (RGC-936) and improved management practices

* Before initiation of watershed management programme.

Conservation Forestry: Conservation forestry has an important role in regulating water regime, soil loss and maintaining biological diversity. Large scale plantation on field boundary as well as in degraded uplands has been taken up in the watershed. Total of 2650 saplings of *Acacia senegal* (1900), *Tecomella undulata* (250) *Dalbargia sisso* (250) and *Ailanthus excella* (250) were planted and maintained with supplemental irrigation from *tankas* (underground storage tanks). Large scale plantation has improved the ecology of watershed.

Silvi-pasture: Availability of adequate fodder supplies to maintain large number of animal population was a major constraint before initiation of watershed management programme. In order to check animal migration and malnutrition by creating fodder bank, silvi-pasture activities were taken up in the degraded community owned uplands. Over 2250 plants of different forest tree species were planted and *Cenchrus ciliaris* grass was sown between trees spacing. Ditch-cum-mound fencing around the area was constructed. Three land use models of silva, silvipasture and controlled grazing land were developed. Hydrological monitoring under different land use models is being carried during monsoon period. The average annual grass seed production from silvi-pasture block is about 100 kg ha^{-1}.

Horticulture: Under crop diversification programme, large scale plantation of *Zizyphus nummularia* (ber) and *Cordia mixa* (Gunda) were taken up. Over 920 ber saplings were planted and maintained on farmers fields. In addition, ber budding of Gola variety on 180 rootstocks was done. On the boundaries of *khadins, Cordia mixa* saplings were planted and are being maintained. With the development of fruit orchards farmers have economically benefitted even during severe drought year.

Improvement in Livestock Production: Several interventions in balanced nutrition and disease control were taken in watershed area to increase the milk productivity of cow and buffalo. Efforts were also made to increase the availability of green and nutritious fodder for the animals. It was observed that milk productivity of cow and buffalo increased by an average of 118 and 61 %, respectively. The increase in cattle and buffalo population during 1999-2003 was 58 and 204 %, respectively (Table 2). This was possibly due to increased water and fodder availability and health management by watershed farmers.

Table 2. Impact on cattle population and milk production

Description	Cow			Buffalo		
	1999	2003	Increase (%)	1999	2003	Increase (%)
Population (No.)	148	234	58	42	128	204
Milk production (kg/animal)	4.8	10.5	118	11.5	18.6	61

Groundwater Recharge: Construction of check dams, *khadins*, *nadis* and other mechanical measures have significantly improved the groundwater reserve in the zone of influence in the watershed. There was considerable increase in groundwater level to the extent of 1.8-3.5 m annually. Data on recharge processes by using artificial recharge method of water ponding (Fig.2) indicated that at the initial stage of water inflow in pond and increased wetted area during June the rate of deep percolation was as high as 120 mm day^{-1}. De-siltation of pond before the monsoon season hastens the recharge process. Thereafter, the percolation followed the receding trend till next high spell in the month of August. Deposition of fine soil matrix on pond surface reduced percolation rate. Due to heavy recharge from pond, the rise in wells located in immediate vicinity of structure was instant.

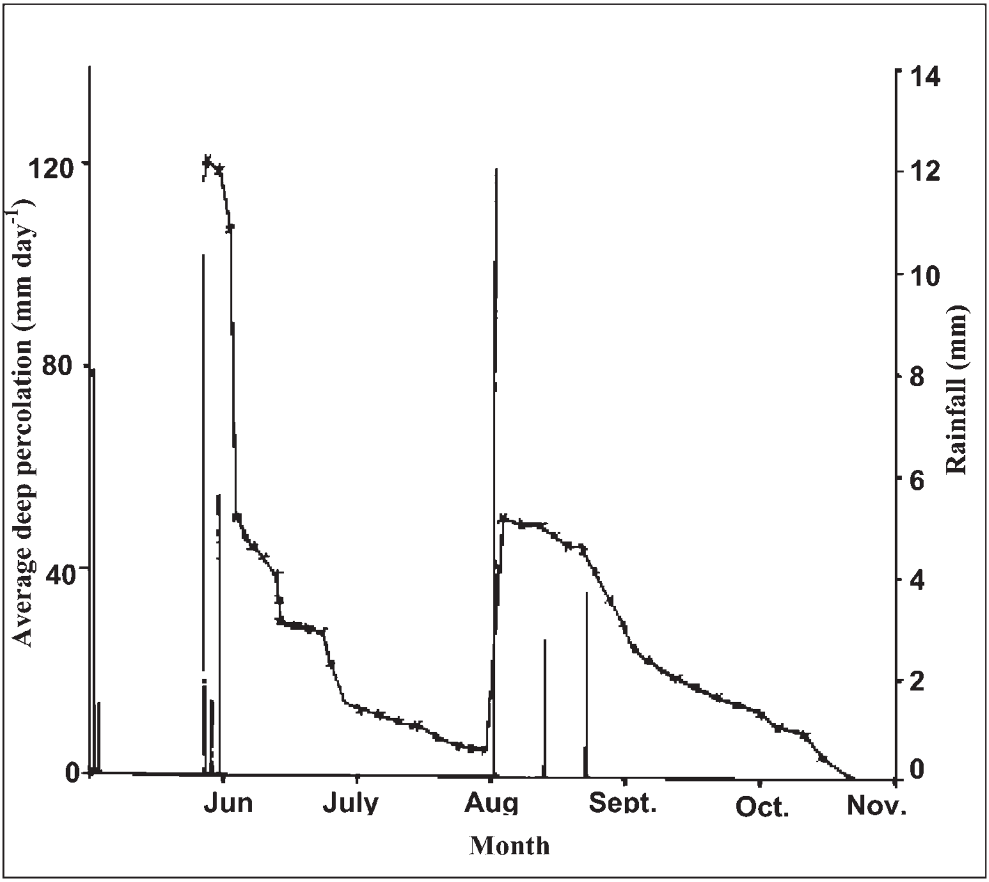

Figure 2. Recharge processes due to water ponding (2000-2004)

Hydrological Monitoring: In watershed the hydrographs obtained from untreated uplands, treated area with silvi-pasture, forest and agriculture fields with conservation measures revealed relative recession time in untreated area followed by treated agriculture fields and forest block. The initiation of run-off was earliest in the untreated areas, whereas the same was delayed by 15-30 minutes in case of treated blocks, indicating the impact of conservation measures on infiltration of rainwater. As compared to untreated area, the reduction in silt load in run-off from treated silvi-pasture block was 60 %.

Sar Watershed

Sar is another watershed developed by CAZRI and acclaimed for its success on several fronts. This watershed not only improved land and water productivity but also brought sustainability in food, fodder, fuel and drinking water during droughts. This was possible due to active cooperation and full participation of local people.

Sar watershed, covering an area of 1480 ha, is located about 30 km south of Jodhpur city. It covers villages in Sar, Rajor-ki-Dhani, Kheda, Sarecha and Phinch.

The area experiences a typical arid climate with annual rainfall of 368 mm in 9-10 rainy days. The watershed area comprises alluvial plains, low sand dunes and sandy undulating plains, hills and rocky eroded pediment. Several streams, originating from the isolated rhyolite hills travel through pediment and agricultural fields and drain into *nadis* or suffocate in the duny complexes. The rhyolite hills are highly degraded due to mechanical weathering and exploitation of vegetation.

Achievements

The benefit of the watershed activities are substantial in terms of water availability and higher crop, fodder and milk production (Khan, 2002). Imposition of land treatment technologies resulted in reduced run-off and higher moisture conservation to benefit crop production. Soil and water conservation measures in agricultural fields reduced surface run-off and enhanced *in-situ* moisture conservation on slopes. In the untreated watershed, average annual run-off was 133.5 mm (28%) with the soil loss of 5.42 t ha^{-1}. Conservation measures namely contour bunds with vegetative barrier was found most effective exhibiting only 19.1 mm or 4% run-off and 0.67 t ha^{-1} soil loss. Contour vegetative barrier of *Cenchrus setigerus* and contour bunding were also effective in controlling run-off as well as soil loss. Peripheral bunding, a common practice in this region was effective for *in-situ* moisture conservation.

Conservation Forestry: Under afforestation programme, 42,344 saplings of *Acacia tortilis, Acacia senegal, Acacia nilotica, Prosopis juliflora, Prosopis cineraria* and *Chlorophospermum mopane* were planted during 1991, 1992 and 1993 on common community grazing land. The saplings were established with supplemental irrigation from conserved water in a 142 m^3 masonry open *tanka* constructed in one part of watershed. The overall plant survival was over 79%. Development of silvipasture in degraded grazing land with conservation measures and seeding of improved strain of *Cenchrus ciliaris* (CAZRI-358) reduced run-off by 28-63% and soil loss by 12-54%, thereby improving water regimes and overall ground cover. Social fencing for 5 years with active participation of watershed farmers and conservation measures helped in improved forage production by 280% (2.15 t ha^{-1} yr^{-1} dry matter) and improved woodlot by 416%.

Rainwater Harvesting and Recycling: Construction of *tankas* of 10,000 litres capacity at 15 locations on farmer's field for supplemental irrigation in the fruit orchards and for raising ber (*Zizyphus mauritiana*) and forest nurseries raised farmer's income by Rs.6000 to 7000 per annum. This has been achieved with the sale of fruit and plants. With supplemental irrigation (60 litres/irr./plant) the fruit yield of ber and pomegranate increased significantly. Compared to control (no irrigation) increase in fruit yield with 2,4 and 6 irrigation for ber was 46.4, 80.3 and 124.0% and in the case of pomegranate it was 69.8, 112.5 and 191.7%, respectively.

Before the initiation of watershed management work drinking water was scarce in villages. To improve drinking water availability *tankas* of different capacities with artificially constructed catchment were developed. Roof water-harvesting system at the local school to store 64,000 litres and at Matt (religious temple) to store 50,000 litres rainwater in *tanka* were also developed. These additional water resources are sufficient to meet drinking water demand for 272 persons round the year. The resultant benefit of rainwater harvesting system is Rs.1,36,000 annually, saving was about the cost of hauling of water by farm women from long distances.

Crop Production and Productivity: Conservation measures in conjunction with improved agronomical practices and improved varieties resulted in higher grain yield of pearlmillet, mung bean and cluster bean. The highest average grain yield of pearlmillet (HHB-67), mung bean (K 851) and cluster bean (RGC 936) was 159, 105 and 467 kg ha^{-1}, respectively in plots treated with contour bund + vegetative barrier, followed by contour bunding, peripheral bunding and lowest was obtained in contour vegetative barrier. However, farmers preferred peripheral bunding over other measures, because it acts as property bund-cum-fence against stray cattle. The adoption of improved varieties on large scale was preferred by the farmers almost for all crops. Initially project staff facilitated farmers in purchase of improved varieties from cooperatives. However, from fourth year farmers adopted independent approach on their own level for purchase of improved seeds. They also facilitated farmer from other areas in adoption of improved crop husbandry.

Groundwater Recharge: In order to induce groundwater recharge, an existing pond was desilted and structured to store 28000 m^3 expected water yield from its catchment. Three 20 m deep infiltration wells in the bed of pond were constructed. The annual run-off from harvested catchment ranged from 28-67% of the rainfall. In a season 18,000-20,000m^3 stored water was added to depleted aquifer through induced recharge. The enhanced groundwater is a major source of drinking water during lean period.

Awareness Programme: Watershed farmers as well as farmers from nearby villages were exposed to technological advancement through visit of demonstrations on field days and on campus and on-farm training programmes. Field days were organized every year at the village level. Farmers were free to discuss the strengths and weaknesses of the programme after witnessing the results on farmer's fields in watershed. The farmers fair at Institute headquarters was an annual feature, where farmers had interactions with the specialists. The event was an opportunity for the farmers to see for themselves technologies developed by the Institute for conservation and sustainable utilization of natural resources in fragile arid ecosystem. Overall response of farmers was encouraging as evident from participation of large number of farmers in these events.

Conclusions

Watershed management for drought proofing has very high potential in rainfed arid areas. However, success in attaining livelihood, upliftment of socio-economic status and environmental objectives through watershed management depends largely on proper technological interventions, equitable access to water resources for stakeholders, people's participation in decision making as well as in programme implementation, infrastructure facilities, access to market, institutional support and credit facility. More studies and demonstrations are needed for creating interest and awareness among the stakeholders in watershed management programmes.

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Mainstreaming the Margins: Water Control Strategies for Enhancing Tribal Livelihoods in Watersheds

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Abstract

Around 100 districts in seven Indian states, cutting across the belly of the country, are home to more than 70 percent of India's Scheduled Tribe population. These districts have hilly and undulating topography and moderate to good rainfall cover and forest area. Synthesizing the results of around 40 studies taken up in this region under the Central India Initiative (CInI), this paper argues that watershed development programs can play an important role of enhancing tribal livelihoods in this region provided they are suitably re-designed to suit the specific context and needs of the tribal people.

The paper argues that while the conventional, conservation oriented, ridge-to-valley approach of watershed development addresses the question of arresting and reversing degradation of natural resources, it does not adequately address the issue of tribal livelihoods and may, in fact, lead to greater inequities. It suggests that a shift from focussing on the 'degree of resource use' to the 'productivity of resource use'; and from the conventional ridge-to-valley to a farms-to-commons approach would have salutory impacts on the livelihoods of the neglected and marginalized tribal communities.

Introduction

The projections for India's population in 2050 range between 1345 and 1587 million (United Nations, 1999; Visaria and Visaria, 1995, 1996). In order to adequately meet the food requirements for the growing population, India will need to produce between 370 and 440 million tonnes of food grains in 2050 (NCIWRD, 1999). The net sown area, currently at around 140 million hectares (m ha), is unlikely to expand and even the most optimistic projections estimate it to be 145 m ha in 2050 (NCIWRD, 1999). While the country might need much larger diversions of available water for the purpose of conventional irrigation projects, the fact remains that solution to the problem of meeting the food, fuel wood and fodder needs of the country's significant rural population hinges crucially on the quality of farm lands and soils being maintained. It is estimated that approximately 16 tonnes of soil is being washed away per hectare of area due to erosion and run-off each year (Tideman, 1999; Honore, 1999). If not controlled urgently, this degradation in farm lands may make the task of producing the necessities of life very difficult, if not impossible. As Honore (1999) points out, 'Soil and water are among the most important natural resources within the eco-system. They form the very basis of life. Yet the exploitation of these precious resources, without checks and balances, has led to their rapid degradation'.

Recognizing this urgent need to conserve the soil and water resources across the length and breadth of the country, the Government of India and the state governments have supported watershed development programs on a large scale. These operate with the twin objectives of soil and water conservation and protecting the livelihoods of the rural poor. The centrality of the twin objectives is even more evident when one looks at the indicators for assessing the impact of the project activities (Bollom, 1998). The Indo-German Watershed Development Program, a torch bearer of the watershed development programs in India, regards the former as very basis of the project activities. And in it 'each and every project activity is scrutinized keeping in mind its contribution to conservation objectives' (Honore, 1999).

While integrated watershed development has been adopted as a major approach all over the country, its importance is seen as being particularly high in regions of the country where agriculture is dominantly rain-fed. These areas account for 65 percent of the net sown area and contribute only 45 percent to the total food grain production. The emphasis on watershed development recognizes that rain-fed areas need to be developed and managed in a sustainable manner. In effect, the purpose of watershed development is to increase the carrying capacity of land and water resources in rain-fed areas (OIKOS and IIRR, 2000). The realization that watershed development programs can contribute in a major way can be seen as translated in the fact that more than 10000 watershed projects have been implemented under the new guidelines of the Drought Prone Areas Program (DPAP) over the past decade with two-thirds of these being concentrated in Andhra Pradesh (24%), Madhya Pradesh (17%), Uttar Pradesh (10%), Gujarat (8.6%) and Tamil Nadu (7%) (Rao, 2000).

Tribal Context

Roughly hundred districts in the rain-fed areas falling between 18° and 25° latitudes north of the equator and cutting across the belly of the country from Banswara-Dungarpur (Rajasthan) in the west to Purulia (West Bengal) in the east are home to more than 70 percent of India's scheduled tribes population. These districts form a contiguous region which is sometimes referred to as the central Indian tribal homelands (Fig. 1).

The districts have fair to high annual rainfall (750 mm in the western districts going up to as high as 1500 mm in the eastern districts), undulating, hilly and mountainous terrain and a fair forest cover. Tribals here derive a portion of their livelihoods from rain-fed *kharif* (rainy season) farming of millets in the west and paddy in the east. The low proportion of irrigated area (roughly 11%) implies that hardly any post-monsoon cropping is done. The balance of their livelihoods is derived from either a gathering economy, dependent on forests or from wages earned by way of seasonal migration extending to several months. Despite high

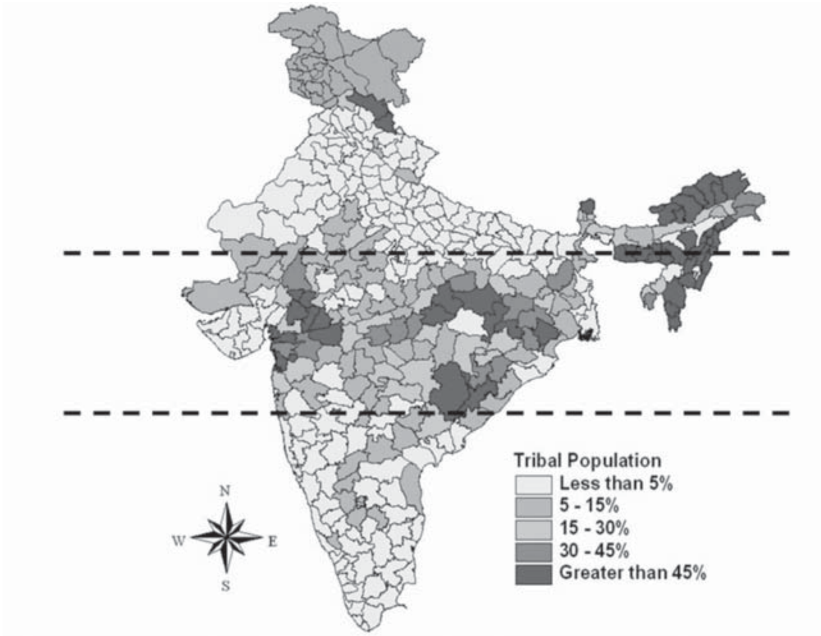

Figure 1. Central Indian tribal homelands

rainfall, the tribals lack any facility for harvesting and accessing water for stabilizing the yields from their *kharif* crops and taking a second crop.

Presence of a profusion of sharp hillocks and forest area in the rural landscape, highly sloping lands, high intensity of rainfall causing huge run-offs and large number of perennial streams are some of the bio-physical features of this region. Remoteness from commercially developed areas, social isolation, strong presence of residual norms of communal sharing, and the continuation of 'immediate return systems' (Pfeffer, 2003) are some of the key social attributes displayed by the tribal communities. The norm that livestock can graze freely on any land after the *kharif* season is prevalent even till this day in huge tracts of tribal lands extending east of Betul district. A large majority of these tribal people were forest dwellers and first-generation agriculturists and hence do not have a tradition of resource-intensive agriculture. The agriculture was, and in some areas, continues to be, of the 'shifting' type. While the abundance of nature has been replaced by competition for residual biomass in several areas, their essential outlook towards life has not changed significantly. As the pressure of population mounts and forests come under increasing threat, their livelihoods have come under severe stress as reflected in Table 1. Tribal districts identified under CInI[1] have lagged behind other areas of

[1]Central India Initiative (CInI), a collaborative research program between the International Water Management Institute (IWMI); Sir Ratan Tata Trust (SRTT), Mumbai; Professional Assistance for Development Action (PRADAN), New Delhi and the NM Sadguru Water and Development Foundation (NMWSDF), Dahod, is aimed at identifying factors that lead to successes or failures of water-centric livelihood interventions among the tribal people in this region. The initiative recognised that improved 'water control' strategies would not only help strengthen tribal livelihoods but also transform the tribal homelands into future granaries for the country.

Table 1. District level comparison of tribal districts with all India averages

Parameter	Average for tribal districts in central India	All India average
Population density*	200.23	324.00
% Forest area*	32.75	19.39
% Rural population**	85.35	74.29
Sex ratio*	970	927
Under 6 sex ratio*	954	933
Infant mortality rate*	81.78	72.77
% Population below poverty line*	42.67	26.00
Extent of hunger (% households going hungry)*	5.63	2.96
Literacy*	60.09	65.38
Female literacy*	62.74	54.28
Female work participation (%)*	26.92	23.28
Average CMIE's index of development*	84.09	100.00
Irrigated area as % of cultivated area**	11.00	34.00
Fertilizer consumption (kg/ha)**	32.32	63.88
Average value of crop output per ha**	2697.55	8578.00
% Net irrigated area to net sown area**	14.98	33.59
% Net area irrigated by major systems**	3.66	9.89
% Net area irrigated by minor irrigation**	16.83	42.28
Groundwater**	11.32	24.28
Surface lift irrigation**	5.51	18.00

* Average for districts in central India based on data from 70 most tribal districts.
** Average for districts in central India based on data from 30 most tribal districts.
Data Sources: Shah and Singh (2003); Census of India (GoI, 1991); Profiles of Districts (CMIE, 1993, 2000; Debroy and Bhandari, 2003).

the country on several parameters. Debroy and Bhandari (2003) have presented a list of 69 'backward and most-backward' districts of the country and as many as 30 CInI districts find a place in their list, alongwith other districts of Uttaranchal, Uttar Pradesh, Bihar, West Bengal and the north-eastern states, many of which also have large tribal populations. This paper looks at the impacts and potential of watershed development interventions in this region, in the specific context of the tribal people.

How Tribal People Relate to Watershed Development Interventions?

The economy of the tribal people in central India, as perhaps everywhere else, can be defined as an interaction between three livelihood spheres: forests, agriculture and migration. While the traditional sphere of tribal livelihoods – forests – has been rapidly shrinking, the alternative sphere of agriculture could not take its place, partly due to the fact that the state did not focus much attention to this aspect of tribal life. As an important sphere of economic activity progressively shrunk in terms of its contribution to their livelihoods, tribal people have been forced to devise mechanisms for survival. Reduction in sustained opportunities from the forests; deterioration in the quality of land resources; missing focus of public policy on tribal agriculture; and increasing population pressure have created a rather common pattern of tribal misery in India. All this forced the tribal people towards migration. We feel that the biggest and most significant impact that watershed development programs can make on tribal livelihoods is by ensuring livelihoods for tribal people in or close to their homelands, thereby contributing towards a reduction in forced migration. However, so far, this potential has not been tapped to any significant extent.

Along with other excluded categories, such as landless, sub-marginal farmers and women, tribal people, even when they have land, have not been able to benefit from watershed interventions (Pangare, 1998). Investment in soil-water conservation alone does not seem to have exerted any significant impact on poverty reduction except through direct employment generation during the implementation of the watershed program (Fan *et al*., 2000). Positive impacts on employment are also indicated from a review of the National Watershed Development Project for Rain-fed Regions – NWDPRA (Deshpande and Narayanmoorthy, 1999). While these results seem encouraging at first, Shah (2001a,b) rightly points three important shortcomings of the reported impacts on employment and migration: (i) increased availability of direct employment during the period of the implementation of the watershed program should not be confused with a sustained increase in employment opportunities as these 'direct' employment opportunities are only one-time and vanish soon after the project implementation period is over; (ii) increased crop productivity resulting from improved soil-moisture alone is often found to be small and uncertain; and (iii) significant reduction in migration is achieved only for families which benefit in terms of substantial increase in irrigation provision. Enhancing access to improved water control[2] is, therefore, critical to the migration-reducing impact of watershed interventions. This has also been noted by Kerr *et al*. (1998) in a review of a number of watershed programs. Likewise, in a study of people displaced by the Sardar Sarovar Project (SSP), Sah (1999) found that access to irrigation has helped 83 percent of the sample households in containing migration. In a comprehensive review of watershed development programs implemented under the new guidelines of the DPAP, Rao (2000) reports significant reduction in migration as a result of an additional 1.70 lakh ha having been brought under irrigation in nearly 2000 micro-watersheds.

Thus, soil and water conservation interventions succeed in checking and retarding forced migration only when these interventions are coupled with provisioning of increased water control for the poor. However, since water control provision in watershed programs is restricted to a few water harvesting structures, any substantial increase in access to improved water control is achieved by only a few farmers in any watershed (*see* Shah and Memon, 1999). Again, by virtue of the geographical location of their lands (on the slopes) and the fact that tribal people form weak demand-groups in the watershed community, tribal people are most often not among the people who benefit substantially from watershed programs.

[2]We define 'water control' in terms of an assured access to timely, reliable and adequate availability of water for use by the tribal farmers.

Can the programs and interventions be modified and re-designed to suit the social and bio-physical context in tribal areas? We present here a few cases of interventions which have broadly worked under the 'watershed' framework and managed to ensure substantial returns for the tribal communities.

Watershed Interventions in Vidarbha

With a view to see how tribals participate in watershed programs and to what extent they benefit from these, a study on watershed interventions in Vidarbha (Khorasi, 2004) was undertaken under CInI. Watershed projects in Vidarbha have been implemented for the last one and a half decades by government agencies as well as NGOs. These programs, particularly those implemented in Wardha and Yavatmal districts, have attracted wide attention. Initial efforts at natural resource management work using the watershed development approach were started by the Association of Sarva Sewa Farms, an NGO based in Wardha. The watershed development programs followed the model of Indo-German Watershed Development Program (IGWDP) and implemented with financial support from KFW routed through the National Bank for Agriculture and Rural Development (NABARD) and under the technical supervision of WOTR, Ahmednagar at several locations in Vidarbha. Subsequently, watershed development projects were also supported by the Government of Maharashtra through their Drought Prone Area Program (DPAP). The DPAP supported projects have been implemented on quite a significant scale. Some other agencies also supported watershed type projects with slightly different approaches. Notable among these were those implemented by Action for Food Program (AFPRO), AFAM and the Aga Khan Foundation (AKF). Roughly, around 100 watersheds have been treated. Of these, about 20 have been under the KFW-NABARD-WOTR program, some 10 odd under assorted support and the rest with the DPAP support. Not all these projects were restricted to tribal areas but also included areas in which the non-tribal families lived.

To examine the relationship between tribals and watershed development projects, eight projects, which enjoyed sound reputation for their implementation quality, were chosen. The key features of the chosen projects are shown in Table 2.

Table 2. Key features of projects chosen for study

Type of intervention	Name of village	Donor/ Agency	Area of watershed (ha)	Population	Families	Tribals (%)
WDP	Rajni	ASEEFA	658	560	117	100
WDP	Kakaddara	ASEEFA	155	310	74	95
IWDP	Vasari/Yeoti	AKF	530	1792	354	62
WDP	Wagdara	AFARM	510	540	110	76
WDP	Dharamwadi	IGWDP	686	680	118	100
WDP	Garamsur	IGWDP	1291	812	184	70
WDP	Andharwadi	S&W Dept.	1525	205	49	100
Forest Protection	Lekha-Mendha	Vriksha-Mitra	(91% forest)	361	65	100

Source: Khorasi (2004); Mardikar (2003).

The study found that tribal people enthusiastically took to the tasks involved in watershed development in all the watersheds. This was due to two main reasons. The first was the relative homogeneity of the tribal society and hence the facility with which the implementing NGO could bring in a degree of social cohesion for implementation of the project. The second was the fact that the tribals in all these watersheds were used to only un-irrigated *kharif* paddy. The extent of migration in this area is lower than that in western Indian tribal districts since the land is able to provide the simple needs of tribals even on a single crop basis. For their cash needs in the rest of the year, they depended on either collecting minor forest produce or on wage work. The watershed development projects provided employment to a large number of tribals in carrying out the bio-physical activities and for engaging them, they did not have to travel far. Thus, watershed projects were popular for their wage work opportunities during the implementation phase. The study also notes that the bio-physical activities had little impact on tribal livelihoods post-implementation. Continuous Contour Trenches (CCT), a dominant component for treating ridge lines and similar ridge line treatments do not contribute to tribal livelihoods at all. It is true that the labour component of these activities provides wage benefits to tribals, but the effect of conservation of moisture brings benefits to lands in the valley portion largely owned by the non-tribal communities. Plots owned by tribals are usually at the hill-top or on the hill-sides and such treatments seldom benefit these plots. The effect of ridge line treatment on tribal farms is even weaker in those watersheds which had a profusion of smaller hillocks. Post-watershed tribals are more or less where they were. At the same time, the study notes that tribals did benefit from the incidental components of the projects. The self-help groups created at the time of implementation of the watershed program have been doing reasonably well. Savings and bank linkages have helped reduce their dependence on moneylenders.

On the other hand, another CInI study (Mardikar, 2003) in Kakardara, a tiny tribal village in Arvi tehsil of Wardha district, clearly brings out how small improvements in the way watershed programs are implemented can significantly enhance the benefits to the tribal people. This village has an area of 155 ha with seventy four families, most of them belonging to the Kolam tribe. The village has undulating terrain with average slope ranging between 5 and 10 percent. A well known NGO, ASEEFA, worked there till the late nineties. In the late 1980's, they initiated a project for watershed development in the village. The work started in 1987, based mainly on *shram daan* (voluntary labour contribution). The project was implemented at a very low cost and the work included: (i) contour bunds, using an implement called *Keni*, in 210 acres of farm lands; (ii) farm bunds, as desired by farmers; (iii) 450 gully plugs; (iv) earthen dams on streams flowing through the watershed; (v) 60 acres of afforestation; (vi) community well and, at a later stage; (vii) two irrigation schemes.

The farmers were first shown the benefits of doing bunding on their farms. They were provided with *keni* (a simple bullock-drawn implement), the one implement required for undertaking the bunds on their own. The bunds yielded sound results the very next year when despite a dry patch, crops did very well in this village while the rest of the region saw large scale crop failure. The tribal people acquired huge confidence in the process and are now willing to come forth for the work required for other components. When the organisation invested in earthen dams, they made sure that a community well was constructed to address the drinking water needs of the village. The dam stored water and that made the community well, just downstream of the dam, a perennial source for drinking water in the village. Subsequent installation of irrigation schemes was really not a part of the initial watershed development plan *per se*, but since the community had responded so well, the schemes were installed.

The project recorded significant and sustained benefits to the tribal people. Significant rise in crop yields were reported (from 100-150 to 400 kg/acre in the case of cotton and from 50 to 150 kg/acre for pigeon pea). From the extra incomes and small savings, the community bought an additional 50 acres of land for tilling. The cost of the watershed development was a mere Rs. 1.02 lakhs, excluding the investments in the irrigation schemes. The project did not follow the dominant 'ridge-to-valley' approach and replaced it with a 'farms-to-commons' approach. It certainly treated the ridges with appropriate soil conservation measures as well as plantation and undertook works on gullies, but that was done after the farms had been treated and after short run benefits of the intervention were demonstrated to the community.

Watershed Programs in Integrated Tribal Development Approach

CInI research also looked at interventions where water control strategies were introduced and implemented as a part of a broader strategy for tribal rehabilitation and development. One example of such an effort can be seen in the work of BAIF Development and Research Foundation (BAIF). The now popular 'BAIF *Wadi* Model' is implemented with a focus on creating micro-environments. The intervention starts with a process of converting a hitherto fallow or least-productive 0.5 or 1.0 acre plot into an agri-horti-forestry plot called *wadi.* Implementing the program on such a plot ensures that this process does not interfere with their existing set-of-practices and is introduced as an additionality. Since agro-forestry programs generally have long (6-8 years) gestation periods, the program aims to create a range of short-run income generation opportunities including wage-income and inter-cropping of vegetables in the initial stages of the *wadi.* Once the *wadis* are established, the returns extend the period of cash inflows to the family beyond the agriculture season. As tribals receive a significant income from fruit once the trees mature, the income stream becomes diversified. This encourages the farmer to invest in land and builds confidence about income opportunities without migration. Once convinced about returns from land, other interventions in agriculture are also better received by the community. The landless farmers in the community are given preference (in certain cases, a monopoly) in associated activities such as post-harvest processing etc. Moreover, while BAIF's intervention restricts its support to tribal people, non-tribal people are also encouraged to take up similar activities with BAIF's facilitation (but without any monetary support).

This model has been successfully implemented by BAIF (and its associate organizations) in several locations in tribal Gujarat, Maharashtra and Rajasthan. CInI studies in south Gujarat, where the program is implemented through BAIF-DHRUVA in Vansda and Dharampur (Bhamoriya, 2004); and in Jawahar taluka of

Thane district in Maharashtra, where the program is implemented through BAIF-MITTRA (Maharashtra Institute of Technology Transfer for Rural Areas) (Deshpande, 2004), indicate that the *wadi* model and the associated package of practices developed over a decade have helped to lift 18000 tribal families out of the poverty trap. Recently, the Government of Maharashtra has initiated the *Jana Utkarsha* (Peoples' Prosperity) Program with the aim of extending the *wadi* approach to tribal areas in 50 blocks of Maharashtra.

Another CInI study (Chakraborty, 2004) looked at the *kharif* paddy intensification program being implemented by PRADAN in Purulia district of West Bengal. This program basically aims at stabalizing the *kharif* yields of tribal farmers through a plethora of on-farm and close-to-farm water harvesting structures (5% model; *Hapas*; seepage tanks) and through the introduction of improved crop management practices. In areas where this program has been implemented in conjunction with the watershed program, the results have been very encouraging. The model can be graphically depicted as shown in Fig. 2.

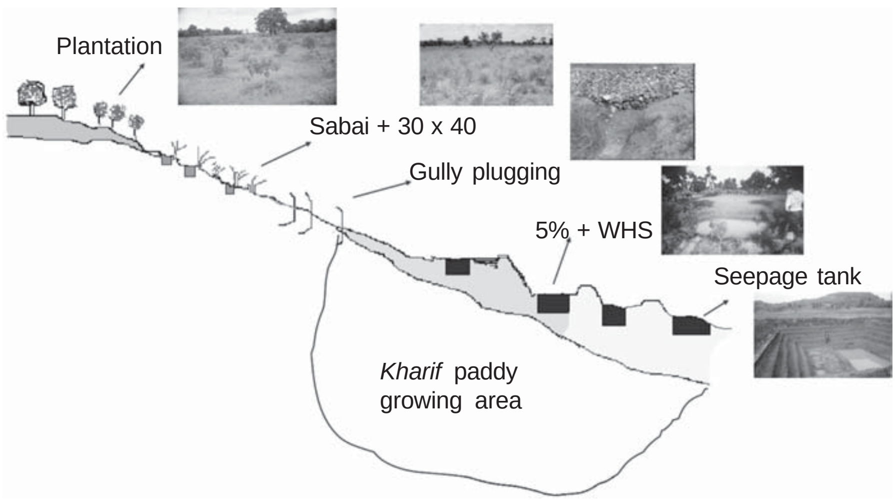

Figure 2. *Kharif* intensification approach of PRADAN (Chakraborty, 2004)

The water harvesting structures at the very top of the topography do not retain much water since it tends to seep out but the *hapa* and 5 percent ponds in medium uplands retain water. The earthen bunds of the *hapa* and the ponds are used to grow gourds and also planted with lemon and other plants. The gourds have also yielded substantial incremental incomes for the farmers. The primary purpose of the ponds is to help them provide protective irrigation to paddy in case monsoon periods show dry patches. Farmers have used 5 percent ponds in the past for this purpose using either shared small capacity diesel pumps or traditional swing bucket for lifting water to the farms. In any case subsequent rains fill up the ponds again. At the end of the monsoon season, when paddy is harvested, the ponds still retain water. The pond itself is used as a source of irrigation for growing vegetable in a small patch of land. When the water retention is very good, farmers can and have been putting in fish fingerlings and harvesting several kilograms of fish by the end of March when the water level in the ponds reduces. Proliferation of these water-harvesting structures in the watershed in Bandudih has also completely eliminated the drinking water problem as these structures have contributed to water retention in the wells.

PRADAN is now taking this program across many of the locations in Jharkhand and Orissa where high rainfall coexists with unstable mono-crop of paddy and acute food insecurity. PRADAN, as well as some other NGOs working in tribal regions including BAIF, are also trying out Systems of Rice Intensification (SRI) which is drawing attention world wide as a compact of paddy cultivation practices that boost paddy yield by 60-120 percent while reducing the cost of cultivation. In eastern India's tribal homelands – where paddy cultivation is central to rural livelihood systems – SRI holds out a big promise that needs to be vigorously explored. Developed after over two decades of experimentation in Madagascar, under conditions not very different from those in the eastern tribal belt in India, SRI promises significant increase in rice yields without the introduction of new varieties of HYV seeds or increase in external chemical inputs.

Tribal People and Panchayati Raj (Village Council) Institutions

Of late, there has been an effort to enhance the role of Panchayati Raj institutions (PRIs) in the implementation of watershed development programs through the widely debated 'Hariyali' guidelines for the IWDP. In this context, we would like to point out some important considerations which need to be kept in mind in the specific context of tribal regions. Badgaiyan (1990) notes that there are three axes of contradictions that operate when any development program/project is implemented for tribal people: (i) the tribal – non-tribal axis; (ii) the axis of contradiction existing between the numerically dominant tribe and the other tribes in any area; and (iii) the class axis.

Tribal–Non-tribal Axis

It would be naïve to think that only tribal people live in tribal areas. In most tribal areas, non-tribal population is present in substantial strength and, generally, forms the numerically dominant majority. Increasingly, the tribal population in India has been dispersing either due to the influx of non-tribals into traditionally tribal regions or due to the large scale migration of tribals to distant lands (Shah *et al*., 1998; Fig. 3). As a consequence, substantial proportion of the benefits meant for the tribal people get distributed among the non-tribal members of the population. If such a process goes on for long, we find a paradoxical situation where tribal areas develop but the tribal people remain impoverished and sometimes end up being worse-off.

Dominant Tribe–Other Tribes Axis

With the establishment of parliamentary democracy, the arithmetic of numbers assumes considerable importance. Constituencies are often not demarcated on the lines of tribal concentrations. Within each constituency, we often find one dominant and various other numerically smaller tribes. So, while the constituencies are treated differently (scheduled constituencies), the smaller tribes find it very difficult

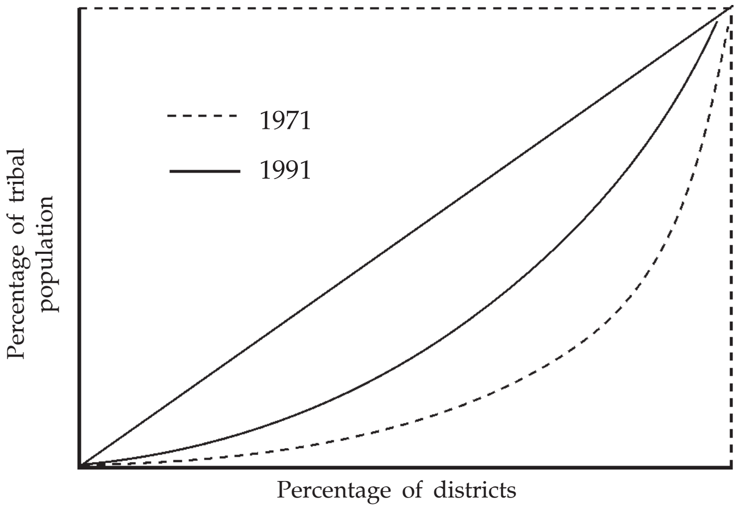

Figure 3. Index of tribal dispersion (Shah *et al*., 1998)

to have representation. Similar 'number games' can be expected in other local level political institutions such as cooperative societies, marketing societies and most importantly in our present context, even in PRIs.

Class Axis

Tribal societies are, in certain quarters, considered to be classic examples of egalitarian and classless societies. While it is true that there are some tribal societies, particularly those at the hunting gathering stage, which are classless, the same cannot be said of all tribal societies in general. The works of Furer-Haimendorf (1962, 1980, 1982) and Mishra (1982) show instances of rigidly stratified tribal societies. Among these tribes, it is possible to identify classes which own and classes which do not own the means of production and political clout. Thus, even within the same tribal community, chances are that certain people will not suitably get represented in PRIs.

These contradictions need to be kept in mind while implementing watershed development (or, for that matter, any tribal development) programs through institutions, which derive their power from the politics of simple majority.

Tribal People and Common Property Resources in Watersheds

The development of Common Property Resources (CPRs) has been identified as an important avenue through which a large number of poor households could be benefitted (Jodha, 1997; Chopra and Gulati, 2001). However, not only are such activities difficult to take up, and therefore are sometimes neglected; these interventions can sometimes alienate a section of the society from the watershed projects. Shah and Memon (1999) found that only 9 of the 16 best forming project implementation agencies (PIAs) in Gujarat carried out some kind of treatment of community pasturelands. Moreover, she also found that the pastures were basically left to themselves with the aim of regenerating the pastures through a community consensus on reduced or absolutely no use. Such an approach takes little or no notice of the communities, which depended on these pastures before the project implementation.

Tribal people have traditionally had a symbiotic relationship with a large number of common property resources, forests and pastures being the biggest examples. However, when access to such resources is controlled with the hope of regenerating them through a natural process for the betterment of the community as a whole, the tribal people lose interest in such interventions. The reasons are quite obvious. For households and local communities who never strongly depended on these CPRs, it is easy to accept and adhere to a limited-use or no-use-till-natural-regeneration principle. The period during which the natural regeneration takes place is, however, most painful for the tribal people and other marginalized communities which depended significantly on these CPRs. Shah (2004) suggests that rather than waiting for pastures to regenerate naturally, specific allocation of water (for pasture irrigation) should be made in the water accounting of each watershed. This would hasten the process of regeneration and therefore reduce the drudgery of the CPR-dependent communities. In addition, she suggests that during the period of the intervention, alternative arrangements such as fodder banks should be made.

Another interesting approach to CPR management can be seen in the work of the Foundation for Ecological Security (FES). Instead of simply restricting and controlling access to forest lands, FES promotes forestry activities on 'wastelands'. These lands become the new source for fuel-wood and other basic requirements of the local communities, thereby reducing the pressure on the forests without stressing the CPR dependent communities.

Mainstreaming the Margins

In a recent paper (Phansalkar and Verma, 2004), we have argued for a shift in tribal development paradigms towards livelihoods enhancement by using water control as the central strategy. The centrality of water control strategies is clearly evident in the works of some of the most prominent NGOs working in tribal regions. This paper has argued that tribal areas pose a special problem in watershed development due both to their biophysical attributes of the region and the social attributes of the communities.

Watershed development has become the dominant, and in several areas almost exclusive, methodology of improved natural resource management in the country. The concept of watershed development originated from soil and water conservation programs in arid and semi-arid areas. Even in India, the initiation of watershed programs was made under the DPAP. Watershed development programs have, ever since, come a long way and are today not restricted to drought-prone areas alone. A number of projects have also been undertaken under the National Watershed Development Program for Rain-fed Areas (NWDPRA) with a number of projects in the high rainfall areas of Chhatisgarh, Jharkhand, Madhya Pradesh and Orissa. However, we feel that the conservation-orientation of the watershed programs, most appropriate for water scarce regions, has not been suitably revised while replicating the watershed framework in the new contexts.

With their proximity to forests; the undulating-hilly-mountainous terrain; and above all their social malleability, tribals and their homelands have become a fond arena for watershed development programs. The approach is essentially oriented towards enhancing long term sustainability of a resource base rather than harvesting the resource for current consumption. Intended consequences of watershed development are in terms of substantial reduction of soil erosion, improvements in biomass availability and through that, reclamation of wastelands for augmenting production of much desired fodder and fuel wood, improvement in the soil moisture regime and improvements in groundwater level for sustainable use. Watershed development programs generally involve a great deal of labour intensive activities and hence create opportunities for wage-work for the poor. Since these opportunities are closer to their homes and since they are automatically biased against the well-off as they involve arduous earthwork, poor tribals are enthusiastic partners in watershed development programs during their implementation phase.

However, the long-run impacts of watershed interventions on tribal livelihoods are less positive and leave much to be desired. The usual repertoire of biophysical activities in a watershed development program is not optimally suited to tribal lands and to the tribal people. While the conventional 'ridge-to-valley' approach addresses the question of arresting and reversing degradation of natural resources; often, tribal farmers are left 'high-and-dry' in quite a literal sense. In watersheds where tribals constitute an overwhelming majority of the population, soil and water conservation measures in the upper reaches also benefit tribal farmers who have lands in the lower reaches of the watershed. This happens when the tribals harvest the extra retained water and use it for growing crops in their farms. However, in watersheds where tribals live with non-tribal farmers – which is generally the case, it is found that the augmentation of water resources in the watershed and its subsequent use benefits the non-tribal farmers to a much larger extent compared to their tribal counterparts. Tribal farms located on the highlands are left more or less where they are, perhaps albeit protected from further erosion.

At the same time, in cases when efforts have been made to modify the dominant approach by focussing the efforts on tribal farms, the tribal people are significantly and durably benefitted. Hence efforts have to be made to devise special provisions that make greater contextual sense. There is a need to shift the emphasis from 'degree' of resource used to the 'productivity' of resource used and the degree of economic and social benefit created by the resource. The approach (es) outlined here will require much more than the Rs. 4000-6000/ha budget set for watershed programs in rain-fed regions but the potential returns from these investments are also much higher. If it were possible to implement suitable strategies for promoting livelihoods of tribal people on a large scale, it would lead to significantly enhanced incomes and employment in these regions. This would result in much reduced hunger, food insecurity and forced migration of the tribals. These efforts would also result in significant addition to the national food production and contribute to strengthening the food security of the country in the long run. It is, therefore, suggested that suitable adaptations, as outlined above, will go a long way in mainstreaming the marginalized tribal communities. Examples of some water control mechanisms which are already in use are provided in Annexure 1.

We therefore argue for a special focus on Tribal Watersheds in Central India which will aim at reducing forced migration by adopting a 'farms-to-commons' approach for enabling and encouraging tribal farmers to improve the productivity of their agriculture. It would be naïve to expect a restrained and sustainable use of the fast depleting natural resources in the region if tribal livelihoods are not secured first. Greater food and livelihood security would create significant and long-term incentives for the tribal people to work as a community in retarding and reversing the rapid degradation of the natural resources in their habitats.

Annexure 1. Examples of Water Control Mechanisms in Central India

There are a number of ways in which tribal farms can be helped in attaining water control. Some of these are seen to be practised by communities themselves while others are being evolved by some of the leading NGOs in the field. We present a brief description of some of these below.

(a) *Cascade of 5% Model Farm-Pond:* A 5% model farm-pond, as the name suggests, is constructed on the most-upstream 5% area of the farm to a depth of 8 feet. This is suitable on upland farms that have deep soil cover, as is found in several patches of Jharkhand. The treatment, done with a focus on rainfall-risk-reduction, is most effective when the tanks are done in a cascade along a land mass with slopes of 5-7 percent. The chief advantage of this treatment is that it harvests run-off water which can be used to provide protective irrigation to the paddy crop in case of monsoon failure or during a specific period of moisture-stress. The seepage from these ponds also helps the crops on downstream farms. Such ponds have also been used for raising fish in Bandudih and Vivekananda watersheds (in Purulia, West Bengal) being implemented by PRADAN. The residual water available in the ponds after the monsoon season can also be used for undertaking small scale vegetable production in the *rabi* season.

(b) *30×40 Treatment with Mixed Plantations:* This treatment comprises dividing a hillock (whether in common pool lands or individually owned lands) into plots of 30×40 feet and making a large enough pit at one end of the plot. The soil and rubble from the pit is adequate to bund the plot on all four sides. The treatment reduces run-off very significantly. Gourds, pigeon pea, small timber and even fruit trees are planted in the plot making it economically very useful. PRADAN has demonstrated how Arjuna and Asan trees (host trees for 'tassar' silk worms) can be grown on such plots. A large hillock with a stand of nearly 700 mango trees in the Amagarah watershed of PRADAN in Kashipur block of Purulia district stands testimony to how the essentially conservation oriented treatment can be used for raising income of tribal people.

(c) *Diversion Bunds:* Creating diversion bunds on a natural water course in a watershed and allowing the diverted water to flow along or through paddy farms till it re-joins the water course several hundred metres downstream is a powerful mechanism of ensuring that run-off is slowed down, that farms are provided with flowing water for augmenting water in the plots and for stabilizing the paddy crop. This simple yet effective treatment emerged in a remote locality in the Mahanadi basin in Mahasamund district where these bunds are called 'Tar Bandhs' (*see* Chandrakar, 2004).

(d) *Diversion Channels:* Creating a diversion channel along a well laid route to divert water from an existing water course to irrigate farms is a simple yet powerful method for assisting stabilization of *kharif* crops. The technology involves only earthwork and creates a community asset which is not very difficult to maintain (*see* Mahapatra, 2004).

(e) *Dabaries: 'Dabaries'* are traditional water harvesting and storage tanks that can be seen in central-eastern India. While a number of these tanks are used for drinking and domestic water use, a large number of such tanks fall in the category of minor irrigation water storage tanks (MIWST). '*Dabaries*' are common property resources (CPRs) by nature and their operation and management is based on community action on the basis of rules and regulation, which influence water control. The common property (*res communis*) '*Dabaries*' have degenerated into open access (*res nullias*) resources and it is necessary to develop economic and social incentives, sanctions, and capacity building programs that promote long-term participation and involvement of water users and panchayats in the maintenance and management of '*Dabaries*' (*see* Marothia, 2004).

(f) *Bori Bandhs:* These have become very popular in the western Indian regions of Malwa plateau and also adopted in Maharashtra by Vanrai and others. They are being slowly adopted in watershed programs. The technology consists of damming a small nallah with earth filled used cement bags. The bund thus created stops post-monsoon flows and stores the water. This enables the riparian farmers to use the water for their crops but more importantly serve as strong mechanisms for recharging groundwater.

(g) *Jal Kunds:* '*Jal Kunds*' are small plastic lined pits that capture directly rainfall water which is used to irrigate fruit trees in the summer season using cans. These are being used extensively by BAIF in their *wadi* program. IDE India is also developing this technology in the Aurangabad region of Maharashtra. Monsoon flows are collected in 10000-litre capacity water bags in the pits made in the farm.

Besides these, integrated programs such as PRADAN's '*Kharif* Paddy Intervention' and BAIF's '*Wadi* Program' need to be sewed into existing watershed programs in tribal regions. None of the above, of course, precludes the initiation of tiny irrigation schemes for lifting and using stored or flowing water for irrigating crops in the second season as has been very successfully demonstrated by organizations such as the NM Sadguru Water and Development Foundation. We are aware that schemes such as lift irrigation can only be a supplementary activity and not a core component of watershed development programs. However, we bring this point only to emphasize that these two activities need to go in tandem and do not compete with each other except perhaps in the matter of funds allocation for donor agencies.

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Integrating Watershed Management Institutions: Examining What, Where and How?

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Abstract

Watersheds or river basins are an appropriate unit for integrated management of natural resources for ecologically consistent human development. Though such regional units are physical in nature, institutions understood as patterned social behaviour evolved over time that are essential for their management do not strictly follow their physical boundaries. Institutions interact in diverse action arenas to facilitate or constrain actors involved in managing watershed. These arenas may be location-specific or generic, formal or informal, and naturally evolved or deliberately created. Diverse institutional rules and actors operate and interact in these action arenas where all decisions related to the use and management of the resources in the watershed are made. This paper aims to examine how watershed institutions can be integrated by exploiting the interactive nature of institutions across action arenas and the interlinked nature of actors' actions.

This paper : (a) unravels the existence of different action arenas operating in a watershed area, (b) makes you understand how interactive institutions are across these action arenas, and (c) derives options or strategies that are available or being used to achieve institutional integration within the watershed. These objectives are attempted with an empirical application of the 'agent-actor-crowd' model to a core water-related issue applicable in each of the four socio-economically and hydrologically distinct hamlets selected from two watersheds in Himachal Pradesh, India. The data are collected from samples of stakeholders in different action arenas using a combination of participatory methods, semi-structured interviews, and intuitive observation.

The analysis shows how the outcomes faced by the 'subjective actors' operating in the action arena at the hamlet level are influenced by their actions (strategic and communicative) as well as their ability to interact with the agents in the action arenas operating both at and above the hamlet level. The results also suggest that the decisions of the agents in supra-action arena (e.g., elected members and district/state level officials) do not necessarily support the agents at the hamlet level (e.g., village leaders) in view of diverse institutions integrating to constrain and facilitate these 'supra-agents'. Describing the interactive nature of institutions and the linkages among action arenas with a simplified flow diagram, the paper reveals the complexities of integrating institutions across action arenas and suggests the need to decompose the institutions to identify the core institutions that facilitate and constrain actors in action arena.

Introduction

Watersheds or river basins are an appropriate unit for integrated management of natural resources for ecologically consistent human development. Though such regional units are physical in nature, institutions understood as patterned social behaviour evolved over time that are essential for their management do not strictly follow their physical boundaries. Institutions interact in diverse action arenas to facilitate or constrain actors involved in managing watersheds. These arenas may be location-specific or generic, formal or informal, and naturally evolved or deliberately created. Diverse institutional rules and actors operate and interact in these action arenas where all decisions related to the use and management of the resources in the watershed are taken. This paper examines how watershed institutions can be integrated by exploiting the interactive nature of institutions across action arenas and the interlinked nature of actors' strategies. The paper has three objectives to address the research gap. First, unravel the existence of different action arenas operating in a watershed area. Second, understand how interactive institutions across various arenas influence management of water resources at hamlet[1] level, and its linkages with poverty and gender that lead people to demand for institutional change. Third, examine the options available at supra-governance (above hamlet) level to achieve institutional integration in managing water resources locally. These objectives are examined with an empirical application of the 'agent-actor-crowd' model to a core water related issue applicable in each of the four socio-economically and hydrologically distinct hamlets selected from two watersheds in Himachal Pradesh, India.

The paper is organised into different sections dealing with conceptual background and methodology adopted to capture the complexity of water resource management, overview of the study area, complexity and messiness of institutions interacting in influencing resources management, the institutions interacting in influencing water management by examining its role in creating 'virtual' scarcity, in creating water distribution problems and affecting the capability of people to access the options available for actors in addressing water resource management at local level, melding different decision-making arenas up to district levels to understand the interactive nature of institutions and their role in facilitating and constraining the agents, and identifying key insights for institutional change and opportunities for decomposing the institutions in the arena to predict models of institutional change.

Conceptual Background and Methodology

Integration of institutions for water resources management for local development cannot be just inferred from secondary documents or from easily observable quantities in the field. The problems are historic in origin, influenced by the social and physical environment in which actors are situated in complex institutional set-up at micro and macro levels. Actors and institutions interact among each other to take decisions related to water management which has been recognised in action

[1]Hamlet is a cluster of houses in a village. A village is the lowest administrative unit having a clear boundary and socio-economic information.

arena[2] (hereafter as arena) (Ostrom *et al.*, 1994). Arena represents a complex system (refer, special issue of Ecological Modelling, 2002; Railsback, 2001) that characterises openness, diversity of actors, non-linear fashion of interaction and heterogeneity. In spite of these, arenas characterise emergent properties, multi-scale interactions, unexpected behaviours and self-organisation capacity which makes them a 'complex adaptive system'. Though a number of factors (physical, social and cultural) influences the arena, institution understood as a patterned behaviour of social group over a period of time, constitute a crosscutting factor and a particular driving force in the decision-making process (Young, 1999).

Action arena as a social practice ordered across space and time (Giddens, 1984) may be location-specific or generic, formal or informal, and naturally evolved or deliberately created. These arenas consist of number of actors, who are involved in performing diverse actions; broadly they may be strategic or communicative (Alexander, 2001). The former represents actions taken for the realisation of particular self-interested goals (coercive power), while the latter aims at achieving collective decisions through communicative action (enabling power). Though these two actions combine in complex forms in a 'strategic context'[3] of the action arena, it is the capability of few actors, who act as 'agents' in accessing other action arenas by drawing upon the modalities of existing institutions in the reproduction of systems of interactions, by the same token reconstituting their properties (Giddens, 1984:2). Using social network approach of following 'agents', the interactive nature of institutions are explored. Though institutions are complex and diverse, they often overlap among number of forces to constrain and facilitate the management of water resources in diverse action arena (Dorcey, 1986). Broadly, these institutions can be categorized as policy institutions, legal institutions and administration institutions[4] and the interactive nature of these constitutes water resources institution (Saleth and Dinar, 1999). However, very little is known about the complexity of interaction, and consequently, the mixture of rules and principles involved in action arena (Cars *et al.*, 2003; Ostrom, 2001; Pahl-Wostl, 2002). To analyse the complexity of interaction among institutions controlling individuals' access to water, a case study approach is important (Neuman, 2003) as it enables to capture the complexities and the relationship between human and environment (Young, 1999). This provides insights for understanding contextual factors influencing institutional phenomenon in a selected watershed, where micro level or the actions of individual people connects the macro level or large scale social structure and processes (Neuman, 2003:33). The approach uses the logic of analytic instead of enumerative induction.

To examine the research objectives, a combination of research methods has been used (Table 1) in order to remain exploratory in describing the role of institutions, the relationship among them and the interaction process in order to

[2]Few terms such as 'forums' (Moench *et al.*, 2003) or 'platforms' (Chamala and Keth, 1995). However, action arenas are appropriate as it describes action.

[3]The strategic context considers wide spectrum of issues, involves a wide range of actors having a shared vision and understanding in making well-informed strategic choices that shapes their future, and more importantly, ability of these actors to administer and enforce these decisions.

[4]This classification is analytically similar to that of Ostrom (1990) and Ostrom *et al.* (1994) categorization of institutional rules as constitutional-choice rules, collective-choice rules and operational rules.

Table 1. Justification for diverse research methods

Sl. No	Research objectives	Methods	Sampling	Strengths	Limitations	Type of Investigation
1.	Unravelling the existence of diverse action arena	Secondary documents	-	Provides information on past baseline data of the region (such as census of India, watershed socio-economic plans and agriculture research information)	It is less contextual and can be used as baseline information	Primary
		Participatory research methods	Transect mapping, wealth mapping, resource mapping and social calendar	Gives an overall picture of the case study area and general perception in the region on issues (quality of land, ownership of land, cropping pattern, social class and annual calendar). Further helps in building rapport with people	Less contextual and information biased against the poor	Primary and lead
		Semi-structured interviews	(i) 5 randomly selected community leaders, village elders, educated adults and irrigation functionaries. (ii) Government functionaries related to water resources, like Dep. of Forest, Irrigation and Rural Development	One-on-one interview will elicit in-depth and truthful information from informants not willing to share in-group interview setting, particularly when rapport is well established (history of village and irrigation management, change in cropping, problems of managing water and reasons for these problems)	Time consuming and highly individual opinion	In-depth
2.	Understanding interactive nature of institutions influencing water management at local level	Focus group discussions (FGD)	2 FGDs with 3-member group consisting of poor members in the village	Generates a common view of the poor, their problems and reasons. Explores new issues and various factors that influences their perceptions	Time consuming and do not provide practical insights on individual actions	In-depth and cross checking
		Structured interviews	About 160 households were stratified based on landholdings and other occupations from 4 hamlets	Helpful in generating necessary, quantifiable, non-controversial and non-sensitive information. Easy to code and tabulate	Less time consuming and not suitable for sensitive and controversial information	Primary
3.	Examine options available to achieve institution integration to manage water resources at local level	Structured interviews	About 160 households were stratified based on landholdings and other occupations from 4 hamlets	Helped in: (i) identifying different strategies adopted by various users in accessing or managing water, and (ii) identifying agents at hamlet who negotiate with other action arenas outside the hamlet	Did not help in identifying other action arenas accessed for managing water	Primary
		Semi-structured interviews	With agents identified by the sample households at hamlet level (Total agents–6 from 4 hamlets)	One-on-one interview with the agent helped in eliciting information on the institutions and its rules that facilitate and constrain the agents action, the arenas he accesses and why?	Time consuming, and gives only formal means of negotiation process	In-depth
			With agents in arenas outside hamlet level	One-on-one interview with the agent helped in eliciting information on the institutions and its rules that facilitate and constrain the agents action, the arenas he accesses and why?	Time consuming	In-depth
		Semi-structured interviews.	With actors in each arena	As the interview is held with actors on the functioning of agents, it helps to illustrate the actual negotiation process and the institutions role in the arena	Time consuming	Cross-checking

capture the complexities of interaction process (Young, 1999). Diversity of methods becomes utmost important in examining complex and interactive nature of water resource institutions, as it helps to build the advantages of different methods and overcome disadvantages of each method. In addition, it helps in validation and also provide opportunities for cross-fertilisation of information and a balanced qualitative and quantitative data that is contextually relevant. More important is its ability to build creativity and compromise (Abbot and Guijit, 1997). A combination of both quantitative and qualitative research methods in a continuous and integrated fashion has been adopted. The fieldwork currently in progress involves staying in the hamlets and carrying out the study using the following methods: (i) documentary research, (ii) participatory research methods, (iii) structured interviews, (iv) semi-structured interviews, (v) focus group discussions, and (vi) participant observation.

Research Setting

The objectives of research in the state of Himachal Pradesh, India are examined. The state represents an intricate mosaic of hills, valleys, fast flowing and turbulent rivers, and soaring high snow covered mountains with significant tensions among competing discourses of capital-intensive forms of economic development, environmental conservation and participatory forms of eco-development (Coward, 2003; Baker and Saberwal, 2003). Taking a case of the most backward district, Sirmaur, in the southrn part of the state (ref. Annexure 1), four socio-economically and hydrologically distinct hamlets were selected from two watersheds representing different agro-climatic conditions. The district is an ideal candidate to examine the actions of actors in accessing water due to presence of diverse agro-climatic conditions within the district (suitable for comparability), scarce availability of water, socio-economic backwardness and existence of diverse irrigation system.

Two watersheds were selected one each from low hills sub-tropical (Shiwalik) zone and mid-hills sub-humid zone. The former is located in low altitude zone (between 600 and 1000 m above msl), easily accessible to plains and well-off, while the latter in mid hills (between 1000 and 2000 m above msl) is relatively remote and backward (Table 2). The two watersheds were selected based on: (i) competing claims over water resources in the region. This is identified by an irrigation source benefitting more number of hamlets/ villages, number of overlapping irrigation sources (such as *Khuls*, canals and wells), different cropping patterns and any conflicts over water use; (ii) ecological characteristics of vulnerability; (iii) willingness of the people to support for the proposed research study; and (iv) access to transportation facilities (as the researcher has to coordinate the research work in two watershed at different agro-ecological regions). The hamlets in each watershed were selected through discussion with gatekeepers and village leaders on its location in watershed (upstream and downstream), economic backwardness of the hamlet, and scarce availability of water (for irrigation).

The two hamlets selected out of 10 hamlets in Khairi-Ka-Kala watershed in the low hills sub-tropical zone (hereafter referred to as low hills) are relatively (compared to other hamlets) backward in the watershed. The first hamlet, Khairwala, is located in upstream of the watershed and has Muslim Gujjars (scheduled tribal) and less numbers of Rajputs (forward caste). These people, though agriculturist,

Table 2. Physiography and socio-economic background of the case study hamlets

Characteristic	Khairi-Ka-Kala watershed		Rajana Watershed	
Revenue Village	Bikram Bagh	Pipalwala	Rajana	Rajana
Case Study Hamlet	KHAIRWALA	PIPALWALA	UPPALA RAJANA	NICHALA RAJANA
Agro-climatic zone	Low hills sub-tropical (Shiwalik) zone		Mid Hills sub-humid zone	
Physiography	Moderate steep to steep low hills of Shiwaliks		Steep to very steep high hills of Lesser Himalayas.	
Altitudinal location (in metres)	400-600		1000-1200	
Rainfall (mm)	About 1000		About 1200-1500	
Intensity of soil erosion	Severe		Moderate	
Slope	Moderate		Steep	
Soil type	Loam	Sand to loam	Loam to claye	Sand to loam
Location in watershed	Upstream	Downstream	Upstream	Downstream
Population (as in 2002) (households)	307 (Muslim Gujjars-Scheduled Tribe) 96 (Rajputs-Forward Caste) (57)	270 (Forward caste) 101 (Scheduled caste) 11 (Scheduled tribe) (64)	357 (Kohli-Scheduled caste) 247 (Rajputs & Brahmins-Forward caste) (75)	393 (Kohli-Scheduled caste) 250 (Rajputs-Forward caste) (80)
Average household size	7	6	8	8
Caste	Muslim Gujjars (scheduled tribe) and Rajputs	Multi-caste	Rajputs, Brahmin and Kohli (Scheduled Caste)	Rajputs and Kohli (Scheduled caste)
Main source of drinking water facilities	Handpump	Handpump	*Bavdi* (stored spring water)	Spring
No. of households having access to toilet facilities at home (% of total pop.)	None	10 (23%)	None	3 (9%)
Dominant economy	Labourers, regular employment (formal) and marketing of milk	Regular employment in formal institutions, labourers and from marketing of milk	Agriculturist and regular employment (formal)	Regular employment (formal) and agriculture
Irrigation type	Lift irrigation system	*Khul* irrigation system	Rainfed	*Khul* irrigation system
Major food crops	Maize and wheat	Maize and wheat	Maize and Wheat	Maize and wheat
Other crops (including cash crops)	Fodder grass	Fodder grass, mangoes (only large landowners) and minor vegetables	Ginger, tomato and vegetables	Ginger and vegetables
Average annual income of household (both cash and non-cash) (in Indian[5] Rs.)	48199	70393	50906	46078

(*Contd.*)

Table 2. (*Contd.*)

Characteristic	Khairi-Ka-Kala watershed		Rajana watershed	
Social Class (main indicators from wealth ranking)				
Rich	Land holdings more than 2 acres, concrete house and good number of cattles	Households supplementing their agriculture with pension from defense or government departments	Landholdings more than 2 acres	Landholdings more than 5 acres
Upper middle	-	-	Landholding size between 1 to 2 acres and regularly employed in Mining industries	Landholdings between 3-5 acres
Middle	Good agriculture land and regular employment in formal and informal institutions	Households supplementing their agriculture with regular income from formal and informal	Landholding size between 0.4 to 1 acre	-
Lower middle	-	-	Landholding size between 0.2 to 0.4 acre	Landholdings between 1-3 acres
Poor	Landholding of less than an acre and working as labourer	Households supplementing their agriculture with income from labour employment	Landholding size less than 0.2 acre and employed as labour (mainly from SC community). They have landholding in tail-end location	Landholdings less than 1 acre
Very poor	Six households (having unirrigated land uphill)	Two households having unirrigated land	-	-

Source: Field survey, 2004.

[5]The conversion rate of Indian Currency is INR 45 = 1 US$.

supplement their livelihood through selling milk and labour employment outside the hamlet. They are remotely located from the main group of hamlets due to their occupation and backwardness. The hamlet has irrigation facility through lift from the nearby river Markhanda, through which they grow maize, wheat and fodder grasses. While the people of Pipalwala hamlet, though agriculturist, depend on employment (formal and informal) from nearby towns in Himachal and Haryana for their living. The *Khul* (diversion-based) irrigation systems that draw water through gravity from the river Markhanda is the only source of irrigation. This enables cultivation of maize, wheat, fodder grass and vegetables for home consumption.

Compared to its counterpart, the hamlets in Rajana watershed located in the mid-hills sub-humid zone (hereafter referred to as mid-hills) are agriculturist (with limited employment opportunities) and economically backward due to remoteness. Here, there are two major castes, the Rajputs (forward caste) and Kohli (scheduled caste), with Brahmins and *Chamars* (another class of scheduled caste) being minor. Further, these hamlets being close-by have the same socio-cultural characteristics. However, being apart from each other by about 100 metres in altitude makes a great difference in their agriculture pattern. While the hamlet Uppala Rajana (located upstream) grows tomato and ginger (also have potential to grow other vegetables) in rainfed conditions (with limited irrigation in May) and organically. It also has a very good soil condition. In contrast, hamlet Nichala Rajana (downstream) is unable to grow tomato and ginger on large scale successfully due to problems of pests and unsuitable soil conditions, in spite of having *Khul* based irrigation facilities. Examining water resource management in these diverse settings offers a range of insights for understanding the management and the options.

Action Arenas Influencing Resource Management

Watershed has diverse land and water resources, in addition to human settlements. The management of these diverse resources involves macro and micro institutions integrating at various levels to take decisions over its management (Fig. 1). This integration is complex, but offers opportunity to examine the integrated nature of institutions. For the purpose of research, the interactive nature of water resource institutions has been examined for irrigated and rainfed agriculture economy, which assumed significance from peoples point of view for their livelihood.

These arenas and institutions only illustrate the complexity and messiness by which they integrate. However, for the purpose of research, only the core water related arenas are examined keeping in view the interest of the people and availability of time for the authors.

Arenas and Water Resource Management

Managing water resources in the case study hamlets require understanding the history of the hamlet, their management pattern and the role of current institutional arrangements. In this, it is important to infer the role of institutions in perceiving water availability, the way it is distributed and in building the capability of actors in accessing water. In each of these categories both micro and macro institutions coalesce in diverse arenas to shape the management. It also reveals how poor are being marginalised.

Constructing Virtual Scarcity

Availability of water is often considered to be infinite and naturally available (through rain). In recent decades, the finite nature is only understood in relevance to surface and groundwater, and therefore emphasis on harvesting rainwater (which is assumed to be infinite). The study demonstrates how external institutions perceive water availability and in the process has constructed virtual scarcity (Fig. 1).

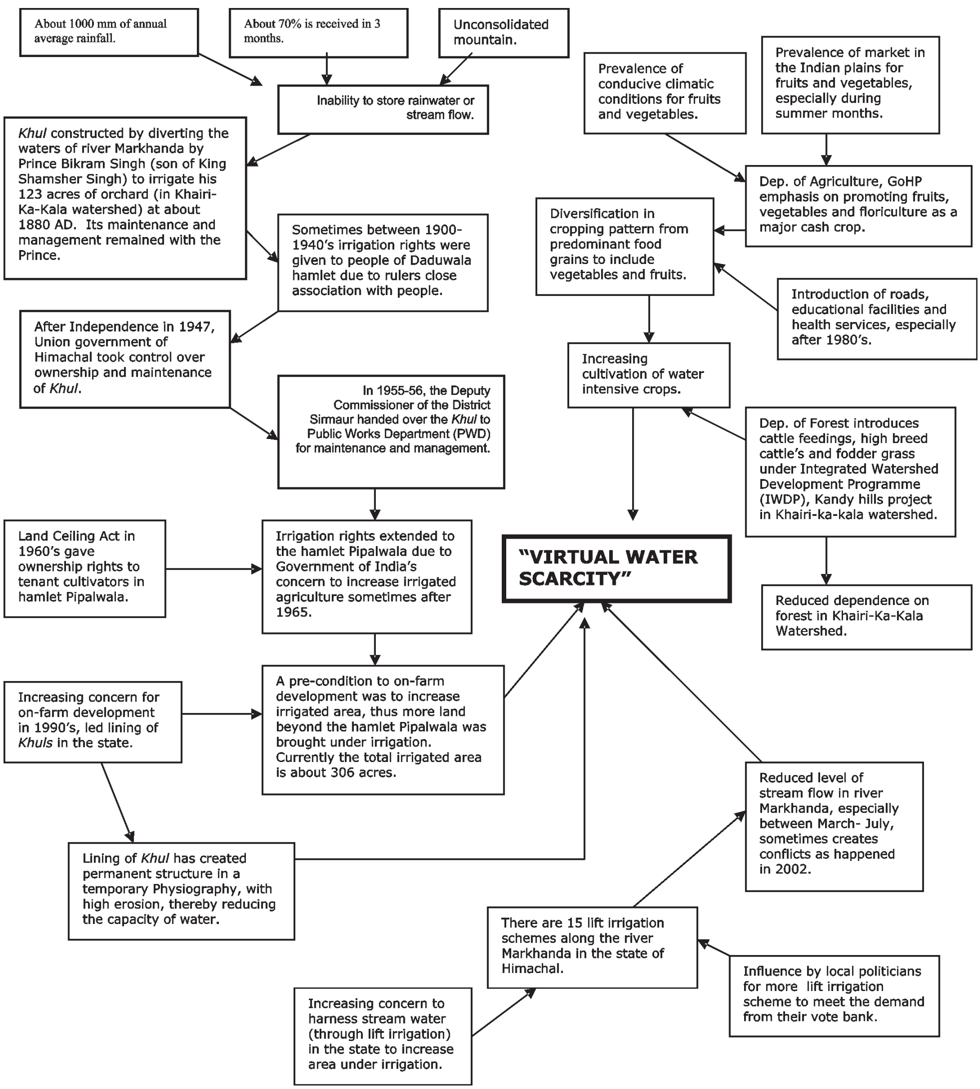

Figure 1. Institutions creating water scarcity

Early settlers (as in the case of Khairi-Ka-Kala watershed), the princely rulers of Sirmaur district, King Shamsher Singh, constructed *Khul* (a diversion based irrigation system) from the river Markhanda to cultivate his orchards about 3 kilometres downstream. The princely ruler solely managed it, as it was a private property. Later, the ruler due to close acquaintance with the people of Daduwala (upstream hamlet) extended irrigation rights. After independence, the Public Works Department of the then Union Territory of Himachal Pradesh, which took over the maintenance and management of *Khul* from the princely rulers extended irrigation rights to the downstream hamlets (one of them being Pipalwala) during 1960's on the perception of increasing irrigated area. Again it was extended during 1990, when the Department of Irrigation and Public Health (DoIPH) lined the *Khul* in the name of on-farm development. The lining though might have improved efficiency of water; it did create scarcity in two ways. First, it had to comply the directive of the Government of Himachal, which states that if *Khuls* are lined, the irrigated area has to be increased[6]. This led to extending irrigated area beyond its capacity from 123 acres in 1880's to 306 acres in 2003. Second, the lining created a permanent structure in a very temporary physical landscape[7] thus demanding regular desilting and channelising. The unregulated extension of irrigated area only provides superficial hopes to the people rather than assured and certainty in availability of water. These developments did not have major impact on the poor in the hamlet Pipalwala. First, about 60 percent (25/44) of the poor in Pipalwala hamlet have landholding less than an acre. Second, due to less landholding and uncertainty associated with *Khul* irrigation, these people depend on employment and marketing of milk for their livelihood (Table 3). Finally, dependence on agriculture land is only for food grain requirements that grow even in rainfed conditions. It is clear from Table 3 that the economic returns from agriculture are very meagre especially to the middle and poor class group of people.

Another major institution creating virtual scarcity is the market. The hamlets in Rajana watershed have been witnessing infrastructure development since 1980's with roads, educational institutions, health facilities and phone facilities. This has resulted in people selling products in market at the same time buying consumer products from market, especially after 1990's. Also conducive climatic conditions has led the Department of Agriculture, Government of Himachal Pradesh to place emphasis on growing cash crops, especially vegetables and fruits for markets in the plains. These have led farmers to increase from small-scale home-based production of vegetables to large-scale commercial market needs. Now in addition to major food crops (maize and wheat), farmers cultivate ginger (one of their traditional crops), tomato and in the last two years *Shimla mirchi* (capsicum) and chilly for market needs. Most of these crops when grown in large-scale are water intensive and therefore require irrigation during dry months. The agriculture economy that

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[6]Personal communication from Mr. Suresh Kumar, Sub-Divisional Officer, Nahan Division, Department of Irrigation and Public Health (DoIPH), Government of Himachal Pradesh, 15 October 2004.

[7]The *Khul* in the study is channelled along the mountain ranges, which due to unconsolidated landscape has a high erosion. This often leads to silt accumulation in the *Khul*, thus reducing its capacity. This calls for desilting the *Khul* very often sometimes thrice a year, which people are unable to do along the 3 kilometre belt.

Table 3. Different sources of income of sampled households

Income class / Social class	Agriculture: % of cash income	Agriculture: % of non-cash income	Diary: % of cash income	Diary: % of non-cash income	Income from employment (formal and informal) (%)	Annual average household income (Indian Rs.)
Pipalwala Hamlet						
Rich	5	24	9	10	52	67553
Middle	1	10	16	14	59	100615
Poor	1	15	15	14	56	45556
Khairwala Hamlet						
Rich	5	28	17	8	42	56839
Middle	0	22	20	13	45	42892
Poor	0	9	11	1	80	50173
Uppala Rajana						
Rich	43	19	0	17	20	95920
Upper middle	19	23	0	33	25	55735
Middle	36	17	0	39	8	51767
Lower middle	18	6	0	54	23	29532
Poor	9	15	0	32	45	25738
Nichala Rajana						
Rich	43	5	0	46	6	52840
Upper middle	21	6	2	54	17	35464
Lower middle	4	2	0	21	72	112110
Poor	7	2	4	37	50	36829

Source: Field Survey, 2004.

was primarily subsistence in the past is responding to needs of market for commercial agricultural economy. It is too early for the Government and the people to realise the need to regulate the market before transforming the village economy into market oriented agriculture economy. The gloomy picture portrayed by media and government programme on growing water scarcity has led people to perceive their inability to respond to market. This is due to inadequacy of irrigation facilities, hence demand for water harvesting schemes (through watershed programme). However, without their knowledge they are attempting to regulate the market as well (this is explained in the latter section).

Institutions Affecting Water Distribution

Distribution of water, though a local phenomenon, is influenced by the size and distribution of landholdings, the role played by external agencies (in facilitating and constraining) and knowledge of users (Fig. 2). Distribution of landholdings and its size is primarily influenced by historical institutional evolution in the hamlets. For instance, the Rajputs (early settlers) who occupied lands in Rajana watershed took control and ownership of all lands. In order to meet their labour requirements, the Rajputs community brought Kohli (scheduled caste) community to work as tenant cultivators on their land. It was the Land Reforms Act of Government of India in 1960's that gave ownership rights to these tenant cultivators. Unfortunately, the decision to part away with the land rested with the Rajputs, who often gave away poor quality in soil and tail end located lands. Being early settlers and landlords, they had the right to decide (even today) on matters pertaining to village administration. Water distributions in *Khul*-irrigated areas were not an exception. Being large landholders and head farmers, the distribution was tailored as land-based distribution to benefit the Rajputs and not the Kohlis. Though the inadequacies of such distribution was shared in private to the researcher by the Kohli community, none of them were able to openly question this to the Rajputs, due to cultural bond of subordination that exists. However, few Kohli community members do break these norms independently using strategic actions - take water directly from *Khul* channels through tubes or pipes. Being categorised as a 'private *Khul*'[8] by Government of Himachal Pradesh, the Department of Irrigation and Public Health (DoIPH) rarely supervises the inefficiency of the irrigation practice, in a way facilitating the inefficiency of water distribution.

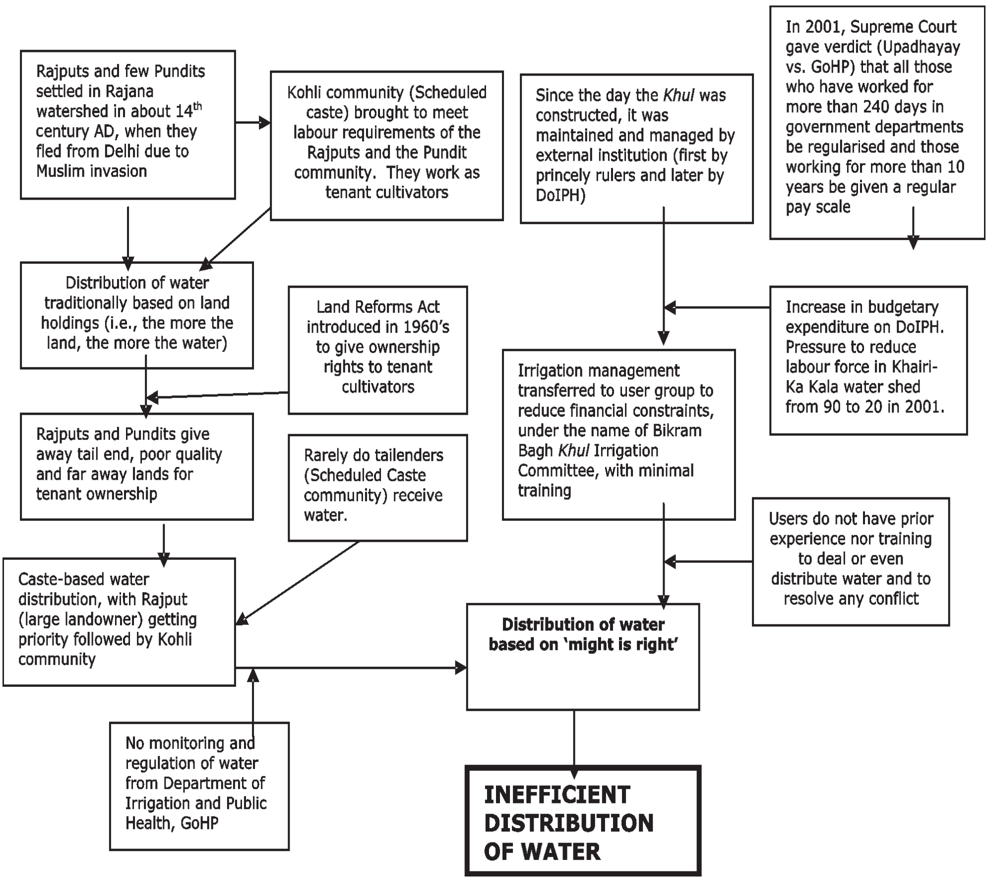

Figure 2. Institutions affecting water distribution

In contrast to water distribution in Rajana watershed where external institutions influenced local distribution practice, in Pipalwala hamlet the water distribution is totally influenced by external institutions on the assumption that people are knowledgeable and efficient in distributing water. The distribution of *Khul* irrigation in Pipalwala hamlet was in the past carried out by the people appointed by the Princely Ruler, who distributed water first to the rulers orchards and then to the people. The distribution was primarily based on first-come-first-serve basis irrespective of the location of field in the command area. After independence, the water bodies were taken over by the Public Works Department (PWD) and later by the Department of Irrigation and Public Health (DoIPH). The DoIPH employed water distributor, without any major change in distribution pattern. It was in 2001 that a Supreme Court directive made DoIPH to regularise all daily waged employs with various other benefits. This led to increasing financial burden on the department. This lead DoIPH to transfer *Khul* maintenance and management to the user group, who neither had previous experience nor they were given any training. Initially, these users followed the pattern of distributing water as was done by the department staffs, but unfortunately due to social bonds of preferential treatment for some and impartiality for others, the distribution has gone awry. Now the distribution is primarily through 'might is right' principle leading to wastage of water.

Institutions Affecting the Capability of Actors to Access Water

Capability of actors to access or utilise water depends on various endowments each household have. Some of the prominent among them are the type of land available for cultivation, household size and gender differentials within households. Type of land available for cultivation is one of the factors influencing household's capability to access water. The landholding size matters the most in all the hamlets. With 30-50 percent (varying across caste studies) of the sampled households having less than an acre of cultivable land (either in *Khul* command area or in unirrigated land), the returns from this is not significant for the poor to invest time and energy in accessing water. In Rajana watershed, in addition to landholding size, the location and quality matters for enhancing or constraining actors' access to water. More than 90 percent of the land owned by the scheduled caste Kohli community is located at the tail-end. Due to inefficient distribution of water and also distance factor to monitor wild animals encroaching the lands (for unirrigated lands in Uppala Rajana), dependence on this particular land becomes expensive and meaningless. In contrast, the rich people in Rajana watershed (the Rajput community) have better access to irrigation facilities and also ability to monitor the land from wild animals, which contributes more than 40 percent of their annual income. The uncertainty in availability of water, inefficient distribution and less returns from cultivable land led the poor and middle class households to depend

[8]*Khul* irrigation systems are classified in revenue records as private (when it is managed and maintained by people) and government (if it is maintained and managed by DoIPH).

on employment (formal and informal) that contributes 50-70 percent of their income (Table 3).

Household size matters for getting adequate returns from cultivating the land, especially in the Rajana watershed. Being remotely located the households have to depend on their family labours for cultivating their lands. It is notable (Table 4) that the family size decreases with the level of poverty.

Sex ratio of these households also matters in utilising the productivity of the land. The richer the household, the higher the sex ratio (Table 4). This is normally found among the Rajput family. It is also found that among these families, the females work more in fields, cattle yard and at home, while men spend time in travelling to towns and doing village works. Sample study of males and females in 4 families (2 from Nichala Rajana and 2 from Uppala Rajana) of Rajput community indicate that females spend about 17-18 hours a day working in fields, cattle yards and at home. Such differentials in work pattern also reflect the need for female children for family labour.

Table 4. Distribution of household size among sampled population (%) - Rajana watershed

Social	Household size				Sex
class	Less than 4	5-8	9-10	11 and above	ratio
Uppala Rajana					
Rich	20	-	20	60	1760
Upper middle	8	30	31	31	1133
Middle	30	70	-	-	889
Lower middle	14	58	-	28	1000
Poor	38	62	-	-	1050
Nichala Rajana					
Rich	-	-	30	70	1000
Upper middle	17	55	5	23	1278
Lower middle	-	62	-	38	1375
Poor	28	44	-	28	952

Source: Field Survey, 2004.

Actors, their Actions and Arenas

The inadequacy of existing institutions in managing water resources are recognised by each actor at hamlet level, who attempts diverse actions to modify the existing institutions, creating new ones or even accessing other diverse institutions. Broadly these actions are classified as strategic and communicative (Table 5) (Alexander, 2001). The former represents actions taken for the realisation of particular self-interested goals (coercive powers), while the latter aims at achieving collective decisions (enabling power). Though both these actions indicate the inadequacy of existing institutional structures in diverse forms of collective actions. It is the communicative action that aims to strengthen or empower the existing institutional structure or attempts to overcome the inadequacy through democratic principes of consensus seeking. This does not mean that strategic actions are less important. For the purpose of research (with limited time and cost factor) communicative actions are examined for their role in promoting water resource development for local use.

Table 5. Diverse actions of households to access water

Hamlets *(interview question)*	Strategic	Communicative
Pipalwala		
If you don't get water from Khul irrigation systems as per your turn, what do you do?	1. Wait, wait and wait… 2. Take directly from *Khul* channel. 3. Buy water from others. 4. I do get if there is sufficient water. 5. I use my might (fight) to get water. 6. I don't depend on this *Khul* water for my income.	1. Inform President of the irrigation committee and get water. 2. Get water by negotiating with the person irrigating at the moment. 3. If I don't get water as per turn, I investigate and take water.
Khairwala		
If you don't get water from lift irrigation systems as per your turn, what do you do?	1. Wait, wait and wait… 2. If water is available I get. 3. I use my might (fight) to irrigate. 4. I take water directly by opening the gate wall, as it is close to my field.	1. If I don't get as per turn, I inform the water operators of the DoIPH. 2. I try to solve the problem through negotiation, if I don't get water as per turn. 3. I investigate and take water. 4. Inform the President of the irrigation committee and irrigate the field.
Nichala Rajana		
Whom do you contact to access water from Khul irrigation system?	1. I don't contact anyone to get water. 2. I take water from *Khul* systems directly. 3. I don't depend on this water for my income.	1. We contact the Rajputs to irrigate our field.
Uppala Rajana		
Who told you to cultivate tomato crop an why?	1. I don't have time to spend on cultivating tomato (as the persons are employed elsewhere). 2. There are not enough labour force in family, so that we can cultivate tomato. 3. As our fields are located near the forest it is difficult to cultivate tomato as wild animals destroy them.	1. The village leader influenced me. 2. I was influenced to cultivate by a schoolmaster. 3. I decided to cultivate myself (by looking at others). 4. The villagers started growing them, so also I.

A simple analysis (Table 6) of the diverse actions adopted by households indicates that it is mostly the middle class households who adopt communicative actions, except from the hamlet Pipalwala. The poor and rich households mainly adopt strategic actions. It is interesting to note that rich households steal water and use their might to access water, while the poor use the action of wait and watch, and depend on employments. In communicative actions, actors communicate with others for collective decisions. In this arena at hamlet level, not all actors take a lead role as 'agent'. It is only those who have capability to draw upon the modalities of existing institutions in modifying or reconstituting their properties by accessing supra-arenas.

Table 6. Percentage of households using diverse actions to access water

Social class	Actions	
	Strategic actions	Communicative actions
Pipalwala Hamlet		
Rich	5	7
Middle	23	16
Poor	14	35
Khairwala Hamlet		
Rich	14	11
Middle	16	34
Poor	16	9
Uppala Rajana		
Rich	7	11
Upper middle	15	19
Middle	3	5
Lower middle	3	17
Poor	14	5
Nichala Rajana		
Rich	0	9
Upper middle	2	52
Lower middle	12	3
Poor	12	10

Source: Field Survey, 2004.

Options for Water Resource Management

There are diverse options available for hamlet-level agents to address the inadequacy of existing institutional arrangements (Table 7). Broadly, they approach the relevant government department (here it is the Department of Irrigation and Public Health-DoIPH), the political representatives and the market. Each of these arenas is accessed for some specific reasons. It is clear for these agents that for technical problems, it is the role of the department (like in case of Khairwala). But in case they require new irrigation schemes, they access both DoIPH for technical clearance and to member of legislative assembly (MLA) for seeking additional funds (like in case of Pipalwala) (Fig. 3).

Though the DoIPH can also mobilise additional funds through sectoral allocations every year, there is greater dependence on the political representatives as they had committed and are also easily accessible to people. While in Rajana watershed, the agent proposes to address through two different options (Fig. 3): (i) increase availability of water through various water harvesting measures (as he has been told during watershed training programme), and (ii) improve infrastructure (transporting and seeking better markets in plains) facilities for marketing their cash crops–ginger and tomato.

Table 7. Different action arenas accessed by agents

Watershed	Khairi-Ka-Kala watershed			Rajana watershed	
Hamlet	Khairwala		Pipalwala	Nichala Rajana	Uppala Rajana
Agents	Mr. Nazim Ali, President of LIS	Mr. Sundar Das, Member in LIS	Mr. Parem Singh, President of KIC; Mr. Sher, Vice-President, KIC	Mr. Charan Singh, Village leader, Chairman of WDC	
Problems perceived by agents	Inadequacy of water	Problem of water distribution	Inadequacy of water	Inadequacy of water	Problem in getting better price for products
Arenas accessed	DoIPH	DoIPH	MLA, DoIPH	DRDA, DoF	Market
Purpose of accessing these arenas	Seeking additional lift irrigation scheme	For DoIPH to take over distribution	For a new lift irrigation scheme	Enhance water availability (harvesting measures) through watershed development	Improve infrastructure for marketing of ginger and tomato

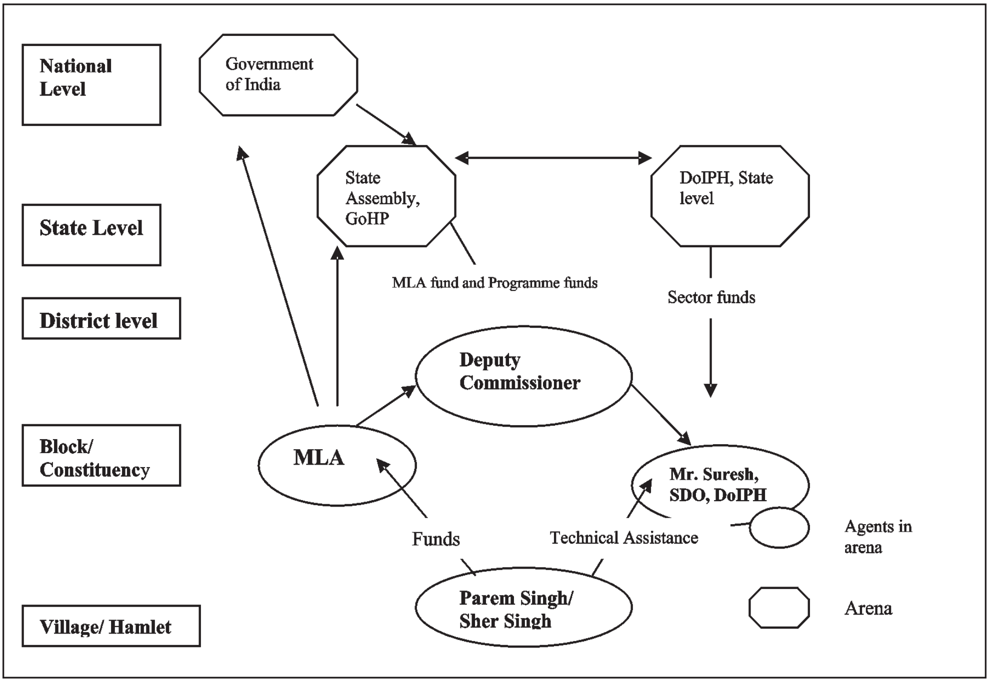

Figure 3. Agents in different action arena

Institutional Integration in Arenas

Agents interact among each other to take decisions within and among diverse arenas. In each, institutions integrate in diverse and complex ways to facilitate and constrain agents' decisions. Understanding the institutions involved will enable to deconstruct the complexity and understand the interactions among institutions in arenas. Though different types of institutions interact in arena, they consist of three basic components that enable agents to take decisions: (i) policy institutions that provide guidelines on who should enter the arena, what position they should hold and how the outcomes have to be; (ii) legal institutions authorise agents to take decisions; and (iii) administrative institutions that enable the agents to transform their decision into actions and their actions into outcomes in cost effective manner.

Examining the institutional integration in arenas indicates how agents emerge and which are the institutions that facilitate their decisions (Annexure. 2, for details on institutional rules, *see* Saravanan, 2004). In both the watersheds under study, informal institutions set the policies for hamlet level agents (Table 8). Of these, the role of social network plays an important role. Though this makes them eligible, the legal authority for taking decisions is provided by the external institutions (DoIPH, DRDA and DoF). This enables them to access administrative institutions to implement their decisions. Of the three agents at hamlet level, the agent at Rajana, Mr. Charan Singh, offers an example. He had been a village leader for past decade and also the *Nambardar* (village revenue collector), but it was only about three years that he is active as an agent. The credit goes to the watershed development programme implemented under the Integrated Wasteland Development Programme (IWDP) of District Rural Development Agency (DRDA). Under this programme, he had been appointed as the Chairman of the Watershed Development Committee. Being the Chairman, he gained opportunity to meet bureaucrats of various departments and also to know about their programmes. This also meets his self-interest need of earning a livelihood by taking these programmes to his villages. These agents play an important role in bringing development programmes to the village, but the challenge lies in monitoring and regulating these agents and their actions to address the concern of water resource development for local use. In contrast, as the agents move higher-up, the role of informal institutions in setting policies reduces. However, for all agents it is only the formal institutions that provide legal authority and administrative support in implementing their decisions.

Table 8. Types of institutions facilitating agents

Agents	Policy	Legal	Administrative
Hamlet level	Informal	Formal	Formal
Block level (MLA/ SDO)*	Informal/ formal	Formal	Formal
District level (PO)**	Formal	Formal	Formal
Market agent	Informal/ formal	Formal	Formal

*SDO : Sub-divisional officer; **PO : Project officer.

Options to integrate institutions from other arenas are limited to government officials than political representatives. The demands made by people are mainly technical, managerial and financial. The line departments are able to address the technical and managerial matters, but not the financial matters. Though they could forward such requests to the District Development Committee or to the Deputy Commissioners, the limitation imposed by the respective organisation hinders them to do so (sometimes, the officials also reject the demand). This makes the hamlet level agents to seek other arenas, such as the political representatives

(MLAs). These representatives have access to diverse sources of fund– the state legislative assembly for including the demand in sectoral allocation, the district development committee for programme funds and within these own funds (allocated Rs. 24 lakhs every year to each MLA for development works in his constituency). Another advantage of seeking these representatives is easy accessibility, the language he speaks, anytime personal access, simplicity in outlook, and willingness to hear and overcome their worries. More important is the trust that this politician builds with the people. This makes lots of difference to the people, though he only forwards the plea made by agents to various departments. In fact, if one goes to meet him, his office functions like a helpline service centre. This is in contrast to Deputy Commissioner's office or even the simple government department.

Agents' decisions in the arena are influenced by the perception they have on the attributes of governance. These attributes help agents' in pursuing their goals by integrating diverse institutions (Table 9). Equity for hamlet agents is said to be *Khudrat ka diya* (given by God) and can only be managed. While the DoIPH uses technical criteria to approve the water and irrigation schemes, MLA uses his vote banks for providing support and District Rural Development Authority (DRDA) gives importance to 'peoples' plan'. Similar is the case with responsibility, coordination, participation and accountability. These differences illustrate the

Table 9. Attributes of governance and arena

Agents		Village	Block		District	Market
		hamlet agents	SDO (DoIPH)	MLA	PO, DRDA	
Attributes						
Equity	Type	Inequity is given by God, it can only be managed.	Based on technical feasibility	More the vote bank, more the support	Better the user group, more the support	Better pricing
	Institutions Facilitating	Village institutions	DoIPH/ Village Institutions	Political party	DRDA-watershed Guidelines	Village institution/ market
Responsibility	Type	Assumed/ assigned	Assigned	Assumed	Assigned	Assumed
	Institutions Facilitating	Village institutions/ Government department	Institution-based and Village institutions	Vote bank	DLWDC/ DoRD	Market
Coordination	Type	Authority-based	Need-based	Authority-based	System-based	Authority-based
	Institutions Facilitating	Village institutions and Irrigation committee	DoIPH	Vote bank	DRDA	Market/ social network
Participation	Type	Authority-based	Rules & regulation	Authority-based	Structure-based	Pricing based
	Institutions Facilitating	Village institution	DoIPH	Power	DRDA	Market/ village institution
Accountability	Type	Authority-based	Rules & regulation	No accountability	DRDA/ DLWDC/ User group	No-accountability
	Institutions Facilitating	Village Institution	DoIPH	-		-

various conditions under which the agent exists and also provides opportunity for designing institutions.

Future Directions

The study reveals that management of water resources is influenced by diverse forces, but the institutional options available are different and do not match the ground reality. External agencies (Department for International Development – DfID and Government of India) impose various concepts in the form of programs attached with funding by creating new institutions. Rarely do these funding agencies attempt to examine and modify the institutional failures of existing distributive governance. This gives less space to strengthen existing distributive governance or even flexibility in implementing these concepts. The poor who are caught between the macro (formal) and micro (informal) decisions are being increasingly marginalised in the process. Addressing them requires effective role of various developments in addressing education, lack of income generating opportunities, overcoming the constraints imposed by natural factors and importantly social factors (control and suppression from upper caste community) that has often led them to poverty. This calls for strengthening the distributive governance of existing sectoral departments.

The paper provides opportunity for utilising agents in facilitating development programs. Agents at hamlet level and block level emerge due to village level informal institutions. However, the legal authority to take decisions is provided by the external formal institutions. This offers opportunity to build on these agents by providing opportunities for existing agents to come forward and create opportunities for new agents at hamlet level. This does not require new institutions to emerge or give responsibility to NGOs (though important), rather calls for government officials to interact with the villagers and share information about various on-going and future programs. This calls for the existing line departments (specially field level officials) to be proactive, visit villages and discuss issues. This does not mean that government officials create user group, or stay in villages, rather try to interact with the people to understand how the contemporary is implemented and what impact it has on people. Promoting agents above hamlet is entirely the role of external formal institutions. However, unclear roles of political representatives and limited role of bureaucrats seems to be of concern in the region under study. It is not clear to whom the political representative is responsible and accountable. Very often people are made to take up the burden (during election) but what mechanisms are in place to oversee their decisions is still not clear. In contrast, bureaucrats have too much of accountability problem, but limited autonomy to take decisions, very often they seek their higher-ups for decision or have to bow to political interferences. Each of these agents have different perceptions and functions in addressing the attributes of governance (equity, responsibility, coordination, participation and accountability). Examination of more of these attributes could serve as major guidelines for policy and programme interventions for necessary institutional change for managing water resources.

The study is only a piece meal attempt as part of the research program. It offers opportunities on two fronts. First lies in further decomposing the institutions in each action arena. Some of the areas for examination lie in identifying different types of integration in place, examining the interaction between formal and informal rules and applying the design principles of institutional and analysis development framework as a heuristic tool. On theoretical front, this will contribute in blending institutional approach, emerging from common property theories with planning theories to predict models of institutional arrangements. The second lies in moving forward with this small piece of preliminary research to examine the feasibility of providing guidelines for policies and programmes at district level.

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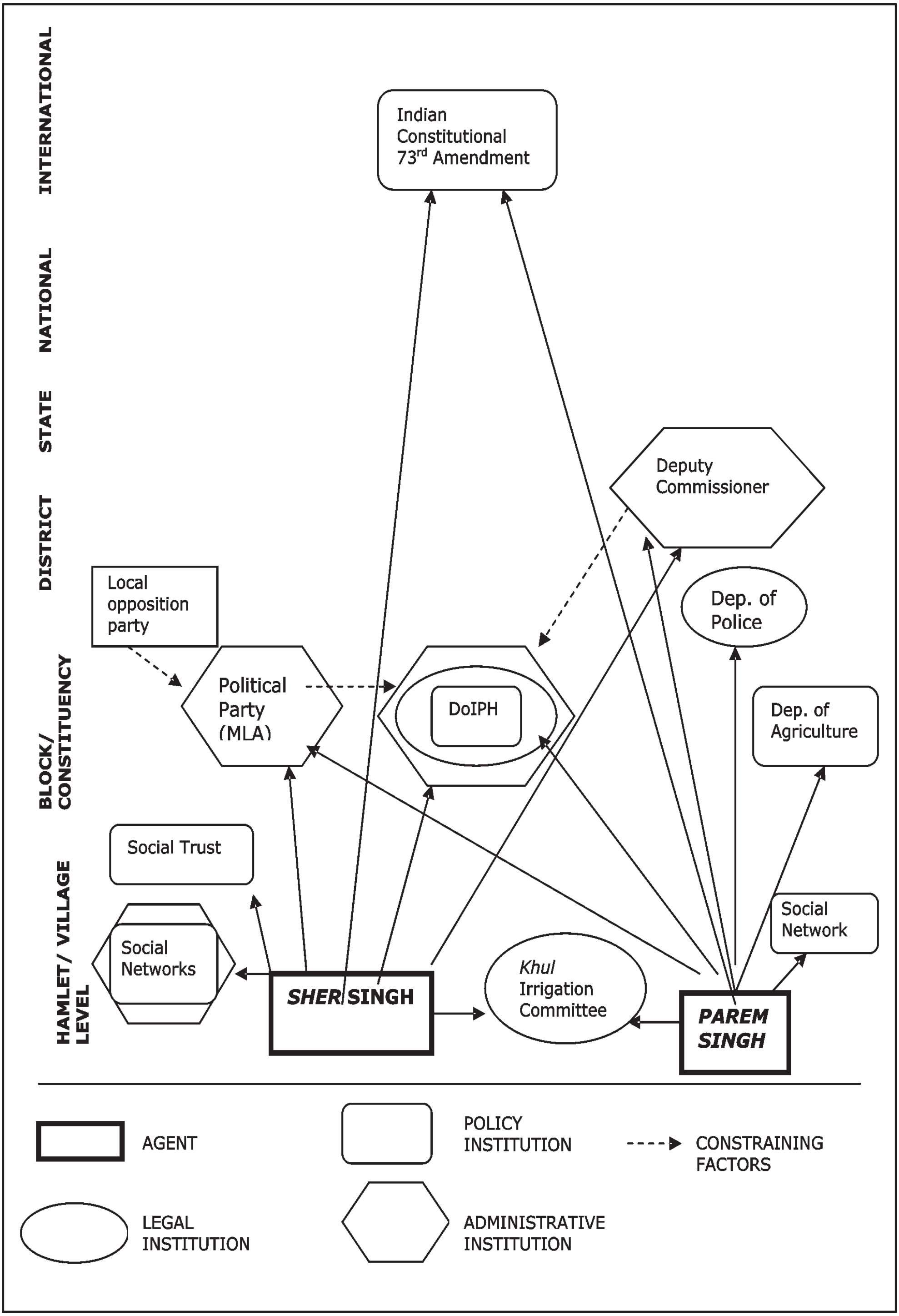
Annexure 1. District-wise selected indicators of development – Himachal Pradesh

District	Area (sq. km)	Population (2001)	Decadal growth rate (1991-2001)	Sex ratio	CBR* 1991	IMR** 1991	Habitation drinking water (percent)	Metalled roads per sq.km	Per capita income (1999-2000) at 1990-91 prices	Rural population below poverty level (percent)	Literacy 2001 (%)
Chamba	6528	4,60,499	17	961	35	104	98	7	6058	62	64
Kinnuar	6401	83,950	18	851	31	123	100	4	7930	27	NA
Kullu	5503	3,79,865	26	928	33	102	98	7	6098	19	73
Lahaul & Spiti	13835	33,224	6	804	28	59	100	2	12559	38	73
Shimla	5131	7,21,745	17	898	29	104	92	20	8304	34	80
Sirmaur	2825	4,58,351	21	901	34	94	89	2	5650	23	71
Mandi	3950	9,00,987	16	1014	30	69	98	25	5313	-	76
Bilaspur	1167	3,40,375	15	992	28	71	100	47	7547	27	79
Hamirpur	1118	4,12,009	12	1102	25	65	100	47	4243	24	83
Kangra	5739	13,38,536	14	1027	28	77	97	32	5736	24	81
Solan	1936	4,99,380	31	853	30	84	96	36	11231	27	77
Una	1540	4,47,967	18	997	29	82	100	47	4480	19	81
Himachal Pradesh	55673	60,77,248	18	970							

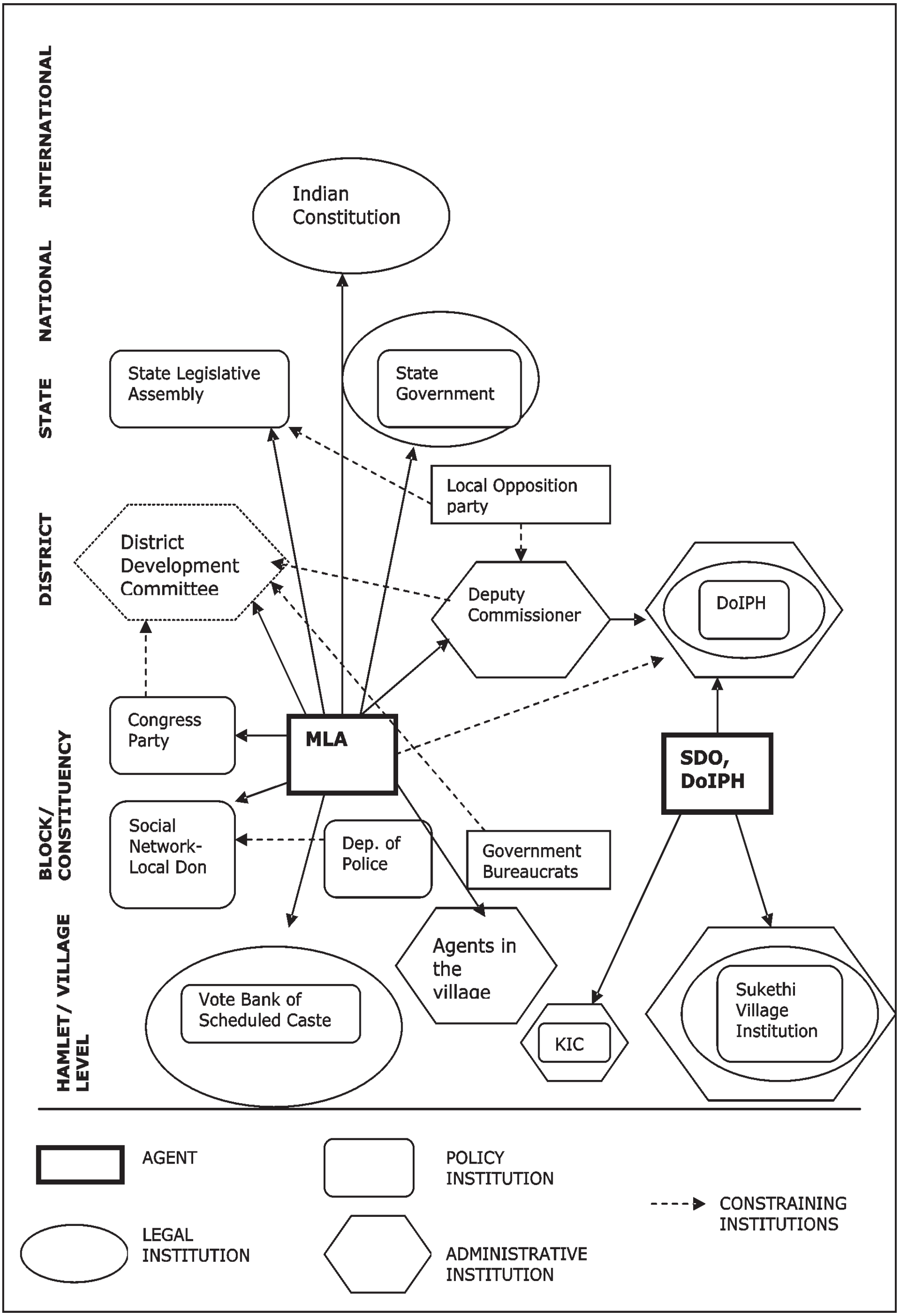
Source: GoHP. (2002) Himachal Pradesh Human Development Report –2002. Planning Commission, GoHP, Shimla.

*CBR : Child Birth Rate; IMR : Infant Mortality Rate.

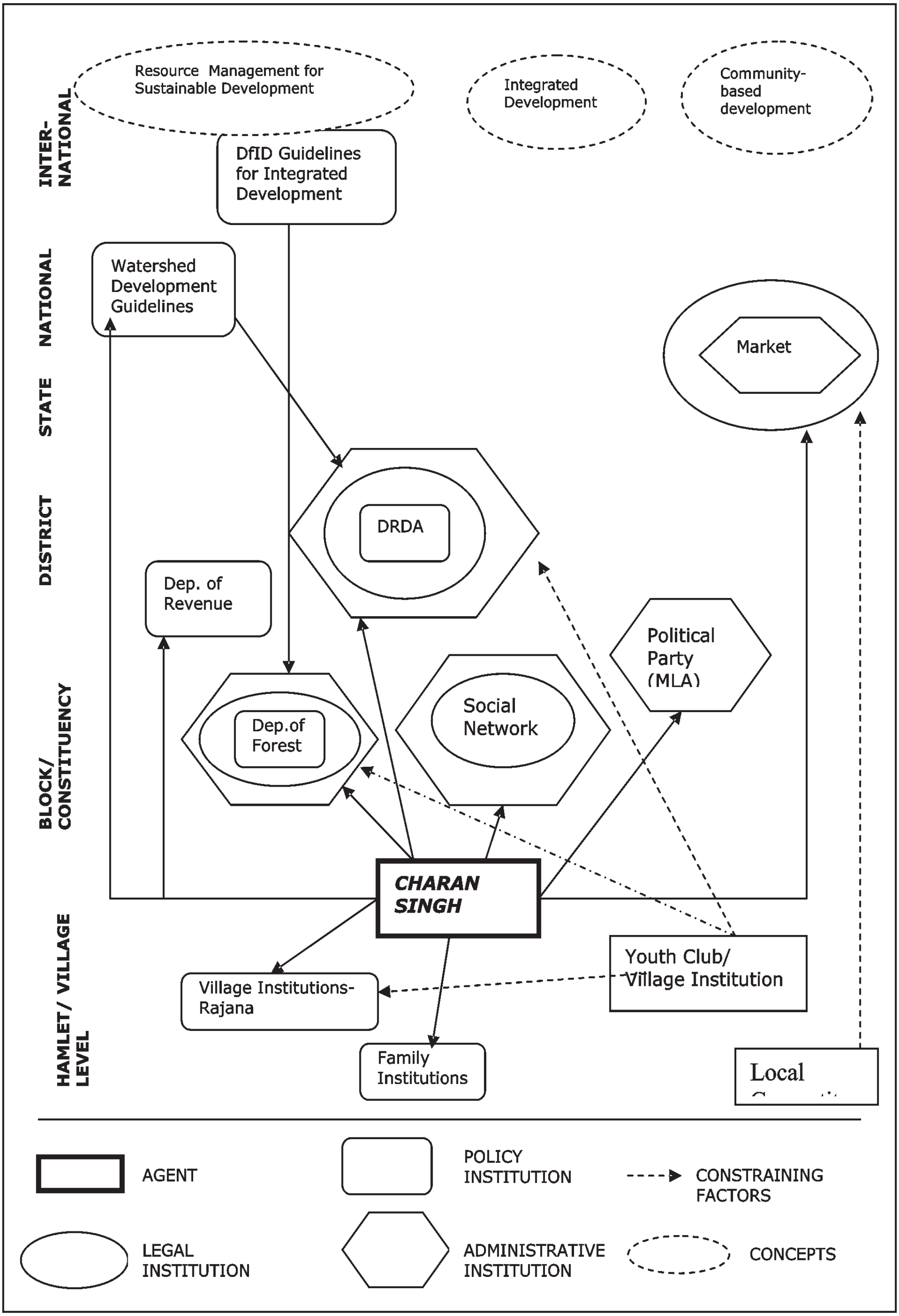
Annexure 2. Institutions Integration In Arenas



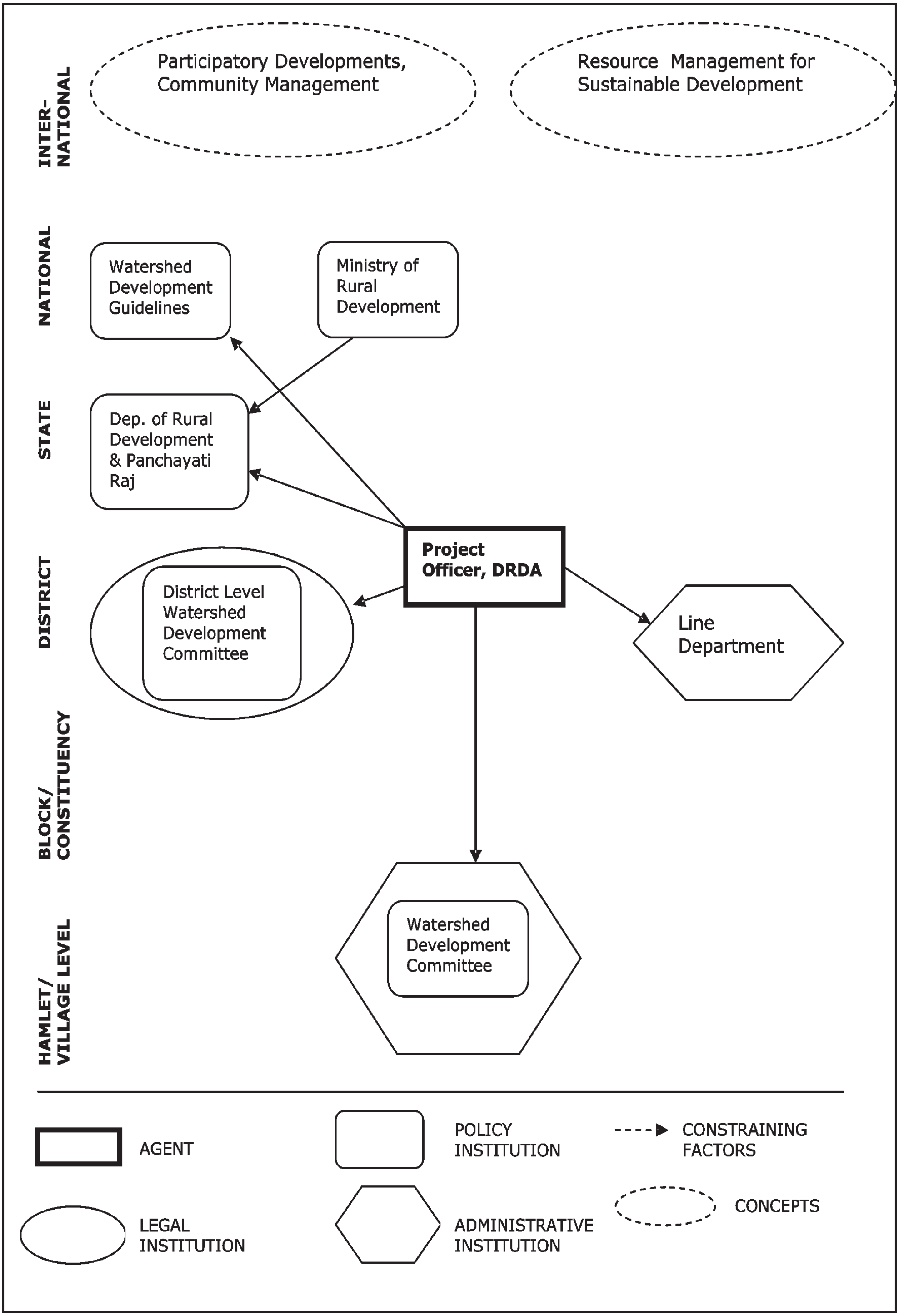
Annexure 3. Institutional Integration at Block Level Arenas, Pipalwala



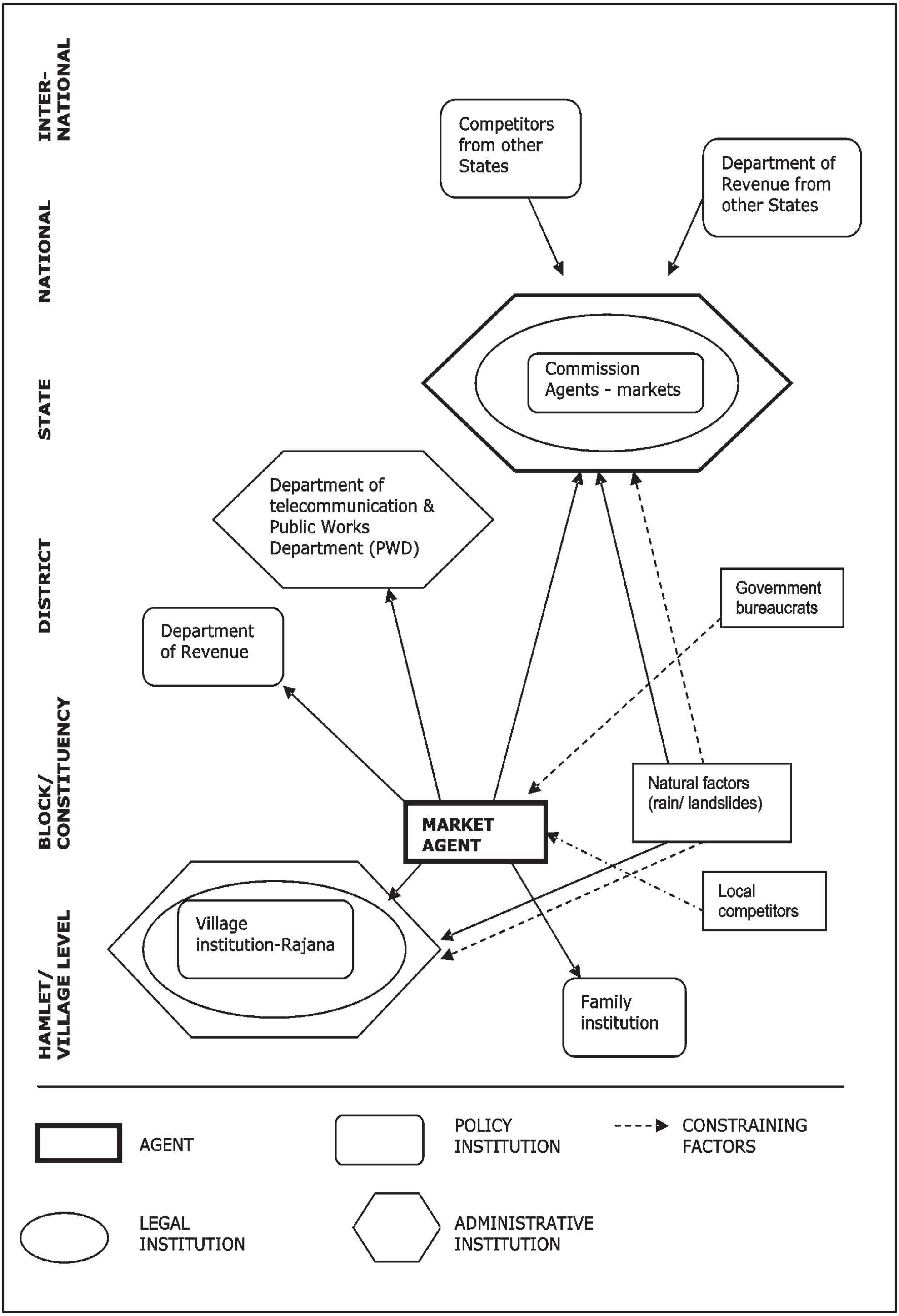
Annexure 4. Institutional Integration at Hamlet Level Arenas, Rajana



Annexure 5. Institutional Integration at District Level Arenas, Rajana



Annexure 6. Institutional Integration in Markets, Rajana



Leapfrogging the Watershed Mission: Building Capacities of Farmers, Professionals and Institutions

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Abstract

The watershed development programs aim at promoting the overall economic development in rural areas through optimum utilization of *in-situ* natural resources to generate employment and restore ecological balance. Both central and state governments have been actively involved in the watershed development activities by making huge investments over a period of time but still these efforts have not produced the desired results. Even though, watershed programs are considered as people-led movements to show a clear road map for future development, still they are myopic programs dominated by the guidelines. One of the major constraints is the lack of capacity building initiatives and follow-ups at different levels. This paper critically analyzes various issues on capacity building of different stakeholders and explores possibilities for leapfrogging watershed mission. More specifically, capacity building at three levels viz., enabling stream, supply stream and demand stream are discussed in detail, where the enabling stream will facilitate for institutional building, supply stream for investment and demand stream for building social capital. The status, gaps and constraints are discussed under each stream. Institutionalizing participatory monitoring and evaluation (through setting up of Participatory Monitoring and Evaluation Cell) at watershed level is a vital one as the stakeholders should be involved at different stages of selection of project activities, planning and implementation with the ultimate objective of sustainability. Further, as part of leapfrogging the watershed mission, the development of resource centers in each region, shift from implementation to facilitation phase, net working of NGOs and interfacing the cross cutting themes with ecosystems are highlighted. The importance of new generation watersheds with shared vision instead of multiple visions is also outlined in detail.

Introduction

Rainfed agriculture in India is characterized by low productivity, degraded natural resources and widespread poverty (Kerr *et al.*, 2000). More than two-thirds of workforce in our country depends on agriculture and natural resources for their livelihoods. This issue made the development planners to implement productive, environmentally sustainable and socially equitable land and water management. It is in this context that the concept of watershed development has been introduced in India. Watershed development has been conceived basically as a strategy for protecting the livelihoods of the people inhabiting the fragile eco-systems experiencing soil erosion and moisture stress. The aim has been to ensure the availability of drinking water, fuel wood and fodder, and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity (Rao, 2000).

The watershed development programs involving the entire community and natural resources influence: (i) productivity and production of crops, changes in land use and cropping pattern, adoption of modern technologies, increase in milk production etc.; (ii) attitude of the community towards project activities and their participation in different stages of the project; (iii) socio-economic conditions of the people, such as income, employment, assets, health, education and energy use; (iv) impact on environment; (v) use of land, water, human and livestock resources; (vi) development of institutions for implementation of watershed development activities; and (vii) ensuring sustainability of improvements. It is thus clear that watershed development is a key to sustainable production of food, fodder, fuel wood and meaningfully addressing the social, economic and cultural conditions of the rural community. Thus, the overall changes including time and space dimension influence the three sub-systems, namely, production sub-system, environmental sub-system and socio-economic sub-system.

Though the watershed development has considerable merit in economical, agricultural, environmental and socio-economic conditions of the people who belong to it, watershed development has not produced desired results in many parts of the country. The watershed intervention need hitherto in many situations have failed to make any discernible impact on adoption of technologies by the farmers even in the adjoining villages. There are several factors responsible for poor performance. They include poor socio-economic status of people, low literacy and conservatism, remote locations, socio-political conflicts, inadequate credit facilities, subsistence orientation, inadequate marketing facilities, absentee landlordism, subdivision and fragmentation of holdings, inadequate storage facilities, lack of proper infrastructure facilities and lack of legal mechanism (Singh and Mishra, 1999). In addition, there are several issues centered on watershed development including financial, technological, people participation, capacity building, institutional support, monitoring and evaluation, and coordination.

Keeping these issues in view the present paper aimed to examine the various watershed development programs in India and critically analyze the various issues in relation to leapfrogging watershed mission with a major focus on capacity building of different stakeholders involved in the watershed development. This paper is based on the evaluation study on impact of Drought Prone Areas Program (DPAP) and Integrated Watershed Development Program (IWDP) conducted in Coimbatore district of Tamil Nadu.

Why Capacity Building?

Capacity building is a process by which groups, institutions and individuals increase their ability to understand and address their development needs in a sustainable manner. Ultimately, development takes place through organizations and institutions. As it is a continuous process, it should be undertaken at all stages of watershed development, viz., planning, implementation and monitoring. Capacity building could be done through imparting training to the target groups, arranging exposure visits and making them more participatory in the whole gamut of implementation of watershed development programs. Empowerment of human resources is an important component in watershed development program. Different people have different roles and responsibilities in project implementation and there is a need to train all the people involved. Training and exposure visits enhance knowledge, skill, attitude and human relationships. Though, a number of measures have been taken for strengthening training at various levels, the experiences show that the training programs should aim at: (i) strengthening those processes, skills and knowledge that help in the delivery of various watershed development activities; (ii) improving the quality and content of the subject matter; and (iii) providing more number of relevant trainings involving more community participation particularly rural women. Therefore, it is essential to examine in depth the whole gamut of training towards capability building among the various clientele groups operating in watershed.

Training is a vital component in development programs particularly watershed development where different roles are to be played by various stakeholders with interest at different levels like villagers, Community Based Organisations (CBOs), Project Implementing Agencies (PIAs), Watershed Development Team (WDT), Government Organizations (GOs) and Non-Governmental Organisations (NGOs). It is a well known fact that training enhances knowledge, skill and attitude, and promotes human relationships. The knowledge may include awareness about dissemination methods, subject matter in the related fields, stakeholder problems and their solutions. Changes in attitude will improve stakeholders' ability on problem solving, behaviour and empathy. Skills comprise ability to communicate with target groups, technological skills, demonstration ability and clarity in understanding concepts and related issues.

The different stakeholders should be trained and encouraged to develop knowledge, skill and attitude to deliver good things to the watershed community. Identification and use of trainers and resource persons both within and outside the project area/state will strengthen the process of capacity building. Exposure visits, interactive sessions and networking among the stakeholders can play a major role in the capacity building of grassroot level workers. Participatory training methodologies encourage innovations. Linkages with research institutes help in providing practical solutions to special problems encountered. As per the 1994 guidelines (implemented in April 1995 and revised guidelines of 2001) for implementation of watershed development, people have new roles in program planning and implementation. This calls for building new skills and capacities. This need is very well recognized and one full year is provided for this purpose. About 10 percent of the total funds are allocated for community organizations and training.

An Overview of Watershed Development Programs in India

Watershed development has emerged as a new paradigm for planning, development and management of land, water and biomass resources following a participatory bottom-up approach. The Government of India has been implementing watershed development programs through different ministries, viz., Ministry of Agriculture, Ministry of Rural Development, Ministry of Environment and Forests, and Ministry of Planning and Program Implementation. The list of various watershed development programs is presented in Annexure1. Some important ongoing watershed development programs include Drought Prone Area Program (DPAP), Desert Development Program (DDP), River Valley Project (RVP), watershed development programs implemented by international organizations like DANIDA, DFID (UK), SIDA, etc., state funded watershed development programs etc. In addition, based on the experience, the Government of India (GOI) has recently created Watershed Development Fund (WDF) in collaboration with National Bank for Agriculture and Rural Development (NABARD). The objective of the fund is to create the necessary conditions to replicate and consolidate the isolated successful initiatives under different programs in the government, semi-government and NGO sector. In addition, several initiatives of peoples' participation in resource management have taken place. Prominent among them are *Chipko Movement,* Save Narmada Movement, AVARD's Irrigation Scheme, Water Council (Pani Panchayat), Ralegaon Siddhi, etc. The Ralegaon Siddhi is one of the successful models of peoples' participation.

Experience shows that various watershed development program brought significant positive impact. There has been a marked improvement in the access to drinking water in the project area, increase in crop yields and substantial increase in cropped area, rise in employment and reduction in migration of labour. Availability of fodder has also improved leading to a rise in the yield of milk. The most important factor accounting for the positive impact of watershed development programs is community participation and decentralization of program administration. Experience from Maharashtra State of India shows that the encouraging performance is attributable largely to the positive response from the people, especially in tribal areas, owing to their traditions of community participation and to political and administrative will for decentralizing administration and strengthening of Panchayat Raj institutions (elected Village Councils) (Rao, 2000).

Despite the significant positive impact due to watershed development program, the existence of different constraints hamper/slowdown the watershed development program. It is evidenced from the past studies that unequal access to land, water and other resources is a major constraint to peoples' participation in many places. Insecurity of tenure in case of sharecroppers keeps them off from improving and conserving the natural resource base. Besides, social insecurity gives rise to conflicting interests between different groups of farmers and farming and non-farming communities, which only culminate in degradation of the natural resources.

Experiences

Capacity Building

The experience from Integrated Wasteland Development Program (IWDP) implemented in Coimbatore district of Tamil Nadu (India), lucidly present the various issues on capacity building in watershed development activities.

Training

It is evidenced that training programs one each for watershed development team members and secretaries and volunteers and user groups were organized as part of the capacity building exercise. These training programs were conducted by different organisations as given in Table 1.

Watershed secretaries, after receiving the training, were better informed of their duties and it was felt that they are discharging their duties as watershed secretaries in carrying out day-to-day activities and maintenance of accounts and records in a better manner. The members of different 'User Groups' were also given training on creating awareness and motivation for high yielding and low cost technologies for adoption.

Table 1. Details of training programs under IWDP watershed program

Name of the training	Resource departments	Level of participants and its number	Duration	Purpose
WDT members training	CSWCRTI Ooty	6 WDT members	6 days (12-10-99 to 17-10-99)	Training as per the new guideliness of Government of India on role and responsibilities of WDT members in IWDP scheme
Watershed secretaries and volunteers	COODU NGO	Secretaries 18, volunteers 18	5 days (21-6-2000 to 25-6-2000)	Imparting knowledge on concept of watershed record keeping, maintenance of registers, accounts, office procedures, etc.
User group training	Jointly by DRDA and Line Departments	Beneficiaries (user group members)	One day (first fortnight of August 2002)	Creating awareness and motivation for high yielding and low cost technologies for adoption

Exposure Visits

Four exposure visits were organised jointly by DRDA and COODU, NGO. Of these, one exposure visit was exclusively for watershed functionaries such as secretaries and volunteers while the remaining visits were meant for beneficiaries (Table 2). Besides, presidents and chairmen of the program, few farmers from each watershed were taken to visit various places. First batch of 60 participants comprising watershed association and committee members, farmer beneficiaries, presidents and chairmen were taken to visit progressive farms, nurseries, research institutions, successful watershed areas and had interaction with scientists, leading farmers and seedling producers for three days during November 1999.

Peoples' Participation in Training and Exposure Visits

Experience from IWDP watersheds implemented in Coimbatore district reveals that the participants who attended the Users' Group training program varied from 60 to 93 percent, while the respondents not attending the training program varied from 7 to 40 percent (Table 3).

Table 2. Details of exposure visits conducted in different watersheds

Level of participants & total number	Conducted by	Places of visit	Duration	Purpose of visit
Watershed association and committee members, presidents, chairmen, farmers, field functionaries, etc. 60 participants	COODU & DRDA	Vallam, Thanjavur, Ghengalpet & Madurandagam	3 days (15 to 17-11-99)	Visited progressive farms, nurseries, research stations, successful watershed areas and interaction with progressive farmers for updating knowledge on watershed concept
Watershed association & committee members, presidents, chairmen, farmers, field functionaries etc. 59 participants	COODU & DRDA	Sathiyamangalam	One day (7-7-2000)	Visited progressive farms, nurseries, research stations, successful watershed areas and interaction with progressive farmers for updating knowledge on watershed concept
Watershed association & committee members, presidents, chairmen, farmers, field functionaries etc. 58 participants	COODU & DRDA	Dindigul, Kundrakudi & Kodaikanal	2 days (20 to 21-01-01)	Visited progressive farms, nurseries, research stations, successful watershed areas and interaction with progressive farmers for updating knowledge on watershed concept
36 participants (Secretaries - 18 and volunteers –18)	COODU (NGO)	All DPAP watersheds in Annur, Avinashi, Palladam, Sulur and Tiruppur blocks	One day (26-6-01)	Exposure for concept of watershed operational procedures and implementation such as record keeping and maintainance of registers etc.

Table 3. Participation in training and exposure visits in IWDP watersheds of Coimbatore district

Particulars	Attended	Not attended	Total
User group training	142	38	180
	(78.9)	(21.1)	(100.0)
Exposure visits	83	187	270
	(30.74)	(69.26)	(100.00)

Figures in parentheses indicate percentage to total.

Of the total respondents, nearly 31 percent attended the exposure visits and gained knowledge. It is evidenced that around 69 percent of the respondents did not attend the exposure visits.

Usefulness of Training and Exposure Visits as Perceived by the Respondents

Out of the total respondents who attended the training programs organized by the IWDP, 94.4 percent of the respondents found the training was very useful

(Table 4). Very few members felt that the training programs were not useful because the duration of the training conducted was insufficient and the subject matter was inadequate.

Table 4. Usefulness of user group training program and exposure visits as perceived by the respondents

Name of training	Useful	Not useful	Total
User group (UG) training programs	134	8	142
	(94.4)	(5.6)	(100.0)
Exposure visits	78	5	83
	(93.98)	(6.02)	(100.00)

Figures in parentheses indicate percentage to total.

Three exposure visits each comprising 60 UGs members were taken to: (i) Madurai, Kodaikanal, Kundrakudi; (ii) Tanjore, North Arcot, Chengulput; and (iii) Sathiyamangalam. In all these exposure visits, the UGs members were exposed to various watershed development and treatment activities. Among the members who attended the exposure visits, nearly 94 percent found the visits were quite useful. Therefore, it is suggested that more number of exposure visits covering different successful watershed models, community nurseries and research institutes involved in watershed development research may be organized. This will help gain knowledge regarding recent technical knowhow and benefits of various watershed treatment activities among the members.

The interaction of members of UGs with Watershed Association (WA)/ Watershed Committee (WC) is a must for the success of watershed development program. In the opinion of 81.5 percent of the respondents the interaction with members of WA/WC was good followed by average (10.4 percent) and poor (8.1 percent). As the interaction of UGs members with other community organization will help solving problems and improve social relations, this kind of interaction may be encouraged and project implement agency (PIA) may pay special attention in motivating the interaction between the groups.

Issues in Capacity Building

The experiences gained in watershed development programs led to the following issues in capacity building in watershed development projects. The issues of capacity building in watershed development projects can be analysed in terms of demand stream, supply stream and enabling stream. The demand stream consists of villagers living within watershed, CBOs like Watershed Associations, Watershed Committee, User Groups, Self-Help Groups and People Organisations. The supply stream consists of both Central and State governments, and other national and international donors who are involved in funding watershed development projects. The enabling stream includes promotional organistaions like NGOs, regulatory institutions like Ministry of Rural Development (MoRD), Ministry of Agriculture (MoA), Ministry of Environment and Forests (MoEF), etc. Capacity building should consider all the stakeholders so that effective implementation of watershed development could be achieved. The issues under various streams and present status, gaps and constraints are discussed hereunder.

Demand Stream

Demand stream in the watershed development projects consists of villagers and local organizations, which are characterized by unorganized, low resource literacy, lack of awareness of various development programs and vested with poor socio-economic conditions. The gaps include poor leadership skills, low skills in management, implementation and very much handicapped with technical skills too. The factors responsible for the demand stream are lack of appropriate policies to promote capacity building, lack of adequate support from PIAs and others, inadequate fund allocation for capacity building and absence of enabling environment to acquire knowledge, skill and attitude. Thus capacity building for the demand stream includes members' training, leadership development, skill building for income generation and employment.

Capacity building of demand stream includes orienting the villagers towards creating awareness on watershed concept and realizing the importance of watershed development, stake building, facilitating their contributions towards physical development, organising them into either SHGs or functional groups like Watershed Associations, Farmers Association, etc, and building the capacities of this group of stakeholders for successful interface and collaboration with the supply stream. The poor villagers particularly women need to be organized and motivated before extending institutional finance. This will help acquire basic skills of leadership, financial management, accounting, etc.

It is also evidenced that most of the programs are of short duration and having content, which is irrelevant. The capacity building exercise in this would seek to build knowledge, skill and attitude of the stakeholders.

Supply Stream

Supply stream includes both Central and State governments, national and international donors, academic institutions etc. involved in facilitating watershed development. These supply streams act as facilitators to implement watershed development activities through PIAs and also ensure adequate funding for physical development in the watershed.

The supply stream, on the one hand, is characterized by fewer dispositions to innovation in micro watershed development, rigid and inflexible policies. While on the other hand, it has excellent technical orientation on the subject of watershed development and ability to mobilize funds for investment on various watershed treatment activities.

The gaps in supply stream include lack of perspective and attitude, faulty approaches and insufficient internal capacity building process. Constraints, which limit the supply stream in this regard, are inadequate or untrained manpower resources, rigid rules, regulations and inflexible procedures in implementing various developmental activities.

The questions, which are critical to the policy makers and others with this scenario is that, what should be done to promote interest and involvement of the government officials in watershed development in shifting from implementers to facilitators?

Capacity building for supply stream would go beyond training and exposure visits, and would cover a visioning, perspective building on community based watershed development and management, changing attitude to overcome insular views, skill upgradation, etc. The capacity building of these players involves building conviction and attitudes through exposures to successful models for creating awareness, better appreciation and skills required to deal with the unorganized sector.

Enabling Stream

Enabling stream includes the external organizations like NGOs involved in promotion and development of CBOs like WA, SHGs, UGs, and functional groups and was through social intermediation. The regulatory government bodies, policy-making institutions also form part of the enabling stream as they play crucial role in providing favourable policy framework and supportive environment, which enables the growth and development of the micro watersheds. For sustained growth of the micro watersheds in relevant context with community, involvement from planning to execution and subsequent management, the enabling stream is important.

Experiences show that the NGOs in the enabling streams are with weak planning and management skills, financial management and good knowledge in community organizations. The gap in this stream is less knowledge on legal and regulatory framework. The effectiveness of the enabling streams is constrained by lack of resources, inadequate content for capacity building and lack of training infrastructure. Hence, the capacity building of these members is essential to have equal knowledge, attitude and skills.

Issues for the Future

In spite of the significant impact in performance, the experience raises a number of key issues, which have significant bearing on improving performance, and the sustainability of watershed development program itself.

Assess the Training Needs

The role that one is expected to play in a watershed program often determines training needs. We need to ask the following questions: (i) What are the roles and responsibilities of the different stakeholders? (ii) What are the activities that stakeholders were involved with during the specified time frame? and (iii) What are the skills/capacities required to effectively and efficiently undertake these activities?

Type of Training to be Assessed

One should assess what kind of training should be imparted to different stakeholders with interest based on roles in watershed development activities and their requirements. This may vary with the different stakeholders and scales. For instance, the community as a stakeholder can be given more training on technical information and skills, women can be given managerial skills, conceptual skills to Watershed Development Committee, decision making to Watershed Development Team and communication skill to government functionaries at different levels and PIA.

Subject Matter

When capacity building is the main focus, enough emphasis must be laid on the technical content of the training and duration of the training program. The curriculum for the training must be clearly defined considering the knowledge level of the stakeholders, their roles and needs.

Transaction Cost and Duration of Training

The transaction cost of attending training program also assumes importance. Hence, the duration of training program should be convenient to the stakeholders without involving huge transaction cost. This is particularly crucial when we impart training to the villagers, and members of Community Based Organisations (CBOs). It is preferable that the duration of training program should be short to the extent possible. Short duration training program will help the local villagers and others to develop skills, knowledge and attitude without incurring huge transaction costs.

Training Methodology

In a training program, methodology assumes importance. Every training program should be ideally participatory in nature. With each stakeholder, the training methodology will be different. For instance, there are number of training methods like small group discussion, practical methods, games, role play, case study method, structural exercises and exposure visits. Employing appropriate training method to the target group is crucial. For instance, case study method will be appropriate for field functionaries/WDT/PIA.

Developing Indicators for Evaluation of Training and its Impact on Capacity Building

Imparting training to the various stakeholders at different levels is not sufficient to fulfil the objectives of the watershed development programs. There is a dire need for developing appropriate indicators to assess the impact of training program on the capacity in terms of knowledge, skill and attitude of stakeholders.

Gender Issues

Training programs in watershed development mostly target men rather than women. Some NGOs hold meetings with women and explain the objectives of the watershed development program to be implemented in the village. Women are given no technical training in watershed development. Even when training is made available for women, a definite gender bias exists in the kind of training, and awareness programs planned for men and women. Women are typically isolated from the scientific and technical aspects of watershed development program. Training modules need to be specially designed to impart skills and knowledge to women in the community as well as those who have been appointed to the decision-making bodies.

The capacity building exercise must lead to the village level functionaries taking over as empowered and confident managers of the program. On the other hand, the PIAs and other external agencies must phase out.

Need for Setting-up of 'Resource Centre' for Training

In spite of the wide implementation of the watershed development program over the years across the country, there is no institutional mechanism exclusively for watershed development training. This leads to inefficiency in different phases of watershed development like planning, implementation and evaluation. As the capacity building has received much attention from the policy makers, there is a dire need for setting up of 'Resource Centres' for training watershed development personnel. The resource centre may be set up at national, state, and regional levels. Also, enough efforts may be taken up to include different divisions so that various stakeholders could be imparted training.

Government should Change its Role from Implementation to Facilitation

At present the government departments and agencies are directly involved in implementation of watershed development programs. Evidences show that these departments and agencies are not much equipped with social mobilization processes particularly formation of CBOs. Also, there exists a big gap between the community and government departments and these agencies could not deliver as planned. Hence, it is high time to think of changing the government role from implementation to only facilitating role in watershed development.

Networking among Institutions

Enabling stream institutions located across the country are working independently and very much handicapped with knowledge, skill and attitude. Promotion of networking of these external organizations particularly the NGOs at regional, state and national level is needed at this point of time. This will help to set standards and provide capacity building support, organizing policy workshops, seminars, conferences, meetings for upscaling and mainstreaming technologies and practices. Promotion of strong network among NGOs is warranted now.

Conclusions

Today watershed development has become the main intervention for natural resource management. Watershed development programs not only protect and conserve the environment, but also contribute to livelihood security. With large investment of financial resources in the watershed program, it is important that the program becomes successful. For achieving the best results, people should be sensitized, empowered and involved in the program. The stakeholders at different levels should be involved at various stages of project activities, planning and implementation with the ultimate objective of sustainability. In addition to the above, empowering the different stakeholders at varying scales will help promote watershed development at a much faster rate.

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Annexure 1. History of Development of Watershed Development Projects in India

Name of the project	Year of launch	Watershed No./area	Sponsoring Agency
Research Watersheds	1956	42	Min. of Agri., GOI CSWCRTI*, ICAR
Soil Conservation in RVP Catchments	1961-62	29 catchments in 9 states	Min. of Agri., GOI
Operational Research Watersheds	1974	4	CSWCRTI, ICAR
Watershed Management in Catchments of Flood Prone Rivers	1980-81	10 catchments in 8 states	Min. of Agri., GOI
Model Watersheds	1983	47	CSWCRTI & CRIDA, ICAR
Watershed Development in Rainfed Areas	1984	28 (3.47 lakh ha)	World Bank
Watershed Development in Ravine Area	1987	0.62 lakh ha	EEC
Drought Prone Area Programme(DPAP)	1987	91 districts 615 blocks	Ministry of Rural Development
Desert Development Programme	1987	21 districts	Ministry of Rural Development
Western Ghats Development Programme (WGDP)	1987	158 blocks 5 states	Union Planning Commission
Indo-German Watershed Project	1990-91	Maharashtra	Germany
Indo-German Bilateral Project	1990-91	Monitoring	Germany
NWDPRA	1991	2497	Min. of Agri., GOI
IWDP (Hills & Plains)	1991	1.12 lakh ha	World Bank
Comprehensive Watershed Development Project	1991	1.13 lakh ha	DANIDA(Karnataka, Tamil Nadu and Orissa)
Rel Majra Watershed Project	1991	1	CSWCRTI, ICAR/ Min. of Env., GOI
Doon Valley Project, UP	1993	1.72 lakh ha	EEC
Integrated Wasteland Development Project (IWDP)	1994	25 states	Ministry of Rural Development
Indo-Swiss Participatory Watershed Development	1995	0.35 lakh ha	Swiss Government
Attapadi Wasteland Comprehensive Environment Conservation Project, Agali, Kerala	1996	507 km^2	OECF, Japan

Source: A.K.Sikka and J.S.Samra (2000).
*CSWCRTI= Central Soil & Water Conservation Research & Training Institute, Dehradun.
ICAR= Indian Council of Agricultural Research.
CRIDA= Central Research Institute for Dryland Agriculture.
EEC= European Economic Community.
OECF= Overseas Economic Cooperation Fund.
NWDPRA = National Watershed Development Program for Rainfed Areas.

Forest-Watershed-Irrigation Linkages: Policy Support for Integrated Management

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Abstract

This paper assesses community based natural resource management (CBNRM) experience in the hills of Nepal through a review of literature and case studies. The aim is to identify methodological tools for the development of appropriate CBNRM institutional mechanisms for the upper watersheds of the Indus-Ganges Basin (IGB) in Nepal and India. Functioning institutional arrangements are expected to contribute to enhanced sustainable livelihood opportunities and reduce the vulnerability of poor rural people in IGB upper watersheds. Improved understanding of the internal and external linkages among multiple communities within watersheds and larger sub-basins is critical to strengthen management practices, particularly of forests and irrigation, by the communities. The analysis of the existing linkages or limitations in co-management of forests and irrigation are important in identifying policy constraints. Action research based on the policy assessment is designed to improve the integration of interventions by government implementing agencies with community-based initiatives. Policy support in turn is intended to increase poor women's and men's food security and improved livelihoods based on community-managed water and forest resources in a watershed or sub-basin context.

Introduction

Because of the increasing pressure on the world's freshwater resources, growing water scarcity problems (both quantity as well as quality), and intersectoral competition for water, the Integrated Water Resources Management (IWRM) approach is being widely discussed and promoted. The Global Water Partnership (GWP) defines IWRM as 'a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP-TAC, 2000 Background Paper No.4). It is realised by all that instead of fragmentation and conflict, competing sectoral interests and responsibilities for the whole water sector can be resolved within a single integrated framework (GWP, 2000). IWRM, therefore, stresses the internalization of water-related externalities (e.g., downstream scarcity caused by over-extraction of water upstream), the equitable allocation and distribution of water to multiple stakeholders, and appropriate balance between water as a basic need vs. water as an economic good. However, the 'integration' task in reality is not so simple. The actual implementation of such integrated frameworks at the national, regional, and local community levels are still in evolution.

Despite increased emphasis in international meetings and policy forums on the need for basin-level planning and application of IWRM, few functioning examples are presented in the literature that provide useful information on how integration is achieved. For the purposes of this paper, forests and irrigation have historically been managed by distinct administrative entities operating within different spatial boundaries, whereas forest and water resource dynamics follow ecological and hydrological boundaries. Because the watershed is a commonly understood spatial unit in hill and mountain environments, communities are increasingly managing forest and water resources along watershed lines. However, the linkage with external institutions, particularly government implementation agencies, demands an understanding of the complexity of merging watershed and administrative boundaries. As a result, operationalizing a viable decision framework at the local level based on IWRM principles has yet to emerge in IGB upper watersheds in Nepal and India.

Poor rural women and men face critical food security and livelihoods challenges, particularly in marginal upper watersheds of the Nepal and Indian Himalayas. Restricted access to often-degraded water, land, and forest resources combined with low productivity of open-access resources invariably result in seasonal or permanent out-migration and the loss of traditional knowledge, labour for management and community solidarity to address resource degradation. The result is insecure livelihoods and vulnerability to a range of environmental and other hazards. There are a number of successful examples of CBNRM innovations—often led by poor women who directly face the brunt of resource degradation and migration—that have led to significant improvements in food security and livelihood sustainability, and have stemmed migration (Pant *et al.,* 2003) due to increased employment in agriculture through increased availability of irrigation water and utilization of forest products. The Community Forestry Policy in Nepal and Joint Forest Management Program in India are examples of successful replication of CBNRM over large areas. The communities need to manage multiple resources, particularly forests and water, and also have to address resource competition issues with other communities, e.g., upstream diversions of water that affect downstream availability. Successful examples of multiple resource management by communities are less common, and generally confined to single sectoral approaches such as the community forestry program and farmer-managed irrigation systems (FMIS) in Nepal and some of the watershed programs in Nepal, e.g., Churia Forestry Development Programme of GTZ (Pant and Kharel, 2000), and India. Farmer-managed irrigation systems can be viewed as an instance of local communities establishing successful institutions for collective benefits (Pradhan and Bandaragoda, 1997; Pant, 2000).

It is hypothesized that the integration of activities of forest users groups (FUGs) and water users groups (WUGs) at the watershed level would improve the management of natural resources and have beneficial impacts on the livelihoods of both resources. This would also facilitate a wider development process at the community level to support rural livelihoods and improved community development options. In addition, it is believed that integration would also help to empower local communities in a broader context of decentralization while providing an improved incentive structure for collective action. The discussion is based on a case study in two hill watersheds in Tanahu and Kaski districts in western Nepal. This paper addresses some of these issues and assesses opportunities for integration of irrigation and forest resources by outlining a methodological approach for a new project under implementation by the International Water Management Institute (IWMI) and civil society partners, under support from the CGIAR Challenge Program on Water and Food.

Present Context and Problems of Community Based Integrated Natural Resource Management

Forests and water for irrigation are two central resources for livelihood enhancement, especially of the poor. Local initiatives for their management are diverse and complex in Nepal and the Indian Himalayas. An important consideration in this respect is that although the rural poor continue to heavily depend on these resources, they have not been subjected to the degree of over-exploitation seen in other parts of south Asia, largely because management is localized and guaranteed by legislative provisions. At the same time, the utilization and management of forests and irrigation by communities have led to the evolution of institutional arrangements that lie at the centre of sustainable resource use.

Institutional Linkages

In recent decades, various agencies including governments in the IGB upper watersheds have invested tremendous effort and resources to build local organizations, seeking to institutionalize FUGs, WUGs and other community based organizations (CBOs). The major shortcoming of these resource-specific institutions, however, has been their ineffectiveness in resolving inter-sectoral conflicts. As a result, these institutions have not been able to address the problems of resource management at a watershed level due to the increasing complexities of managing mulitple natural resources. For example, each year landslides triggered by haphazard road construction activities wreak untold damage to forests, agricultural land, irrigation infrastructure, and human settlements in the hills of Nepal and India. Effective watershed-level management would help in reducing such calamities. With increasing focus on integrated natural resource management there is a need for watershed level institutions to facilitate integrated approaches to the management of natural resources. The development of watershed level institution is expected to overcome problems associated with the land, forest and water management by integrating the activities of various local level institutions like WUG, FUG, local elected institutions and other interest groups while at the same time providing crucial institutional external linkages, e.g., in the case of road construction.

At micro-watershed level, there are instances of local communities who have initiated efforts at integrated resource management through the use of water for various economic activities and watershed management along with income generation activities (Pant and Bhattarai, 2001; Pant and Kharel, 2000). These successful experiences at village level provide a basis for integration of natural resources at the watershed level and help in building appropriate institutional mechanisms. It would, therefore, be more appropriate to conceptualize integration towards institutional collaboration through implementation of complementary activities at the watershed level. Ultimately, this would contribute to the evolution of higher-level institutions for watershed or river basin management, and could also be an effective planning unit for IWRM including natural resources (GWP-TAC, 2000 Background Paper No.4). The emergence of an institutional mechanism at the watershed level could be helpful in tackling the cyclical nexus between poverty and natural resources management, thereby benefitting the poor (World Bank, 2002). Underlining this, common property resources (CPRs) are a crucial element of poor people's coping and adaptive strategies. Because institutions can play an important role in redistributing resources in favour of the poor, poor people's access to the natural resources on which they depend could be mediated by institutional arrangements that create an enabling environment for the poor.

Many local level water management groups in Nepal and India have received institutional recognition by the government, while some are without formal recognition, which has restricted their access to external resources. Similarly, the management of forests by local communities in the hills of Nepal and watershed samithis (committees) and joint forest management committees in India can be cited as examples of sustainable resource management. This offers an opportunity to understand the relationships between FUGs and WUGs at the watershed level where the twin resources are clearly linked. In order to create real livelihood opportunities without affecting other users' options, multiple communities must coordinate their actions.

A recent study by Pant *et al.* (2003) suggests that informal interactions between WUGs and FUGs do exist, however, this has not evolved towards an integrated approach to resource management to address the issues related to resource degradation, access and competition among multiple users. Active policy and institutional reforms are underway in Nepal and the Indian state of Uttaranchal, but institutional fragmentation remains a key barrier to integrated approaches on the ground. Uttaranchal recently created a Watershed Directorate to coordinate actions of government agencies for forest, water supply and irrigation management. Similarly, recent Nepalese government policies, particularly the Water Resources Strategy (WECS, 2002), have emphasized integrated resource management at the sub-basin and basin levels. However, lack of appropriate institutions at the local level has constrained the integration of activities. Linking upstream and downstream resource management activities at the sub-basin levels in order to integrate the benefits and institutionalize win-win solutions for both forest and water-dependent women and men has not been systematically addressed either from the practical implementation or research perspectives. Gender and intra-community dynamics are critical to the internal functioning of institutional mechanisms for water and forest management. The role of local and national or state government policies and programs as well as civil society organizations and NGOs will increasingly influence local action at the household and village levels. One of the challenges in this respect is to facilitate the evolution of an institutional base for the linkages between various resource management groups.

Challenges and Opportunities

In addition to protecting or conserving resources, many CBNRM institutions are fostered at the local level with broader goals of reducing or eradicating poverty by empowering the local community. They could provide the basis for integration and higher-level institutional linkages if mobilized in that direction. Conflicts over resource use and concerns over equitable distribution of resources among all users including poor men and women are the major challenges faced by CBNRM groups at present. Experiences from the field suggest that CBNRM groups and concerned stakeholders also foresee the usefulness of improved institutional linkages. In addition, facilitation of strong local-level institutional integration could more effectively advocate and influence policy-making and redress existing policy ambiguities regarding CBNRM. The case study (Pant *et. al.*, 2003) done in the hills of Nepal indicates that decentralized management of natural resources is a promising resource use and conservation approach but it has a long way to go to achieve the goal of poverty alleviation through CBNRM due to lack of appropriate institutional mechanisms to promote it at the local level. The field survey suggested that some of the communities have already felt that need, however, the integration of the natural resource management activities needs further exploration. This requires intensive interaction with communities to understand the dynamics of resource use, particularly if policy reform is to support the integration of irrigation and forest management at the local community and watershed levels.

The major areas for integration required are at the policy, legal and institutional levels. In both Nepal and Uttaranchal, there appear to be major policy gaps in promoting integration of development activities despite the rhetoric on integrated design and implementation of programs. Ambiguities at the policy level are manifested in legal provisions, which in turn are fundamental to the identification of rights, role and delineation of authority among various stakeholders. Fragmented planning and implementation of a range of developmental activities have encouraged the promotion of sectoral interest to the neglect of integrated development. The institutional roles of the planning and implementing partners at the grassroots level need to be coordinated. At the same time, the local elected officials should support coordinated water, forest and land management and seek to implement programs and apply financial resources in a coordinated manner. Likewise, regular consultation among various users through external facilitation could be an appropriate step towards evolvement of higher-level institutions through users' initiatives for better integration. The capacity of the district level institutions and local elected officials needs to be strengthened, as they play a vital role in facilitating integration of activities at local level.

Proposed Action Research

Keeping in view the need to identify appropriate institutional mechanisms for resource integration and external linkages to support CBNRM, an action research project titled 'Linking Community-Based Water and Forest Management for Sustainable Livelihoods of the Poor in Fragile Upper Catchments of the Indus-Ganges Basin' (to be jointly implemented by IWMI, the Stockholm Environment Institute – York, the Institute for Water and Human Resources Development, and People's Science Institute under financial support from the CGIAR Challenge Program on Water and Food; see www.waterforfood.org) is being initiated in the hills of Nepal and Uttaranchal. The goal is to contribute to enhanced sustainable livelihood opportunities and reduced vulnerability for poor rural people in upper watersheds of the Indus-Ganges basin in Nepal and India. This will be achieved through improved understanding of existing linkages or limitations to couple forest and water management leading to policy support to the respective governments on appropriate institutional frameworks and to program support for implementing agencies.

Research Questions

Using an action research approach the following questions will be addressed:

- What are the policy and legal measures and their associated institutional structures that permit integrated forest and water resource management in Nepal and Uttaranchal state in India?
- What are the constraining and facilitating factors to promote opportunities to strengthen livelihoods based on forest and water resources by improving their productivity in two Himalayan sub-basins?
- How can integrated water resources management and watershed level planning be facilitated through expanded mandates for local CBNRM institutions by strengthening users' roles and linkages with external resources?
- What are the mechanisms to scale up integrated water and forest management at the sub-basin level?

Activities

Following from the questions listed above, a series of research activities are being initiated.

Analysis of legal, policy and institutional frameworks

a) Review of policy, legal and institutional provisions for the management of natural resources in order to understand how they are applied or modified in practice. Attention will be paid to the implications of governmental programs on local people's livelihood.

b) The implications of existing policies for the scope and performance of various institutions at the local level will be analyzed to assess their effectiveness in propagating local-level resource management, both for forest and water separately and for integrated management.

c) Initiation of dialogue at the policy level through separately and combined (Nepal and Uttaranchal) workshops that will bring together 25-30 participants in order to design a detailed analytical and methodological framework. It will also serve to inform stakeholders to ensure their participation in the study.

d) Review of literature and field studies based on the methodology defined will be undertaken to examine past experiences with integrated resource management in order to understand successes or failures and their causes.

Promote livelihoods through enhanced forest and water productivity

A rapid resource and livelihoods assessment will be conducted in parts to create baseline information for time series analyses of these issues in future. The outcome will be a set of context-specific data collection tools geared to individual examples of linked forest and water management. The water and forest resource use and demand priorities of different stakeholders in at least three communities—upper, middle and lower reach—in each sub-basin will be assessed using user-defined cumulative checklists and participatory research methods. The types of resource scarcity and stress users have observed over a period of time and their coping strategy will be assessed.

Examination of expanded mandates for local users groups

a) Assessment of different approaches, experiences and management options for water, land and forest management in Nepal and Uttaranchal through expert consultation with experienced civil society, local government and resource management agencies will be done. Identification of *models of good practice* for management of these resources and their replicability will be explored through role-play exercises with resource users.

b) Assessment of existing challenges and opportunities in the use of resources by identifying groups having access and control, groups deriving benefits, and groups excluded from access to natural resources and the management decision-making process.

c) Analysis of the effectiveness of local resource management institutions and the potential for expanding their mandates to include integrated resource management. This will be done through the analysis of existing management practices, constraints and opportunities.

d) Development of an action plan for improving community-based resource management through interviews, surveys and role-plays activities.

Scaling up mechanisms for IWRM

a) This activity will focus on the implementation of the action plan prepared as per foregoing activity for improving community-based resource management. A common water-forest management federation (*Pani-Ban* in Nepali or *Jal-Jangal Samiti* in Hindi) consisting of about 25 resource users and up to 5 local government representatives will be initiated at the sub-basin. Members of existing water users group, forest users group, watershed management groups, local government, NGOs, and advocacy groups will be the members. Federation members will meet once a month during the first year, and quarterly thereafter to identify and solve problems. External experts may serve as resource persons. The objective of the federation is to link forest and water resource users and provides a bridge to external resources.

b) Organizing a workshop to facilitate interaction between policy makers and other stakeholders to come up with viable solution to address problems identified during the study period.

Methodology

The methodology for this study is outlined below.

Activity 1

- Desk top study of the government policies and legal provisions on water, environment, forest and social organization. Review of land, water, forest, cooperative, environment act and laws, local development act and association registration act.
- Focus group discussion, key informants, ethnohistories, direct observation, PRA with local users, local officials to gather information on resource management practices, influence of policy on local resource management with focus on identifying constraining and facilitating factors for CBNRM.
- Workshop to inform policy level stakeholders (25-30 persons) to get their suggestions on the proposed study.
- Collection and documentation of the experiences from the program implemented in the past and present.

Activity 2

- Initiation of dialogue and interaction with local stakeholders in selected sites on the approach for action research in the field. Assessment of resource base and social mapping of the study area using PRA tools and other measurement techniques.
- Assessment of change pattern in resource base (through interviews, key informants, direct observation, oral histories) with stakeholders with focus on gender analysis of resource tenure, and use and conservation knowledge and skills, gender access to resource and its implications, gender role in time of stress and coping strategy. Gender analysis of resource tenure and use and conservation knowledge and skills, gendered access to resource

and its implications, determination of gender role with an emphasis on gendered resource access and the critical need to address feminization of resource management due to male out-migration. GIS information and an assessment of sub-basin hydrology based on reported data and water balance simulation methods (simple, landuse dependent rainfall-run-off approaches in the SWAT modeling framework).

- Assessment of resource needs and demands of households in one community each in upper, middle and lower reach of watershed through semi-structured interview. The community thus selected will be heterogeneous to reflect the need of various stakeholders.

Activity 3

- Identification of approaches in the implementation of CBNRM applied by various institutions, organizations and civil society in consultation with development practitioners from these organizations. Organization of one expert consultation meeting to identify management options for CBNRM. The management options will be discussed with the users to adapt to the local conditions. Exchange visit of local users between Uttaranchal and Nepal will be organized.
- Categorisation of groups having better, less and no access and control of resources and structured and semi-structured interview, focus group discussion with them to know reason for the situation and how access and control to resources could be increased. The data will be disaggregated to identify gender role in access to and control of resources and its implications in resource management.
- Structured questionnaire surveys on food security strategies at the household and village level focussing particularly on water management in both rainfed farming and small irrigation schemes, and wealth ranking and livelihood and policy analyses.
- Administration of checklists to the officials of local institutions (elected, I/NGOs, CBOs) and other stakeholders involved in development activities at local level. Dialogue and interaction among representative of these institutions will be organized to expand their mandate.
- Interviews, surveys and role-plays activities for action plan development for improving community-based resource management.

Activity 4

- Identification of representative (25-30) of resource user groups through discussion with various resource users group.
- Facilitate development of working modalities of the committee in consultation with the committee members and help develop action plan for institutional linkage, coordination, NRM management strategy to improve inter-community benefits and reduce conflict.
- Organisation of workshop for policy level stakeholders.
- Synthesis of research activities.

Expected Outputs

The following output will be generated through this study:

- Report on comparative analysis of the policies and legal provisions relating to management of land, water, forest and association registration act.
- Documentation of discussion points and reports on the resource management dynamics as expressed by the users at the local level and workshop report detailing the discussions and suggestions of policy level stakeholders.
- Report on the review of experience in the implementation of integrated natural resource management in the past.
- Documentation of the availability of resource and livelihood dependence on these based on the experience of local stakeholders along with covering resource endowment, socio-economic and institutional information/data base in each of the 5 sites through measurement and comparative analysis of database.
- Establishment of disaggregated database for household resource needs, demands, sources, gaps in resource demand and availability, and alternative means applied to fulfil gap. Differentiation of need of various resource users with focus on gender role is emphasized.
- Documentation of the approaches and experiences of related agencies and development of alternative approach for implementation in the field.
- Disaggregated database and analysis of the households, and groups with gender focus on their relative access and control of resources along with analysis of information and preparation of report on food security and livelihood strategies of household in the study area.
- Documentation of experience and identification of options for dialogue among policy level stakeholders for their feedback and preparation of action plan.
- Formation of *Pani-Ban* or *Jal-Jangal Samiti* in Nepal and Uttaranchal, India respectively for implementation of action plan and documentation of the methodologies applied by the community.
- Preparation of workshop proceedings, research reports, working papers and journal articles.

Conclusions

The brief review provided here has analyzed the existing gaps, at both the policy and implementation levels, and provided insights into the issues that need further investigation for the operationalization of CBNRM to co-management of irrigation and forest in the IGB upper watersheds in Nepal and Uttaranchal, India. Involvement of primary stakeholders in the identification of the constraints and opportunities through dialogue and interaction among representative of these institutions is expected to facilitate integration of the twin resources as well as to expand the communities' mandate for resource management at the local level.

This will be beneficial for the development of an institutional base at the local level through action plans for external institutional linkages, coordination, NRM management strategy to improve inter-community benefits, and to reduce conflict. The recommendations from the action research are expected to contribute to policy reforms that promote scaling up community-based approaches for Integrated Water Resource Management.

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Watershed Development and Resource Management in Eastern and Central Africa: Relevance and Potential of India-Africa Knowledge Exchange

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Abstract

Data provided by the Human Development Report (UNDP, 2003) indicate that 60 percent of the combined population (285 million) of the countries of eastern and central Africa, currently lives below the one USD poverty line. This requires poverty reduction at a rate of over 10 million people per year, to meet the Millennium Development Goals of reducing by half those suffering from poverty and hunger by 2015. The regional and country level strategies recognize that the high level of poverty and chronic dependence on food aid, despite ample amount of gross land and water resources, is largely a result of failure to effectively manage the natural resource base for agriculture. Firstly, climatic variability leads to frequent failure or low productivity of rain-fed agriculture with cereal yields of about 1.0t/ha. Secondly, there are high levels of degradation of land, water and water-related ecosystems in the intensively cultivated highlands. Thirdly, there is a high rate of nutrient depletion leading to rapidly decreasing productivity of land and water resources. Fourthly, even where innovations and technologies have been introduced for overcoming these constraints, adoption has been low due to poor enterprise development. However, although temporal fluctuations of soil-moisture is the main constraint identified by small holder farmers, most of the past watershed management projects have mostly focussed on erosion control and afforestation without due attention to improvement of livelihoods, micro-economics and equity. Generally, there is a knowledge gap on optimising integrated solutions. This paper assesses the natural resources challenges for agriculture in the ten countries that are members of ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa) and then discusses lessons from the past - especially in soil and water conservation work. One of these lessons is that technical innovations and technologies by themselves are not adequate to bring about increased productivity of land, water and labour. There is a need for equal emphasis on innovations in policy, marketing, institutions, infrastructure and financing. The emerging strategy of ASARECA to address these issues is briefly described and the paper concludes that technologically, countries in SSA (Sub-Saharan Africa) have attempted almost similar interventions as those implemented in south Asia. What has been different is the impact of these interventions. It is observed

that explaining these differences will be a good entry point for strategic formulation in SSA. Equally important, many years of experience in SSA can also contribute to further development of strategies being pursued in south Asia. Therefore, collaboration and partnership between SSA and south Asia with respect to strategies for integrated management of watersheds is a strategic necessity of paramount importance.

Introduction

The review has been set in the context of the ten countries in eastern and central Africa, which are members of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The ten countries are Burundi, D.R. Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda. However, most of the issues discussed are equally applicable to the rest of Sub-Saharan Africa (SSA).

With respect to food security, SSA is currently (2004) at the stage where most Asian countries were 40 years ago. The majority of its people are farmers producing mainly crops and livestock for food. Yet, the region spends about USD 18 billion to import food annually, receives nearly 3 million tonnes in food aid even in 'normal' years, and still leaves 200 million of its people chronically hungry. On the other hand and as a result of the Green Revolution, productivity of wheat, maize and rice was doubled or trebled over the last 40 years, mainly here in Asia and in Latin America (Tribe, 1994). This was achieved through breeding of high yielding crop varieties with very high response to water, fertilizers and pesticides. Successful adoption of these varieties required availability and utilization of adequate amount of inputs. Does this give us a clue of why the revolution succeeded in Asia and not in Africa? Perhaps yes, because the Green Revolution period in Asia coincided with a period of rapid growth in the non-agricultural sectors. This parallel growth provided both the required inputs at affordable costs and also increased local markets for the food sector. Even in Asia the Green Revolution did not happen everywhere, which provides some insights on the underlying factors of its success or failure (Conway, 1997). Review of literature on the successes and failures of the green revolution show that small holder farmers with good access to irrigation and agro-chemicals benefitted while resource poor ones were by-passed by the revolution (Altieri, 2002).

The SSA region itself provides some clues, because adoption of Green Revolution type of approaches was also common in the export crops sub-sector in most of SSA, even before the Green Revolution period. The use of fertilizers and pesticides, even by small-holders has been common for crops such as coffee and cotton in SSA (Ndjeunga and Bantilan, 2002). This is, however, no longer happening due to current trends of very low commodity prices. Nevertheless, it is evident of the link between availability of markets and adoption of the Green Revolution type of innovations and technologies. We note also that during the Green Revolution period, SSA was experiencing poor or non-existent markets for food crops as non-farm sectors were shrinking. At the same time, markets could not be trusted to supply the food anyway due to poor infrastructure, and hence nearly the whole population adopted subsistence farming. Furthermore, crises in the form of civil strife and political experimentations resulted in poor governance and conflicts. These coupled with natural disasters which caused phenomenal damages on infrastructure as well as bad strategies of international aid, led to disastrous damages to individual assets, social capital, institutions, and hence resiliency of the people.

This paper elaborates on these issues and makes a case for serious consideration of questions such as:

- What can the SSA region, in general, and the ECA sub-region, in particular, learn from India and the rest of south Asia with respect to integrated management of natural resources (specifically land and water) for income and food security?
- Did the Green Revolution in Asia follow the ability to pay for modern inputs?
- If yes, what mechanisms worked best - availability of credit or attractive farm-gate prices?
- What was the role of strategic public investments such as rural infrastructure to improve access to the expanding urban markets brought about by the parallel industrial development?
- Which of these can be replicated in SSA?
- Is the management of natural resources (specifically land and water) for agriculture a follower or leader in the struggle for sustainable incomes and food security?

The paper presents a brief description of the land and water resources base for agriculture available in the ECA sub-region with occasional reference to the whole of SSA, reviews the performance and lessons from past investments in land and water resources development, management and conservation for agriculture in the ECA sub-region and looks at the priorities being identified by ASARECA with respect to management of natural resources for increased productivity and competitiveness of the agricultural systems. This leads to discussion on how knowledge exchange between India (or South Asia) and Africa can help to answer the outstanding questions and thus help sharpen priorities and strategies for management of natural resources in general and watersheds in particular. The knowledge management and exchange framework is also discussed (Hatibu *et al.*, 2004).

The Land and Water Resources for Agriculture in the ECA Sub-region

The ten countries that are members of ASARECA cover a total area of about 8.5 million km^2 and have a combined population approaching 285 million people. Most people live in the rural areas but the densities are low ranging from 13 people per km^2 in Sudan to 311 people per km^2 in Rwanda. Nevertheless, the ECA sub-region has areas with the highest population concentrations in SSA, poverty hot-spots, and high vulnerability to vagaries of climate.

About 80 percent of the population derives their livelihood directly from agriculture, and contributes an average of 38 percent to the gross domestic product (GDP) of most countries (Table 1).

Table 1. Profile of ASARECA member countries

Country	Area ('000/ km^2)	Population (million)	Population density (per/km^2) and population growth rate (%)	Population living below $1 a day (%) 1990-2002	GDP per capita annual growth rate (%) 1990-2002	GDP (Mill US$)	Contribution of agriculture to GDP
Burundi	28	7.1	255 (2%)	58.4	-3.9	719	49%
Congo, DR	2,350	58.3	25 (3%)	41.7	-0.5	5,700	56%
Eritrea	126	4.3	34 (2%)	59.3	1.5	582	25%
Ethiopia	1,127	67.3	60 (2%)	26.3	2.3	5,990	52%
Kenya	587	31.3	53 (2%)	23.0	-0.6	12,100	19%
Madagascar	587	16.4	28 (3%)	49.1	-0.9	4,510	27%
Rwanda	26	8.2	311 (2%)	35.7	0.3	1,740	42%
Sudan	2,506	32.4	13 (2%)	36.0	3.1	13,500	37%
Tanzania	945	35.9	38 (2%)	19.9	0.7	9,380	45%
Uganda	241	23.4	97 (3%)	36.4	3.9	5,870	31%
Total	8,523	284.6					

Source: Compilation by Mogaka and Muchena from Poverty Reduction Strategy Papers of countries in ECA; World Facts Index; National Development Plans, World Bank: World Development Indicators; UNDP, 2004.

Land Resources: In Plenty but Fragile

At the SSA level, it is estimated that there are more than 200 million hectares of land with arable potential, more than 700 million hectares of range lands and more than 200 million hectares of woodlands. The ECA sub-region is also rich in terms of wildlife, livestock and fish resources. However, one of the main characteristics of land use in the sub-region is the high concentration of people and livestock in highland areas because of some high potential features such as long length of growing period, cooler climates and deep soils. At the same time there are vast stretches of land with good soils, such as in the Sudan, which are currently not used due to shortage of water. Land degradation is a major problem in the areas of concentration of rural and urban population. Examples include the well known erosion in the highland of Ethiopia as well as the Lake Victoria basin due to very high densities (between 500 and over 1000 people per km^2) of rural population. The lake is now suffering very high concentration of silt and it is also seriously affected by eutrophication as a result of disposal of raw sewage from urban centres in the basin. Therefore, many parts of the highlands have reached high levels of intensification and urgently require strategies for increasing the productivity of land, water, labour and capital. What can we learn from Asia on this?

The main challenge is that more than 95 percent of crop and livestock production is by small holder subsistence farmers and pastoralists, mostly using low inputs. Furthermore, vast proportions (42%) of arable land in SSA region have inherently poor fertility compared to those of south Asia (4%). On top of the inherent low soil fertility, the use of fertilizers (both organic and inorganic) is very low at only one tenth of the world average (Table 2). As a result, there is now a general net removal of large quantities of nutrients from small holder fields due to inadequate replenishment. Soil fertility in small holders' fields is deteriorating at an alarming rate especially in terms of levels of nitrogen, phosphorous and soil organic matter. Estimates made at continental level show that the rate of loss of nutrients from small holder fields are in the range of 660 kg N/ha, 75 kg P/ha and 450 kg K/ha (Buresh *et al*., 1997). Strategic interventions are, therefore, called for to reverse these unsustainable exploitation. The outstanding challenge is to design combinations of organic, inorganic and biological sources of nutrients and application techniques that enhance nutrient-use efficiency by plants. This will call for crop selection, precision application and targeting of nutrients, and adequate availability of soil-moisture.

However, in some parts, long-term erosion and deposition has increased the fertility of soils located at the bottom of the toposequences and in alluvial plains. These areas have great potential that is yet to be utilized specially in countries, such as Burundi, Rwanda and Uganda. Furthermore, Vertisols are estimated to cover some 55 million hectares in the semi-arid areas of mainly Chad, the Sudan, Ethiopia, Kenya, Tanzania and 11 other countries in SSA. Most Vertisols are inherently fertile due to their occurrence at the lower parts of the landscape where flood water and nutrients accumulate each season. They, however, remain largely un-utilized because they are difficult to manage. Therefore, facilitating the sustainable utilization of Vertisols presents one important challenge in the development of watersheds in ECA. Is this another potential proposition for collaboration and learning from South Asia?

Table 2. Comparison of regions in terms of use of manufactured fertilizers

Region	Fertilizer use, kg (N, P_2O_5, K_2O)/ha		
	1980-81	1990-91	1997-98
Sub-Saharan Africa	8	10	9
Africa	21	22	21
Middle East & N. Africa (excl. Egypt)	45	67	62
South Asia	37	80	104
East Asia, SE Asia & China	121	179	235
Latin America & Caribbean	100	100	75
Developed countries	120	112	86
World average	88	100	100

Water Resources – A Major Challenge

Temporal and spatial variability of climate especially rainfall is a major constraint to productivity, competitiveness and commercialization of crop and livestock systems as well as sustainable management of watersheds in ECA. Coefficient of variation of rainfall in semi-arid areas can be as high as 50 percent and most of the annual rainfall is often received in few rainfall events within 3-5 months of the year. It is common for countries in the sub-region to move from flood-induced disasters to drought-induced ones and back to floods again within a space of five years. Droughts following floods have been a major cause of famines affecting millions of people in the last 50 years (Table 3). A major drought affecting several countries is recorded in ECA at least every 10 years with amazing regularity. The most memorable of these disasters is the 1984 famine that hit Ethiopia affecting 8.7 million people and leading to about one million deaths. Therefore, understanding, adapting and coping with climate variability is an important aspect of NRM for agriculture in the sub-region. Research has started to show some links between climate variability in ECA sub-region and prevailing patterns in the Indian Ocean. Is this also strong candidate as an issue for collaborative research between India and the ECA sub-region?

Table 3. Effects of droughts, floods and famines in SSA in the past 30 years

Details of events	Droughts & famines	Floods
Events which were declared disasters	508	448
Number of people which were affected (million)	368	32
Number of people who lost lives (million)	1.08	0.02
Estimated cost of damages to individual and public assets (billion US$)	5	3

Source: EM-DAT- the OFDA/CRED International Disaster Database, Université Catholique de Louvain - Brussels - Belgium (www.em-dat.net).

However, despite the climate variability problems, water is abundant in SSA in the form of renewable annual rainfall. Most water is depleted through direct evaporation from open water surfaces. A classic case is Lake Victoria where water balance analysis show that nearly all the water that falls as rain directly on the lake is evaporated directly back to the atmosphere. Furthermore, the proportion of water that is depleted from a particular basin by direct evaporation or evapo-transpiration is more than 60 percent of inflows. Nevertheless, the sub-region has many river basins covering an area of more than 100,000 km^2. These include the Congo and Nile rivers, which are among the few largest rivers in the world. The sub-region is also home to several lakes each with more than 25 km^2 surface area, including Lake Victoria and Lake Tanganyika counted among the largest lakes in the world. Wetlands are critical ecosystems in the sub-region with the Sud marshlands in the Sudan being one of the largest continuous wetlands in the world. Even in highland countries such as Burundi, Rwanda and Uganda, wetlands are important components of the water catchment systems. In general, most of the countries in ECA have adequate water resources but are faced by an economic water scarcity due to inadequate investments in water control structures and systems for effective management of water resources. Even in the semi-arid areas there is plenty of rainwater but more than 60 percent of the rainwater often goes back to the atmosphere unutilized for any productive purposes. The main requirement is management interventions, which enable beneficial plants to use effectively, through transpiration, the rainwater available on the farm. However, opportunities have been missed due to a failure to observe this simple rule in the past programmes on managing land and water.

Experiences in Management of Land and Water for Agriculture in the ECA Sub-region

Most past work in the sub-region has focussed on soil and water conservation (SWC), especially erosion control. Another focus has been on irrigation biased towards civil engineering structures for water diversion. Investments in the management of the medium of plant growth so as to optimize water use efficiency at field level have been the least addressed aspect. This section reviews these trends and draws some lessons.

Fertility Management and Improvement

Two major reviews of soil fertility management in SSA were published recently (CIAT-TSBF, 2003; Buresh *et al.*, 1997). The conclusion is that fertility management requirements are well known but are hardly applied especially by small holders. In the 1970s, nearly every country in the sub-region had established manufacturing and local supply of inorganic fertilizers. Most of the factories have been closed down and most of the fertilizer is now imported requiring small holders to pay nearly double the world price for it. Small holder farmers experience a double squeeze in terms of high costs of inputs coupled with very low farm-gate prices. Hence, the minimal application of inorganic fertilizers as described in the previous section. How can this vicious circle be broken? Certainly the cost borne by the farmers must be reduced while increasing returns. We need a better understanding of how public investments in knowledge; institutions, infrastructure and one off NRM interventions can be used strategically to break the vicious circle.

Soil and water conservation (mainly erosion control)

Due to the dramatic visual effects of erosion, most past SWC programmes in the ECA sub-region were oriented towards control of soil erosion to save the land, rather than the people in the target areas. Most SWC statistics only presented the extent of work rather than achievements and impacts (Table 4). Recent assessment show that a high proportion of the erosion control structures have failed due to poor construction and/or maintenance and to date, there has been very little follow-up to determine the survival rate of the thousands of seedlings distributed free to villages, schools, other institutions and individuals. Therefore, SWC measures often did very little to increase land productivity within the croplands. These shortfalls have been reviewed by many authors starting with Hudson (1991) who identified reasons for success or failure and defined what SWC practices should offer in order to be adopted by farmers. Other reviews include Scoones *et al*. (1996), Pretty and Shah (1994), and Hatibu *et al.* (2001). Such re-thinking of SWC policies a re-evaluation of indigenous soil-and-water conservation techniques (Reij *et al.*, 1988, 1996; IFAD, 1992). The question then became what external interventions increase adoption of knowledge in ways, which facilitate adaptation and innovation by farmers themselves? Two major publications, one from the ECA and one from India have attempted to deal with this question. An evaluation of watershed development projects in India concluded that in order to succeed there is a need for 'watershed plus' – that is, greater success was obtained in watershed management projects that were complemented by good linkages to markets (Kerr *et al.*, 2002).

Similarly, the 'more people less erosion' case study of Machakos-Kenya showed that improving road connection between Machakos and Nairobi and the canning plants, encouraged increased production of vegetables, which in turn was the reason for the adoption of terracing (Tiffen *et al.*, 1994). This kind of findings should inform future strategies and plans for the management of watersheds.

Table 4. An example of SWC statistics of the past - Eritrea (1992-2000)

SWC Intervention	Total (1992-2000)
Hillside terracing, km	18,394
Bench terracing, km	56
Stone bund terracing, km	29,088
Soil bund terracing, km	18,211
Fanya-juu terracing, km	4,339
Check dam construction, km	2,693
Earth dam construction, No.	80
Embankment construction, km	500
Micro-basin construction, No.	1,267,873
Diversion construction, km	39
Canal construction, km	41
Pond construction, No.	115
Well development, No.	155
Area closures, ha	195,117
Planting and replanting of seedlings, No.	61,579,666

Source: Reported by Tesfai in Hatibu *et al.* (2001).

Rainwater harvesting

Small holder farmers are generally and rationally keen to start by reducing risk of crop failure due to dry spells and drought before they consider investments in soil fertility, improved crop varieties, and other yield enhancing inputs (Hilhorst and Muchena, 2000). Therefore, shortage and/or variability of soil-moisture limit the variety, quantity and quality of products that a small holder can produce, leading to a very narrow range of options for commercialization. Rainwater harvesting has proven to provide a large potential for doing this in ways that enhance food and income security in the semi-arid areas.

In-situ rainwater harvesting

In-situ rainwater harvesting is basically soil and water conservation re-oriented towards promoting infiltration of water into the soil rather than only preventing erosion. Rainwater is conserved where it falls, but no additional run-off is introduced from elsewhere. There are many technologies and practices available for achieving this and only few examples are given here. The first is conservation tillage – specifically ripping and sub-soiling requiring tractor and/or animal power. The subject has generated a large literature with several extensive reviews (Kiome and

Stocking, 1993). Another important approach is pitting, which is commonly practised in Sahelian countries such as Mali, Burkina Faso and Niger (Reij *et al.*, 1996). A notable example in the ECA sub-region is the 'ngoro' technique of the Matengo Highlands in Mbinga District of Tanzania. The strip catchment tillage and contour barriers across-slopes are used to intercept run-off from upslope and promotes infiltration in the cropped area. In all approaches the basic principles are simple:

i) Optimize infiltration to reduce non-productive depletion of the rainwater through evaporation and run-off, while reducing erosion and increasing re-charge of groundwater;
ii) Increase the water-holding capacity of soil within the root zone to make most of the captured water available to plants;
iii) Ensure an efficient water uptake (i.e high ratio of transpiration/evapo-transpiration) by beneficial plants, through appropriate agronomic and husbandry practices; and
iv) Optimize the productivity of water used by plants, in terms of value of products, through the choice of crops with sufficient demand in accessible markets.

Run-off farming system

Run-off farming system is technically similar to the previous but it is designed to provide more water for crop growth through the diversion of storm floods from gullies and ephemeral streams, into crop or pasture land. For run-off farming to be effective it must be an add-on to already elaborate *in-situ* systems. Using this approach, many farmers in semi-arid areas of Tanzania have changed from the cultivation of sorghum and millet, to rice or maize with follow-up legume crops that exploit residue moisture in the field. This system is now widely used in nearly all the semi-arid areas of central Tanzania (Meertens *et al.*, 1999). The system accounts for over 70 percent of the area cultivated with rice and over 35 percent of the rice produced in Tanzania. It has enabled farmers to grow a marketable crop in dry areas, providing opportunity for poverty reduction. As a strategy for upgrading rainfed farming, this approach has been shown to work very well under different conditions in Asia as well. India and China provide examples showing that external water harvesting systems, which add run-off water to the cultivated area, are relatively common.

Small-scale storage of harvested water

Small-scale storage of harvested water improves the control of run-off water and complements the storage capacity of the soil. It helps to deal adequately with the most critical problem, which is often the inter- and intra-seasonal variability and intra-season dry spells. Studies in eastern Africa have shown that agricultural dry spells exceeding 15 days often affect maize grown on sandy soils during the critical flowering and grain filling stages, at a frequency of 3 out of 4 rainy seasons (Barron *et al.*, 2003). Such dry spells often wipe off the benefits from crop (full scale) transpiration before and after the dry spell. The crop could, therefore, use high quantities of water for transpiration but produce very little grain and biomass at the end, leading to very low productivity of water. Small scale storage of harvested water can help to provide protective or bridging irrigation to reduce or reverse the negative effects of dry spells while increasing the productivity of green water flows (Oweis *et al*., 1999). Introducing storage systems as well as efficient water application technologies can increase the effectiveness of the rainwater harvesting systems. This involves farm ponds, charco dams and small to medium size reservoirs coupled with efficient application of the water in required quantities, when it is required and in the root zone where it is effectively used by plants. On-farm research in Tanzania is demonstrating that protective irrigation to bridge dry spells can lead to three folds increase in returns especially when integrated with improved inputs and agronomic practices (Fig. 1).

The most important outstanding issue are that although the principles of rainwater harvesting have been known for a long period and the potential benefits proven, they are not widely adopted. Limited studies have shown that farmers rarely adopt innovations and technologies that do not bring them more incomes or benefits (Robbins and Ferris, 2002). If they do, they face a fallacy of composition, which means that less income is earned as more is produced.

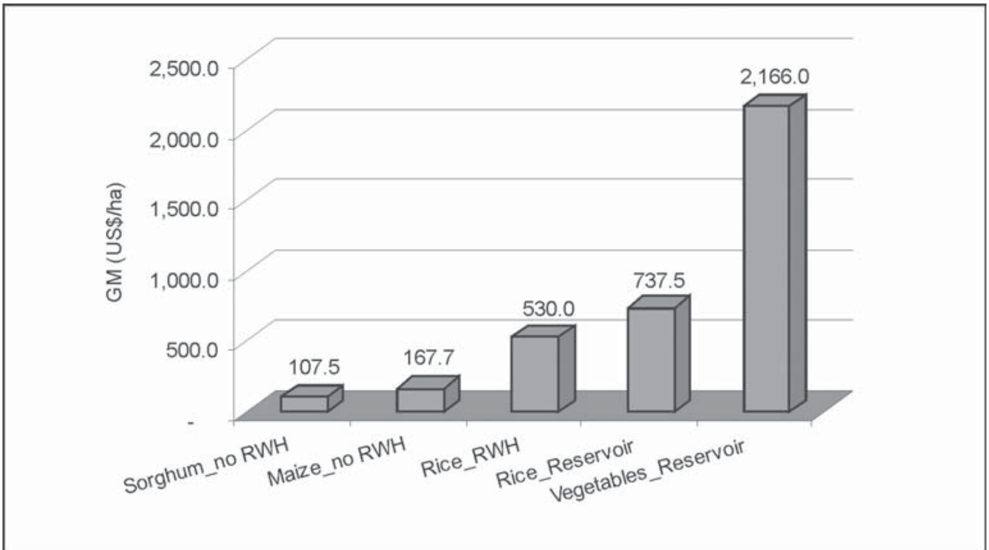

Figure 1. Improvement of gross margins (GM) with run-off farming systems (after Hatibu *et al.*, 2004)

Irrigation Development and Investments

The management of agricultural water and especially irrigation is a major policy thrust in the whole of SSA as well as in ECA. For example the Comprehensive African Agriculture Development Programme of The New Partnership for Africa's Development (NEPAD) identifies the extension of the area under sustainable land management and reliable water control systems, as a priority focus of investments for agricultural development in SSA. However, this is a challenging objective since it is estimated that only 3.5 million ha of the 51 million ha arable land in the region is irrigated and 85 percent of the irrigated area is in only in two countries, Sudan and Madagascar. We review the situation in a sample of few countries in the region so as to assist in the discussion on implication for knowledge exchange between south Asia and SSA with respect to irrigation development.

Sudan has one of the largest irrigated agriculture and perhaps the longest experience in SSA. About 2.3 million hectares out of 8-10 million hectares under cultivation, is irrigated using free flow open channel systems. Most of the water is obtained from the Nile River but in the north of the country, irrigation depends on groundwater in about 12 basins. Although small private irrigation schemes exist especially for horticulture production, large-scale schemes with tenant farmers are still the main approach to irrigated agriculture in Sudan and the irrigation sector is dominated by few but very large irrigation schemes.

Ethiopia is perhaps the opposite of the Sudan that despite being the source of a high proportion of the water in the Nile basin, irrigation is estimated to be only 2 percent of the cultivated land. Main reasons being the challenging land terrain which makes it physically and economically difficult to hold water in situations where most of it is available as huge flood flows over a period of 2-3 months. Centuries of erosion have filled valley bottoms with sediments, making the construction of irrigation structures difficult. There are several examples of failed irrigation projects and structures as a result of siltation. Furthermore, in the major rivers, water flows in deep gorges making the construction of irrigation structure expensive. At the same time experience shows that the use of irrigation for cereal production in the highlands, have had little success (Hatibu *et al.*, 2001).

Kenya has about 85,000 hectares with irrigation systems and this is also a very small proportion of land under cultivation. In contrast to the situation in Sudan, more than 50 percent of irrigation in Kenya is privately developed in commercial private sector farms involved in the production of export crops such as tea. Public owned schemes constitute only 10 percent of the area under irrigation. Nearly 40 percent of the irrigation is controlled by small holder commercial farmers.

Tanzania has a large number of irrigation schemes (estimated to be more than 600) of various sizes. Official statistics show that irrigated area in Tanzania is about 227,000 hectares of which 120,000 ha are made up of approximately 200,000 small holdings of less than 5 ha. Only about 25,000 ha are large centrally managed irrigation schemes.

Ironically, irrigation is developed to a very limited extent in the countries with the highest and more regular supply of water, namely, Burundi, D.R. Congo, Rwanda and Uganda. Irrigation is limited to small holder systems and mainly for horticulture. However, a new opportunity is emerging with respect to improved productivity of water in the Nile basin. This is with respect to the concept of 'virtual water' trade being discussed within the concept of increased and equitable sharing of benefits rather than water under the Nile basin initiative. Under this strategy, trade in agricultural products will facilitate production in the cooler highlands where productivity of water is highest leading to increased supplies at reduced water depletion. This approach will require accelerated development of strategies for sustainable management of watersheds in the upper-catchment countries, communication infrastructure, and trade protocols.

Emerging NRM Strategy of ASARECA and How Knowledge Exchange with South Asia Can Help

ASARECA is now developing a sub-regional strategy for improving the management of natural resources to deal with some of the problems described. This is, therefore, a very opportune time for the ECA sub-region countries, either individually or collectively, to learn from the past experiences of India and south Asia. The emerging strategy of ASARECA was discussed by a regional stakeholders workshop during 26-28 October 2004 in Nairobi, and it contains three main thrusts for ensuring resource to consumption continuum: (i) NRM knowledge, information and technologies for improved development and performance of agriculture and other NR-based enterprise; (ii) policy and institutional arrangements; and (iii) capacity building and knowledge management strategies to ensure accesses and utilization of knowledge from global, regional and national sources.

The thrust on NRM and enterprise development is driven by the realization that the management and conservation of natural resources cannot be separated from economic development and poverty reduction challenges. There is a need to increase the understanding of the potential held in the agro-ecosystems with respect to production and environmental services and then to find and implement sustainable enterprises that enable NRM to contribute effectively to poverty reduction, economic development and enhancement of the natural resource base. Some critical questions upon which knowledge exchange with India and south Asia would help, include:

- What are the economics of different approaches to NRM?
- With respect to the watershed or basin approaches – what needs to be integrated and what are the optimum levels of integration?
- What is the role of markets and how can these be strengthened through strategic combination of public and private investments?
- Do environmental services and externalities of improved management of agro-ecosystems, justify public investments and what are the accounting procedures?

The thrust on policies and institutional frameworks is considered central due to the fact that technical solutions are very well known but are hardly being implemented. The logjam was described very well by WEHAB (2002), which stated that farmers in poor areas do not produce because there are no accessible markets and agro-industries; there is no investment by the private sector because there is no rural infrastructure; governments do not invest in rural infrastructure because of the low production volume; and so on. This is where we need to deal with the question, is NRM a follower or leader in the sustainable development. Issues which could benefit from knowledge exchange between India and ECA include:

- Strategic public investments – otherwise known as subsidies;
- Secure access, control and tenure by local managers of resources;
- Institutions and local organizations, and their powers and authorities in planning, implementation and evaluation; and
- Inclusiveness in negotiating policy, strategies and regulatory frameworks.

The thrust on capacity building and knowledge management is designed to ensure:

- Adequate human resource at all levels from resource users to policy makers for ensuring innovations and adaptation;
- A better and well informed framework for decision and choice making again at all levels – through improved availability of knowledge and its management and utilization;
- Leveraging more benefits from existing knowledge from both research and field experiences including indigenous knowledge; and
- Increased linkages between research, development and training in NRM.

It can be seen that in all the three thrusts of the emerging ASARECA strategy, there will be considerable benefits of evaluating the evidence from south Asia with respect to how past and current investments in NRM and watershed management have contributed to the recorded improvements in production, poverty reduction, and economic growth. There is a need to learn from both positive and negative experiences since doubts have been raised about the social impacts of NRM in south Asia, especially with respect to equity in access and sharing of benefits (van Koppen *et al.*, 2002). These lessons are required to assist in forming a consensus on how natural resources can be managed at field, watershed and basin levels in ways that minimize costs while maximize benefits in economic, social and environmental terms.

Conclusion

Technologically, countries in SSA have attempted almost similar interventions as those implemented in south Asia. What has been different is the impact of these interventions. Explaining these differences will be a good entry point for strategic formulation in SSA. Equally important, many years of experience in SSA can also contribute to further development of strategies being pursued in south Asia. Therefore, collaboration and partnership between SSA and south Asia with respect to strategies for integrated management of watersheds is a strategic necessity of paramount importance. One critical issue would be an assessment of best-bets with respect to policy frameworks which seems to have been a strong factor in the NRM success registered in India and other south Asian countries and perhaps the main contributor to the failures observed in SSA.

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Upper Catchment Management: Opportunities for Developing Linkages, Proposals and Partnerships

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Abstract

Upper catchments are endowed with rich natural resources and characterized with great physical and cultural diversity where environmental changes are often coupled with severe socio-economic consequences. Conservation of natural resources in these mountainous area of India is of utmost concern for sustainable development and improving livelihood securities. This paper presents and shares experiences of upper catchments especially those of Western Ghats and Hill Area Development Program, Nilgiris (India), and explores opportunity for developing linkages and partnerships for participatory process understanding, required changes in participatory watershed research and development, collective action, and coordinated management including convergence approach and exploring the opportunities for upstream-downstream linkages and partnerships keeping view of the complementarities and the conflicts, and brings out priority areas for developing linkages and new proposals in partnership mode. Global attention to watershed management is increasing and it will continue to increase in view of growing water scarcity and need for resource conservation.

Introduction

Upper catchments are important source of water, energy, ecological diversity, basic raw materials, flora and fauna. Upper catchments in developing countries are not primarily for providing environmental services to downstream urban, agricultural and industrial users, but are also inhabited by a large number of people. A majority of local population is poor and depends on agriculture and allied activities for their livelihood in these areas. These are also the areas of great physical and cultural diversity where environmental changes are often coupled with severe socio-economic consequences. Although significant opportunities exist in upper catchments for improved water, land and biomass management, but the complexity and diversity of resource users for a variety of uses within upper catchments, do limit potential improvements in water management. Land use decisions can affect the availability and quality of water locally and downstream, and this relationship between land and water forms the basis of many watershed management programs.

Upper catchments give rise to important river system and provide catchments to important river valleys projects in India. The changes in land use and land cover together with other developmental activities are reported to have brought modifications/alterations in hydrology, water flows, nutrients, sediments, pollutants, resource degradation as well as loss of productivities and biodiversity, and erosion of socio-economic conditions almost everywhere in the upper catchments. Sustainable development of upper catchments with proper land, water and biomass care with active participation of civil societies is, therefore, recognized not only critical for the livelihood improvements of the uplanders, but also for the lives and prosperity of the large population downstream.

Flow of water and services between different parts of the catchments links interest of communities in the upstream and downstream reaches. Challenges in the upper catchments, therefore, range from risks of low productivity or resource degradation, through inter-dependencies among different groups within the basin to complex interactions between socially, economically or politically diverse groups. Proposal Document of Challenge Program on Water and Food rightly mentions that potential improvements in water management can be obstructed where the communities are 'hydrologically dyslexic'. Resolution of the '*hydrologic dyslexia*', i.e., the institutional disconnectivity that occurs between hydrologically connected people, will increase the potential gains offered by management of bio-physical resources in the upper catchments. This may occur at community, catchments and basin scale and results from the deficiency of institutions that could enable more effective use of shared resources (CPWF, 2002). It also reflects the barriers that prevent collective and/or coordinated management actions needed in management of upper catchments.

Extent and Challenges of Upper Catchments

In India, mountainous area is spread over an area of about 93 million hectare constituting 28.3 percent of the total geographical area of the country. Details of the mountainous areas in India are as below (Das, 1982):

Region	Area (m ha)	Percentage of geographical area of India (percent)
Himalayan Region	51.43	15.6
Vindhya Region	9.27	2.8
Western Ghats	7.74	2.4
Eastern Ghats	18.02	5.5
Satpura Ranges	6.60	2.0
TOTAL	93.06	28.3

The Himalayas are the highest and the youngest mountain eco-system. These are spread across 8 countries of Asia, viz., India, China, Nepal, Afghanistan, Pakistan, Bangladesh, Bhutan and Myanmmar. In India, the Himalayas extend over a length of 2500 km from north-west to north-east with a width varying from

250 to 300 km representing 15.6 percent of the total geographical area of India. The Himalayas in India cover 14 states (fully or partly) and 90 districts in two distinct geographical flanks, i.e., Western Himalayan ranges and the North-eastern Himalayan ranges. The Himalayan region is inhabited by 33.8 million people, i.e., 4 percent of the total population of the country. The Himalayan mountains are the source of major river systems of India, *viz.,* Ganges, Bramaputra and Indus. Average annual rainfall in the region varies from <150 to >4000 mm representing the lowest and the highest rainfall zones of the country. The major soil groups are skeletal and calcareous to brown forest podzolic, brown red and red yellow. These soils are alkaline to acidic in nature. The natural vegetation consists of willows, tropical deciduous, alpine, temperate and wet evergreen forests. A large number of crops belonging to cereals, pulses, oilseeds and others are cultivated in the region. This region has relative advantage for horticultural crops because of its specific environmental conditions.

The southern hilly eco-system of India largely lies in the western and eastern ghats (hills) comprising 25.76 million hectares (7.9% of total geographical area of India). These hilly ecosystems give rise to important rivers of south India including east and west flowing rivers and these are rainfed rivers contrary to snowfed rivers of the Himalayas in the north. The Western Ghats are the range of mountains along the west coast about 1600 km long, 80 to 100 km wide, running continuously from the Tapi valley to Kanyakumari interrupted at Palghat. They are a steep and rugged mass of hills, with elevation varying from 100 to 2700 m. Western Ghats are largely spread over the states of Maharashtra, Karnataka, Tamil Nadu, Kerala and Goa supporting a population of 44.2 million. The mean annual rainfall ranges from <600 mm to over 6000 mm at Mahabaleshwar. Eastern Ghats are scattered, broken and of much lower altitude than Western Ghats, though geologically they seem to be distinctly older than the Western Ghats. Beginning in north Orissa, they pass through the coastal region of Andhra Pradesh to Tamil Nadu cutting across Karnataka. The elevation generally ranges from 150 m to over 1600 m with a general increasing trend from south towards north. Eastern Ghats receive lesser rainfall (600 to over 1400 mm) than that of Western Ghats (Sikka *et al*., 2004).

Soil types in the Western Ghats consist predominantly of laterite and lateritic, black (shallow and medium), red sandy, red loam and forest soils. A small area of mixed red and black, coastal alluvium, riverine alluvium, dark brown clayey and deep black soils are also found in this region. The Eastern Ghats predominantly consist of red sandy soils followed by red loamy soils, red gravelly soils, mixed red and black soils and deep black soils, red earths, medium black soils, alluvial soils, lateritic soils, coastal alluvial soils, deltaic alluvial soils and laterite soils. Generally in medium to high rainfall areas, soils are predominantly red soils whereas in high to very high rainfall areas soils are laterite and lateritic with deep to medium black soils mostly in low to very low rainfall areas. The Western and Eastern Ghats are endowed with one of the rich flora and fauna of plant and animal kingdom. Most of the food grain crops, pulses, oil seeds, cash crops, plantation and spices crops are grown in this region. As the climate of the region has both extremes, i.e., dry area and humid, all variation of cropping system is prevalent and so is the diversity observed in forest and grassland distribution. Zonation of Eastern and Western Ghats has been done for natural resource management by Sikka *et al.*

(2004). Eastern and Western Ghats have been divided into 8 and 10 hydro-ecological regions, respectively.

The upper catchments are faced with a unique set of challenges, chief among them for catchment management are:

- Land degradation due to faulty land use management and heavy erosion.
- High run-off, scarcity of water, water accessibility and depleting mountain streams.
- Increased pressure on land and water resources, loss of productivity and loss of habitat and genetic diversity.
- Deficient human capital combined with poverty and high out-migration.
- Inadequate investment and infrastructure.
- Inadequate development of farming system including fisheries and livestock technologies appropriate to the region.
- Inadequate understanding of land and water use changes on mountain hydrology and hydro-ecological aspects, and critical points of interaction and/ links between hydrology and human population.
- Inadequate participatory research in relation to watershed management and watershed research.
- Unaccounted for environmental services to downstream regions.

Upper Catchment Management Intiatives and Programs

There have been many variations in conceptual models, objectives and implementation approach of soil and water conservation programmes. The initial protection and conservation oriented piece-meal approach got enlarged to restoration of degraded areas and then to protection-cum-production oriented objectives of related natural resources and eco-restoration following watershed based approaches. Watershed Management (WSM) has now emerged as a new paradigm for planning, development and management of land, water and biomass resources in upper catchments with a focus on social and institutional aspects besides bio-physical aspects following a participatory "bottom up" approach. In India, multiple agencies have been involved in the growth and development of watershed programmes with an array of watershed schemes having multiple objectives ranging from on-site land and water productivity to improving water yield into reservoirs, moderation of peak flows and floods, enhancing dry season base flow, ecorestoration, and checking soil erosion and sedimentation. Some of the important WSM programmes in the upper catchments include River Valley Projects (RVPs), Catchment Area Programmes in Flood Prone Rivers, Western Ghats Development Program (WGDP), Hill Area Development Program (HADP), Integrated Wasteland Development Program (IWDP), various afforestation projects, and other national and international projects. The current strategy of various ongoing national, bilateral and internationally aided projects of WSM is based on the concept of conservation of rainwater, groundwater recharge, promotion of diversified and integrated farming systems approach, management of common property resources and augmenting family income. Most of the WSM programmes envisage sustainable institutional arrangements at watershed level in the form of local level people institution as an integral component of these projects for promoting participation of civil societies and ensuring sustainability (Sikka and Sharda, 2002).

The research efforts in watersheds have also progressed from piece-meal, plot and field based studies to multi-disciplinary, integrated experimental watershed based approach. There have been rather limited research initiatives at watershed or catchment scale. A lot more efforts have gone into biophysical aspects of watershed research than those on social and participatory research aspects with a focus on livelihood improvement. Hydrological and environmental aspects of watershed management in upper catchments have been studied only to a limited extent.

Implementation Issues and Coordination Mechanism

Management of upland watersheds has to accommodate the interests of multiple uses and users for a variety of purposes and this cuts across multiple jurisdiction and multiple agencies. Western Ghats Development Program (WGDP) of the Union Planning Commission shifted its strategy from seventh plan onwards to take up integrated development on compact watershed basis keeping in view the over-riding priorities of eco-development and eco-restoration as well as the basic needs of the people like food, fodder, fuel and safe drinking water. However, it used to be done by following sectoral approach, and so was the case with the Hill Area Development Program (HADP) of the Nilgiris in the prestigious Nilgiris Biosphere Reserve (NBR).

Central Soil and Water Conservation Resrearch & Training Institute- Regional Centre (CSWCRTI RC), Udhagamandalam and HADP, Nilgiris evolved and demonstrated integrated watershed development approach in a scientific manner following a participatory process, to bring first participatory thinking and coordination amongst line departments. A Watershed Management Authority with PD, HADP, Nilgiris as Nodal Officer, was constituted with heads of line departments as member, CSWCRTI RC for research and technical support, and advise and leading NGO for social mobilization. Macro-watersheds were prioritized and further delineated into small micro-watersheds (400-500 ha). It was made mandatory that micro-watershed plans will be prepared following participatory approach by local level people institutions together with concerned officials and NGO (for each watershed NGOs were identified and people institutions formed). The Model Watershed Management Plan prepared by CSWCRTI in collaboration with local people, line departments and NGO was used as a guideline. Western Ghats secretariat of the Planning Commission also circulated this to serve as a guide for WGDP. The Working Group on HADP/WGDP for Tenth Plan has also recommended similar watershed approach for other HADP areas. This clearly demonstrated the strength and need of developing a strong coordination mechanism at the level of government departments at the district/macro level, involvement of NGOs as an equal working partner and institutionalizing the local participation through involvement and creation, and empowerment of local level people institutions, and continuous linkage with research organization for research and technical support.

Effective integration of activities and varied interventions would require centralized mechanism for coordinating sectoral agencies, multi-layered user organizations, and pluralistic institutional arrangements. This requires serious research focus on structural treatment of institutions by considering their linkages and functionalities within the framework of Catchment Management Authority or River Basin Management framework. In order to be more holistic in approach, there is a need to converge other rural development schemes and programmes for integrated development of watersheds in the upper catchment. It is also seen that micro-organizations are capable of faster and more significant change than larger organizations. A higher-level network of micro-organizations developed organically are robust, flexible and capable of responding to dynamic situations. This would also require research partnership in understanding group dynamics, institutional and policy reforms to encourage responsible decentralized governance and management of watershed resources. Research efforts are also required to develop cost effective rural service delivery mechanism/system relevant to the needs of the poor and socially disadvantaged.

Priority Areas for Linkages, Partnerships and Proposals

The very nature of research and management of upper catchments due to its multiple uses and users, diverse socio-ecological and biophysical variability requires multi-disciplinary, multi-institutional and multi-locational, multi-users research and development efforts through linkages and partnership approach. This could be achieved through networking/consortia approach, which is now gaining momentum through a number of national and international network/consortia involving GOs, NGOs, private sectors and civil societies. Challenge Program on Water and Food (CPWF) is one of such consortia, which devotes one theme exclusively on upper catchments.

Efforts are needed for integrated and user oriented research and action programs for upper catchments, taking into account the sustainable livelihood of mountain communities. Land and water are intimately linked, and management of land and water has to go together to reverse or check degradation and enhance water productivity. The causes and consequences of degradation and management implications are better understood at larger scales of watersheds or catchments that enables policy instrumentation for effective land, water and biomass management. Most of the research efforts on run-off, soil erosion and nutrients are limited to plots or field scale and their projection or extrapolation beyond that to watershed or catchments scale has its own constraints. It becomes even more erroneous to attempt such extrapolations in hilly catchments where 'Hortonian' flow concept hardly works as their hydrology is mostly driven by 'partial' or 'contributing' area hydrology concept.

Some priority areas for undertaking watershed research and watershed management in upper catchments through partnership and linkages are discussed in this section.

Hydro-ecology of Upper Catchments

Collaborative studies on the hydro-ecology of upper catchments in order to better understand the hydrological and ecological processes and controls to update our knowledge under changing land use, water management, vegetation management and human interactions across the scales – small experimental watersheds to large catchments seem quite relevant. This could be considered by setting up spatially distributed experimental network preferably through nested watershed approach supported by watershed modelling. This could involve partnership approach of taking advantages of watershed management, watershed hydrology, forestry/ecology and social science related institutes in the upper catchments. On-going and/or proposed watersheds under various watershed management programs in upper catchments could become real field experimental sites to undertake such studies.

Issue of Scales in Watershed Assessments

Scaling issues in watershed studies are complex and extrapolation from one watershed to another watershed and to another scale is a challenging task. Modelling is the commonly used approach to scaling watershed knowledge. However, the complexity of land-water interactions often precludes the use of simple models, while complex models are often too data intensive and rely on many assumptions. Amongst various methods of examining processes and its extrapolation in watersheds, the analogous and system approaches linked to GIS and remote sensing are proving to be effective in predicting land use impacts on hydrology (Schreier and Brown, 2001). The analogous approach uses a measure of similarity between sites and is relatively easier, but static. While the systems approach focuses on processes, measures rate of change and identifies critical pathways of movement and so has advantage of being dynamic. However, consideration of social-spatial scales are equally problematic and further complicate the scaling issues, especially in developing countries where biophysical issues interact with poverty, food insecurity, property right and land tenure in upper catchments. Research efforts are needed to address these issues of biophysical and social-spatial scales by developing proposals in a partnership mode involving biophysical scientists, socio-economists, watershed managers and policy experts.

Participatory Change Processes in Watershed Management and Watershed Research

Disenchantment with 'blue-print' or 'top-down' approach of development was followed in the 1980s by a surge in 'participatory' or 'bottom-up' approach for development and management of watersheds, largely initiated in upper catchments. There has been a paradigm shift from technology transfer to the management of local land and water resources through participatory user organizations to local governance. The current approaches involve two key actions:

- Development and empowerment of Watershed Associations (WAs) as new form of governance to govern and manage watershed resources.
- Supporting these local level people institutions to help build their capacity to better manage their resources through compatible technologies, and land and water management practices.

Stakeholders in uplands need participatory decision support methods that enable land use and management change while protecting collective soil and water resources for livelihood improvement. Research is required with existing research and development groups/institutions to identify and demonstrate innovative, pro-poor participatory technology development processes and that strengthens social capital and the ability of various stakeholders to manage land and water resources collectively. Methods for effective participatory learning processes and instruments that support change should be identified in which researchers, field functionaries of GOs and NGOs, and end users work together to define problems, evaluate solutions, develop and disseminate technologies and innovations. User participation in watershed research provides an opportunity to design appropriate mechanisms for organizing stakeholders and facilitating collective actions (Johnson *et al.*, 2001).

Upstream-Downstream Conflicts and Complementarities

The land use and water related actions taken in one part of the catchment may have implications elsewhere in another part of a catchment to a varying degree. Upstream and downstream water conflicts are common and there is a growing literature on the subject, yet there is a knowledge gap on how land and water management in upper catchments can effect downstream communities and what could be done to minimize the negative externalities specially in a basin with high degree of hydrological dependence and vulnerability as well as social, cultural, economic and ecological diversity (Gichuki, 2004). Difficulty in assessing upstream - downstream interactions opens a challenging opportunity for the researchers to identify methods to assess the relationship between upstream - downstream land and water management practices to enable increased water productivity while protecting the landscape from adverse changes in hydrology or degradation processes, such as soil erosion, loss of soil fertility and agro-biodiversity. Even within the upper catchment conflicts often arise for their survival and livelihood dependence on the catchment resources and other developmental activities with the protection and conservation of environment and ecology. Most of the time, we get caught into the dichotomy of economic development and environment and this poses a greater challenge to keep the balance between the two by involving/ adopting sustainable economic development approach. This is where a greater challenge lies and well-conceived participatory watershed management in the upper catchments may become an important tool. Participatory integrated watershed management was conceived as a strategic framework to tackle this problem by planned and scientific way of using land, water and biomass resources in the upper catchments. At times, even the well-intentioned watershed management programs are being questioned and seen as a threat to downstream reaches. The results of various watershed management programs in the hilly catchments of India do suggest that these well intentioned and well planned watershed management programs in the upper catchments not only protect and conserve the land and water resources locally but also enhance their availability and utility in the downstream reaches through reduced peak flows and flash floods, reduced soil erosion and sedimentation and maintain dry season river flows. It is, therefore, necessary to examine upstream - downstream interactions with a balanced view of both conflicts as well as complementarities especially in the context of watershed management in upper catchments. Though, small scale experimental studies have been there by CSWCRTI and other institutions engaged in watershed research, but as such, there are hardly any large scale initiatives in this regard to study such interactions of watershed management in upper catchments on the upstream -

downstream interactions through carefully planned studies. This has a great potential and opportunity for future research through networking.

Trade-offs and Environmental Externalities of Catchment Management

Many upper catchments fulfil a vital role of water provider for downstream users. The benefits of local investments in resource conservation at watershed scales in the upper catchments are generally not appreciated or realized locally as these also have offsite beneficial impacts in the downstream reaches. This sometimes limits the ability of the land user to invest in resource conservation. This also initiates the debate on who pays for conserving the resources in the upper catchments for the benefit of downstream dwellers. Considerable efforts may have to be made in looking into the ways and means to compensate small holders in the upper catchments in conserving the resources to provide for the multiple offsite environmental benefits to the downstream dwellers. Research is required to identify and develop negotiation processes and instruments that can secure water resources for downstream users while providing income generation for marginalized upper catchment dwellers. Learning and negotiation processes should be implemented and the likely impacts of such processes on poverty alleviation quantified. This is a challenging area of research which definitely calls for a greater amount of linkage and partnership with the researchers engaged in biophysical and social aspects of research in the basins.

Property Rights, Land Tenure and Collective Actions

Watersheds include resources that have different types of rights and rules associated with diverse individuals and groups, and diverse resources, resource users, and the institutions that govern their access, use and management. One of the major problems in hilly watershed is that of small and fragmented land holdings, and on top of that dominance of leased-in land holders and sharecroppers with short periods of land tenureship. Though farmers are convinced of different resource conservation measures, but they would not like to make any investment to implement even low-cost structural measures or vegetative measures. Even if some small holders are convinced, this may not make a noticeable impact unless collective action is taken. This suggests need for research in collective actions and to develop technologies suiting to such conditions of small holders and holders of leased-in lands through participatory technology development involving watershed based farming systems suiting to biophysical and social needs of variety of stakeholders.

Water, Poverty and Livelihood in Upper Catchments

Watersheds in the upper catchments are inhabited by large population, majority of them are poor and/or socially disadvantaged with histories of marginalization. Water is used in a variety of productive, economic and consumptive activities that contribute to livelihoods. Food production, income generation from fisheries, livestock, agro-processing depend directly on the quantity and quality of available water. Land use and water management decisions in the watershed can affect the availability and quality of water locally and downstream and so their livelihoods (CPWF, 2002). Issues of distribution and access are critical in understanding the role of water in rural livelihoods. Research is required to determine what access poor communities currently have to land and water management, and how that is likely to change over time with changes in the demand and other factors.

Conclusion

Research proposals in partnership are needed to develop methods of diagnosing the importance of water in rural livelihoods, and identifying pressure points with greatest impact on well-being. These tools must also be linked to methods for monitoring and evaluation, and for assessing the impact of effective management of water, especially on poverty alleviation. Research should identify how many dimensions of poverty are dependent on the multiple uses of water and how the resultant relationships can be quantified. A pro-poor resource management policy will need a clear understanding of the linkages between poverty, land degradation, water management and biomass management within catchments.

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Technology Refinement and Adoption Process in National Watershed Management Project

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Abstract

Watershed development approach with government support, in India, started in mid fifties. The first scheme namely 'Soil Conservation Works in the Catchments of River Valley Projects (RVP)' was launched in 1962-63 to control the siltation of multipurpose reservoirs. The second mega project 'Drought Prone Area Development Programme (DPAP)' started in 1972-73 for drought proofing the vulnerable areas and mitigating the impact of drought. This was followed by Desert Development Programme (DDP) in 1976-77 for development of desert areas. Integrated Watershed Development Programme (IWDP) was launched in 1988-89 with an objective of development of wastelands based on village micro watershed plans.

Introduction

In 1983 two schemes: (i) Pilot Project for Propagation of Water Conservation / Harvesting Technology for Rainfed Areas on Watershed basis; and (ii) Popularization of Seed-cum-Fertilizers-drills were initiated in 19 districts located in15 states. These were popularly known as 'Model Watershed Development Projects'. Based on valuable information generated through these projects, a National Watershed Development Project for Rainfed Agriculture was launched in VII Five-Year Plan covering 97 districts in 16 states which were subsequently modified to introduce a project and area approach to watershed development in VIII Plan and named as National Watershed Development Project for Rainfed Areas (NWDPRA).

During nineties a series of changes were incorporated in the planning, implementation and management of watershed programmes by: (i) formulation and adoption of common guidelines for DPAP, DDP and IWDP; (ii) adoption of Common Approach for Watershed Development; (iii) restructuring of NWDPRA Programme; and (iv) revised guidelines "Hariyali" for DDP, DPAP and IWDP Programmes.

The past experience of four decades of implementation of watershed programmes in India have shown that technologies, their adoption process and management has undergone a series of changes in tune with evolution of programmes and interlinkages of technology with other aspects of the programme.

Technological Refinement and Adoption Process – Lessons Learnt and Experiences Gained

Throughout the world and, particularly in India, watershed development programme has also evolved as a comprehensive development concept and a vehicle for efficient utilization of natural resources for the benefit of local community with special attention to the rural poor. In the absence of a measurable definition of ecological security, the watershed development programme ought to become an instrument to progressively promote conservation of natural resources and stabilization of the geo-hydrological regimes in order to ensure that the annual increment in the bio-mass generation is enough to support all life forms in the watershed area.

During the last 30-40 years valuable lessons have been learnt and experiences gained in the implementation of watershed development programme in the country. A paradigm shift has taken place in the technological approach, the salient features of which are enumerated below.

From Erosion Control and Safe Disposal of Water Centered Conventional Soil Conservation Technology to Rain Water Conservation Technology based on Indigenous Systems

Conventional soil conservation technology of Tennesse Valley Authority (TVA) model bears around control of soil erosion and safe disposal of rainwater with central focus on prevention of siltation of reservoir. The interest and concerns of watershed community is incidental and peripheral.

Under tropical and sub-tropical conditions, particularly regions with monsoon type of rainfall, precipitation is limited to 3-4 months followed by dry winter and hot summer. Even during rainy season, rain falls on a few days with high intensity storm, interspersed with dry spells. Thus, the availability of water is erratic and unpredictable. The felt need is how to relocate rainwater received in 3-4 months to make it available throughout the year. This is possible through innovation and reinforcement of indigenous devices, sunken structures of ponds and wells on dry-lands and wetlands and improving flow life of streams and springs on high lands with mountainous terrain. It is equally important to distribute and conserve water throughout the landscape encompassing villages, grazing lands, cultivated fields, wastelands and forestlands.

The lessons learnt indicate that following hydrological principles would have to be followed:

- Convert maximum possible surface flow into sub-surface flow – by collecting in sunken devices (ponds) and recharge the dug wells, tubewells and aquifers. Spread water through vegetative cover and increase off-season water availability in streams, springs and rivers.
- Reduce velocity and volume of water before it reaches the drainage lines. This would increase their flow life.
- Ensure water availability to the lands of marginal farmers located on upper reaches of the watershed and along foothills.

- Attempt water conservation in areas in consonance with their geo-hydro-thermo regime. The total annual precipitation of Jaiselmer (a town near Thar Desert) is 218 mm but potential evapotranspiration is 2064 mm. How do people in such areas survive and live? It is through the indigenous rainwater management systems. By reinforcing them with modern scientific technology their efficiency can be increased for the benefit of the local communities, vegetation and livestock.
- Rainwater conservation holds the key to preventing degradation of natural resources and promoting their regeneration to optimize production and productivity.

From Rigid Engineering Structures to Flexible Devices with More Reliance on Vegetative Measures

Rigid engineering structures have been found inappropriate under tropical and sub-tropical geo-thermo regime. Often such structures crack, crumble and collapse, sometimes destabilizing the banks of the drainage lines. These structures are costly to install and the need for maintenance funds increases as they age on.

On the other hand, vegetative measures are low cost, simple and their efficiency increases with time with the growth and expansion of the root system and the vegetative cover. This involves the reversal of the approach followed in conventional technology where vegetation is planted to stabilize the engineering structures. In the new approach and technology, the ultimate aim is to establish vegetation and a series of filtering and flexible structure-gabions, loose boulder structures are installed to promote the growth of vegetation for sustainable conservation of the natural resources.

From Uniform and Standardised Conventional Measures to Location Specific Production Supporting Conservation Devices

Under conventional approach it was presumed that after the conservation measures had been installed, the production system would follow. This approach has not succeeded throughout the developing world. In fact, the whole approach has got to be reversed. Conservation measures are to be conceived, planned and implemented to serve the chosen land use. Conservation measures would be different for various crops and pieces of lands located in the toposequence. The present approach is that good land husbandry and a scientific production system will also serve as conservation measure. The basic principle, however, should be that conservation measures need to be conceived as means and the production system as ends.

Build upon Indigenous System and Devices

In every region conservation measures have been developed through trial and error over the centuries. Such devices have been neglected due to variety of reasons – political, administrative and technical. Moreover, they are under strain from growing population pressure. Nevertheless their fundamentals are strong and attempt should be made to respect them, understand them and reinforce with modern science and technology. Wherever this blending approach has been followed excellent results have been obtained both in the sphere of conservation measures and production systems.

From Purely Technical Approach to Socio-technical Approach

It has been repeatedly observed that the projects based on sound technical parameters but with little social sensitivity have not succeeded both from technical points of view and social consideration of equity and distributive justice. Many projects have proved that unless the survival biomass needs of the rural poor in terms of fodder and fuel are satisfied, the plantation and pastures would continue to be vulnerable and unsustainable.

From People's Participation to Government, Donors and NGOs Participation in People's Programme

Soil conservation programme was initiated as a public work for national good i.e. the activities and interventions were planned and implemented to protect the reservoir which provided irrigation to downstream areas and generated electricity for industrialization. No doubt these are commendable and laudable objectives. But the local watershed community would own, operate and maintain the devices only when it provides them tangible, short-term and direct benefit. Therefore, at this stage it is more important to enhance social sensitivity of all the interventions and all sections of the rural households should be directly benefitted. In fact, natural resources management should be people's programme and outsider should participate with enabling financial and technical support. The capacity building of the individual, their groups and institutions is equally important, if not more, than the technical interventions.

There are many examples when socially sensitive technical modifications have been made to ensure the availability of water to the lands of marginal farmers located at the upper reaches of the watershed. The fuel and fodder supply have been significantly increased through participatory management of common property resources. Such projects have created better technical impact without any adverse impact on people living in the downstream areas.

Rainwater Conservation is the Central Point for Success

Wherever success has been achieved the conservation and utilization of rainwater has been the motivating force. Projects like Sukho Majari (Himalayan Foot Hills), Haryana; Ralegaon Sidhi of Anna Hazare, Maharasthtra; Johad Project of Tarun Bharat Shangh in Alwar, Rajasthan have succeeded and attracted so much attention because they brought about water conservation and improved availability of water. The scheme of Propagation of Water Conservation/Harvesting Technology in Rainfed Areas launched by the Department of Agriculture & Cooperation, Ministry of Agriculture was also adopted by Ministry of Rural Development in the early 80s. The Indian Council of Agricultural Research also collaborated in these schemes. Water conservation and harvesting was the central point and success of the watershed development projects under this scheme earned them the name of model watersheds. These projects paved the way for formulating NWDPRA and influenced the scheme of DPAP. Success on the ground attracted many bilateral and international donors to participate in watershed development programme in India.

Technological change plays a key role in development process. But sustainable development requires that technology should not only be growth promoting but also environment friendly. There should be emphasis on synergetic relationship between indigenous technological innovations and adoption of modern technology. Besides, the real test of success of a technology depends in watershed programmes on its cost effectiveness and wider replicability under various farming situations.

HARIYALI - Planned Investment in Watershed Development

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Abstract

The degradation of land is attributed to natural, abiotic and ever increasing biotic pressures on the fragile ecosystems in the absence of adequate investments and appropriate management practices to augment and conserve the land and water resources. The Department of Land Resources in the Ministry of Rural Development has been addressing the problems of land degradation, wastelands and groundwater depletion through implementation of Area Development Programs. Three major programs are the Integrated Wastelands Development Program (IWDP), the Drought Prone Areas Program (DPAP) and the Desert Development Program (DDP). These programs aim to harvest water in drought prone, desert and rainfed areas through participation and close involvement of the user communities.

The three programs were implemented on the basis of their own separate guidelines, norms, funding patterns and technical components based on their respective and specific aims as conceived in different departments. After the creation of Department of Wasteland Development (DWD) in 1992, these programs were brought under it for treatment of non-forest wastelands through a common approach based on scientific criteria. The operationalization of the guidelines for watershed development since April 1995, common to the three programs was an important step in this direction. To achieve quick, visible and sustainable results, area development, strictly on watershed basis with active people's participation has become the guiding principle of these programs.

Introduction

Land degradation is currently estimated to affect about 3,600 million hectares of the world's total land surface. About 16 percent of the world's agricultural land is affected by soil degradation. Desertification directly affects, or puts at risk, the livelihoods of more than one billion people. In Africa alone, an estimated further 5-6 million ha of productive land are affected by land degradation each year. This means that several million hectares of new land has to be opened up for agriculture each year just to offset the effects of degradation.

Substantive increase in population has resulted in not only over-use of resources but also fast depletion of the natural renewable resources. Socio-political scenario in a typical ecological setting has been the very basis for defining the watershed. That means the land involved is not totally flat land but has ridges and valleys, having identifiable common or individual land as wasteland in a watershed and have boundaries common with the village boundaries or a group of villages. Villages traditionally governed by Panchayats (village councils) represent people's mandate at the grassroot level where accountability is directly to the people.

Watershed is that piece of land, which drains through a common point. Watershed could be at a macro level when we think in terms of 'the Himalayas' or the country as a whole. However, going down into the smallest unit that acts as a watershed for the practical purpose of tackling soil and water management for effective harvesting the associated benefits, 500 ha has been taken in India as an artificial unit which may not necessarily form a micro-watershed. This unit is able to define our average land holdings around a village in India.

With 70 percent of the population still dependent on agriculture and vocations related to land and primary sector, the optimal utilization and productivity from land is one of the major concerns of the government particularly when 63.85 m ha land has been identified as wasteland by the National Remote Sensing Agency. Further, 19.6 percent land of the country is located in arid zone, 37.0 percent in semi-arid and 21.1 percent in dry sub-humid region. To mitigate the frequent droughts, attempts were made as early as 1950s, but systematic efforts were made by the Government in 1973-74 when Drought Prone Areas Program was initiated, followed by Desert Development Program in 1977-78. This is followed by creation of National Wasteland Development Board (NWDB) in 1985 and start of Integrated Wasteland Development Program in 1989. It was then felt that not much could be achieved under these programs being implemented in a disjunctive manner by different departments under their own set of guidelines and sectoral approach. Sectoral approach in watershed management has inherent tendency for overlaps as also over-use of resources.

Presently, three major watershed programs, namely, Desert Development Program for arid zone (hot and cold desert areas) in identified blocks, Drought Prone Areas Program for semi-arid and dry sub-humid region in the identified blocks only and Integrated Wasteland Development Program covering left over areas in the above regions and also implemented in moist sub-humid and humid regions of the country are under implementation.

Wastelands/Degraded Lands

The report of the Technical Task Group constituted by the Planning Commission of India in 1987, *inter alia*, defined wastelands as *'degraded lands which can be brought under vegetative cover with reasonable efforts and which are currently under-utilized and the land which is deteriorating for lack of appropriate water and soil management or on account of natural causes.'*

Broadly, the causes of degradation include:

- Increasing biotic pressure on the fragile eco-system,
- Population pressure, unplanned urbanization and rural poverty,
- Breakdown of traditional institutions for managing common property resources, and
- Lack of appropriate management practices.

Extent of Wastelands

Planning for the development of wastelands/degraded lands calls for the availability of up-to-date information on their geographical location, extent and spatial distribution. Until recently various sources of wasteland estimates were in currency. These varied vastly from 38.4 to 187.0 m ha. Various estimates are given in Table 1.

Table 1. Area under wastelands at different times

Source	Area in m ha
National Commission on Agriculture(NCA-1976)	175.00
National Waste Land Development Board (Ministry of Environment and Forests, 1985)	123.00
National Remote Sensing Agency (1995) (NRSA-Wasteland Atlas-2000)	63.85

Wastelands Atlas of India

In order to have precise spatial distribution of the wastelands, a study on the “Identification of Wastelands in India” was commissioned in collaboration with the National Remote Sensing Agency (NRSA), Hyderabad. As a result, the Wastelands Atlas of India has been brought out, which contains maps on a 1:50,000 scale for different categories of wastelands occurring at the village level in the districts. The boundaries of micro-watershed have also been incorporated in the maps. As per the Wastelands Atlas of India, the total extent of wastelands in the country is 63.85 m ha, which is about 20.17 percent of the total geographical area of the country. The wastelands are categorized in Table 2.

Table 2. Categorywise wasteland of India

Sl. No.	Category	Total wasteland (km^2)	Percentage of total geographical area covered
1	Gullied and/or ravinous land	20,553.35	0.65
2	Upland with or without scrub	194,014.29	6.13
3	Waterlogged and marshy land	16,568.45	0.52
4	Land affected by salinity/alkalinity-coastal/inland	20,477.38	0.65
5	Shifting cultivation area	35,142.20	1.11
6	Under-utilised/degraded notified forest land	1,40,652.31	4.44
7	Degraded pastures/grazing land	25,978.91	0.82
8	Degraded land under plantation crop	5,828.09	0.18
9	Sands — Inland/coastal	50,021.65	1.58
10	Mining/industrial wastelands	1,252.13	0.04
11	Barren rocky/stony waste/sheet rock area	64,584.77	2.04
12	Steep sloping area	7,656.29	0.24
13	Snow covered and/or glacial area	55,788.49	1.76
	Total wasteland area	6,38,518.31	20.17

Source: 1:50,000 scale wasteland maps prepared from Landsat Thematic Mapper/IRS LISS II/III Data.

These areas can be broadly classified for our use as:

Category	Area (m ha)	Percent
Forest	14.065	22.03
Non-forest	49.787	77.97
Total	63.852	100.00

Past Efforts

Substantial areas in India periodically experienced drought leading to considerable loss of agricultural productivity and livestock wealth despite large sums having been spent by the government in the past as ad-hoc relief measures. Except providing employment opportunities and enhancing purchasing power of the distressed populace inhabiting the areas during relief operations, the problem remains unresolved. Ecological degradation on account of large-scale denudation of forests and excessive grazing has resulted in soil erosion and decline in the productivity of land. Systematic effort for long-term ameliorative measures to tackle these problems of drought started only after planning for economic development was launched in the country. This led to the establishment of a suitable institute for research in core needs of desert areas, and launching of dryland farming projects in several areas with emphasis on moisture and water conservation measures.

Existing Policy Strategy and its Impact

Prior to 1994

Rural Works Program was launched in 1970-71 with the objective of creating assets designed to reduce severity of drought in the affected areas. The program covered one-fifth of the area of the country and 12 percent of the population in 54 districts and 18 contiguous districts for working on a long-term strategy. Mid-term appraisal of the fourth plan (1972) renamed the program as Drought Prones Areas Program (DPAP).

In the interim report of the National Commission on Agriculture (1974) hot desert areas were identified and it was suggested that a development program consisting mainly of afforestation and livestock development should be taken up. In its final report, the National Commission suggested that the program of the cold desert areas, Jammu & Kashmir and Himachal Pradesh should be studied in depth. As a result, Desert Development Program (DDP) was started in 1977-78. A Task Force set up by the Ministry of Rural Development headed by Dr. M.S. Swaminathan reviewed DPAP and DDP in 1982 and suggested modifications. DPAP was withdrawn from the areas covered under DDP and greater emphasis was laid on productive agriculture in irrigated as well as dryland areas. Infrastructure oriented schemes such as chilling plants excluding dairy units were started. Stress was laid on land based activities including pasture and fodder resources.

The main thrust of the program continued to be income generating activities and infrastructure oriented schemes and scope of activities taken up under the programs became sufficiently wide. Subsequent commissions found that, in the process the programs deviated considerably from the avowed objective of ecologically integrated development of drought prone and desert areas through drought-proofing and control of desertification.

Lack of conceptual clarity and the consequent shift in the objectives to be pursued under the programs and the low priority assigned to these programs by the implementing bureaucracy accounted for the dismal progress of the programs.

Hanumantha Rao Committee Report of 1994

The implementation of DPAP and DDP in a fragmented manner by different line departments through rigid guidelines and without well-designed plans did not bring about the desired achievements. The program had inadequate provisions for people's involvement. Even after an expenditure of Rs. 17 billion ($ 340 million) under DPAP and Rs. 5.5 billion ($ 110 million) under DDP since inception till 1993-94, appraisal of the impact of the activities undertaken revealed discouraging outcomes with no significant improvement in vegetative cover, groundwater table, drinking water, fuel and fodder, etc. Only 5.7 million ha under DPAP and 0.51 million ha under DDP were treated. This necessitated revamping of the strategy for implementation of these national programs.

Accordingly, a high level technical committee headed by Prof. Hanumantha Rao, was constituted in 1993. The Committee reviewed the programs comprehensively and delineated the following major factors for unsatisfactory performance:

- Multitude of activities over widely dispersed areas of very small sizes.
- Ad-hoc planning without integrated approach to land and water management; planning without people's involvement.
- Non-viable work plans in the absence of multi-disciplinary agency at watershed, block and district level.
- Plans not oriented to the local needs and activities not taking cognizance of indigenous technologies.
- No appropriate mechanism for maintenance of the created assets.

The Committee visited a large number of areas to take stock of the ground realities and held discussions in the government, with the beneficiary communities, public representatives, voluntary organizations, etc. and underlined a strategic approach for the implementation of these programs with the following major tenets:

- For the harmonious management, development and utilization of land, water and vegetative resources, watershed was identified as the scientific unit for area development. It has the advantages of optimised water resource utilization through basin-wide management (which is most crucial in DPAP and DDP areas), provides the best method to diagnose the state of natural resources in a given watershed and relates fluctuation in water regime to the other objectives of area based development.
- Watershed management efforts must incorporate soil and water conservation and land-use planning to account for economic, social and institutional factors.

- Treatment plan for the watershed should include all categories of land whether private, village commons, revenue or degraded forest lands.
- If degradation of the resource base is more or less similar in more than one micro-watershed the criteria to be used is: scarcity of drinking water, large population of scheduled castes/scheduled tribes, preponderance of common lands and watersheds where actual wages are significantly lower than the minimum wages.
- Positive role of voluntary organizations as agencies for coordination of project implementation between people's organizations and district funding agency and extending public awareness and imparting training to the stakeholders.
- A micro-watershed with about 500 ha will be taken up for management and development.
- Unified approach and convergence of all rural development programs.
- Need to effectively monitor and evaluate the programs.

Guidelines After 1994 – A Continuous Process of Change

Department of Land Resources, in the Ministry of Rural Development formulated the Common Guidelines for Watershed Development for implementing these programs and also Integrated Wastelands Development Program (IWDP) of the Department made effective from 1995. These guidelines were further reviewed in 2001 to include heuristic modifications for contemporary outlook and practical approach to secure people's participation by inclusion of entry point activities, probation period for new projects and exit protocol. The role of Panchayati Raj institutions (PRIs, Local Councils) in watershed development programs was specified to a limited extent in the Revised Guidelines 2001.

Since, Ministry of Rural Development was the controlling ministry on Panchayati Raj (Local Councils) in 2003, its policy of devolution of powers to PRIs by the states was in consonance with the 73rd constitutional amendment. It motivated the framing of the 'Hariyali Guidelines' by suitably modifying the earlier guidelines in order to make the PRIs pivotal stakeholders in all the watershed programs of Rural Development Ministry. The basic framework of all these guidelines, however, is based on the recommendations of the High Level Technical Committee and the objectives and strategies of DPAP and DDP currently adopted owe much to them. At the time of framing guidelines for watershed development in 1994-95, PRI framework was not strong enough. The institutional frame-work of watershed associations and committees for the implementation of watershed development programs are being perceived as parallel bodies, with very little co-ordination between them and the Gram Panchayats / Gram Sabhas (Village Council). With the devolution of necessary powers, the Gram Panchayats/ Gram Sabhas are expected to perform far better as they are:

- equipped with statutory rights and mandate for natural resources planning,
- have potential to plan according to people's wishes and integrate watershed management into wider development activities,
- have capacity to draw on services of the departments in an integrated manner and press for political pressure on line departments at higher levels,

- potentially equipped with the powers to impose local taxes or user charges,
- committed to "reservations" for representation of women and weaker section as per the constitutional provisions.

A comparison of the present guidelines (Hariyali) with the previous guidelines is shown in Table 3.

From the foregoing comparison, it is evident that very little difference by way of project formulation and implementation has come except that a gradual change has occurred to involve more and more public institutions as originally envisaged in different high-level reports.

Table 3. Comparison of guidelines

Hariyali 2003	Watershed Guidelines 2001
(a) The Panchayat Samiti / Zila Parishad (District Committee) has the first right to act as Project Implementing Agency. If these panchayats are not adequately empowered, a Line Department/other suitable agency of the state government may be the PIA. As far as possible, the Block/Zila Panchayats are to be encouraged to act as PIAs. In the absence of these options, a non-governmental organisation may be appointed as PIA.	(a) Project Implementing Agency (PIA) may be a Line Department or NGO nominated by District Rural Development Agency/Zila Parishad.
(b) PIA provides necessary technical support through its Watershed Development Team to the Gram Panchayat for implementation of the projects.	(b) PIA provides necessary technical support through its Watershed Development Team (WDT) to the Watershed Committee for implementation of the projects.
(c) Entry-point activities have been deleted and the development work component enhanced to 85% of the project cost from the previous level of 80%.	(c) Entry-point activities provided for gaining peoples confidence and support. 5% of the project cost earmarked for this purpose.
(d) 10% administrative cost to be shared by the PIA and Gram Panchayat.	(d) 10% of the project cost provided to PIA towards administrative overheads both at PIA level and village/watershed level.
(e) District Rural Development Agency (DRDA) releases work component (85% of the project cost) to the Gram Panchayat bank account opened separately for the purpose. This account jointly operated by Sarpanch (village head) and Gram Panchayat Secretary.	(e) DRDA releases work component fund (80% of project cost) to the watershed committees. Bank account opened separately for the purpose. This account operated jointly by chairman of WC and Watershed Secretary.
(f) Total project cost released to DRDA in 5 installments @15, 30, 30, 15 and 10%.	(f) Total project cost released to DRDA in 7 installments @ 15% each in 6 installments and 10% as final installment.
(g) In addition to the public contribution as Watershed Development Fund, Gram Panchayat to impose user charges from the user groups for use of common utilities. User charges may be utilized by the Gram Panchayats for maintenance of asset of the project and for any other purpose as it may deem fit.	(g) Public contributions to be collected and maintained in the form of a Watershed Development Fund (WDF) for the purpose of future maintenance of the assets created under the project. User charges of community assets are continued to be paid after the project period for post-project maintenance.

Coverage under the Area Development Programs

Area and Activities

Projects under area development programs are sanctioned on watershed basis. For the practical purpose of tackling soil and water management for effective harvesting the associated benefits, 500 ha has been taken as a suitable unit for watershed (micro-watershed). This unit is able to define our average land holdings around a village.

The funds under these projects are utilized on activities relating to community mobilization, training of all functionaries involved in the project and development works such as soil and moisture conservation works (bunding, continuous contour trenches, gully plugging, check-dams, etc.), creation and maintenance of drainage lines, water harvesting, afforestation, horticulture, pasture development, etc. for the treatment of degraded/wastelands as per the approved action plan of the concerned program prepared by the stakeholders with the assistance of project implementing agency. Area covered and the expenditure made under different progress is shown in Table 4.

Table 4. Area taken up for treatment and funds released under different watershed programs (Oct. 2004)

Scheme/ Program	No. of projects sanctioned	Area taken up	Cost (million US$)
DPAP	21353	10.676 m ha	1113.84
DDP	11465	5.732 m ha	642.876
IWDP	829	5.911 m ha	636.136
Total	33647	22.319 m ha	2392.852

Since the launching of 'Hariyali' guidelines, the Ministry has sanctioned 2535 new watershed projects under DPAP, 1562 new watershed projects under DDP and 355 new watershed projects covering an area of 1.84 million ha under IWDP. The total cost of these projects under the three programs comes to Rs2332.33 crores (US$ 466.46 million). The project duration is generally five years. The Hariyali guidelines are expected to usher in a new era of empowerment of PRIs and effective local self-governance in the management of watershed development program in the country.

Monitoring and Evaluation

These activities are carried out by the independent evaluators deputed by the State Govt./quick evaluation studies by the central government/area officers of ministry/state and district Watershed Advisory Committees. State Vigilance and Monitoring Committees of concerned Members of Parliament and local members of Legislative Assembly are also constituted to monitor the watershed programs.

Evaluation and Impact

The efforts made so far have shown encouraging results. In respect of DPAP and DDP projects sanctioned during 1995-96 to 1997-98, which have either been completed or are nearing completion, the Ministry had commissioned impact assessment studies through independent organizations. Some of these studies have since been completed. The results indicate that with the implementation of watershed projects under IWDP, DPAP and DDP programs, the overall productivity of land and water table have increased, and there has been a positive and significant impact on overall economic development in the project areas. The studies also revealed that green vegetative cover has improved in desert areas having a positive impact in checking soil erosion by water and wind. The studies indicated that the availability of fodder and fuel wood has also improved in program areas.

Watershed Development: Adaptation Strategy for Climate Change

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Abstract

Agriculture is the dominant land use and mainstay of Indian economy. Around 84% of the country's total water consumption is accounted for by agriculture. About two-thirds of the cultivated area in the country is rainfed, comprising primarily of the arid, semi-arid and the drought prone areas, which contribute to only 45% of agricultural production. Scientific evidence points towards climate changes further exacerbating thermal and water stresses, which in turn may adversely affect the productivity of agriculture. The Inter-governmental Panel on Climate Change (IPCC) in its Third Assessment Report (2001) has specifically considered agriculture as highly vulnerable to impacts of climate change in the south Asian region. These findings are of major concern for India, where agriculture accounts for 25% of GDP, but more importantly provides livelihoods to nearly 67% of the population. Various resource conservation programs and schemes are being implemented to promote efficient utilization of water, land, nutrients and pesticides for sustainable food production in the country. These practices and technologies help in mitigation and adaptation to climate change. Integrated watershed development has emerged as an effective approach in augmenting water supply through conservation of rainwater in dry and arid farming systems, taking into account various kinds of land use based on crops, horticulture, agro-forestry, silvi-pasture, forests and livestock development as well as income generation opportunities for the landless and the poor. The key attributes of watershed development are *in-situ* conservation of water and optimum use of soil and water resources in a sustainable and cost effective mode. Watershed approach is, therefore, proving as a good instrument for adaptation to climate change.

Introduction

Agriculture is the dominant land-use and the mainstay of Indian economy. Looking at its broader sense, agriculture includes all land based and biomass producing activities, such as cropping, animal husbandry, grasslands, forestry, horticulture and fisheries etc. With only 2% of the world's land (329 million ha) and 4 % of its fresh water resources, India sustains 16 % of the world's human population and 18% of cattle population. At around 24%, agriculture and allied activities continue to be the single largest contributor to Gross Domestic Produce (GDP) and also employ nearly two-thirds of country's workforce.

India has made lot of progress in agriculture since independence in terms of growth in output, yields and area under many crops. The net sown area has stabilized around 142 m.ha of land since 1970s, accounting for 47% of the reporting area of the country. Around 84% of the country's total water consumption is accounted for by agriculture. About 40 percent of the cultivated land is under irrigation, which account for 55 percent of total food grain production, whereas 60 percent of the cropped area, comprising primarily of the arid, semi-arid and the drought prone areas, contribute to only 45 % of the production.

Low levels of productivity and low input usage characterize rainfed agriculture. Crop production is subjected to considerable instability from year to year due to its dependence of rainfall, which is highly erratic and variant in space and time. More than 200 million of the rural poor live in the rainfed regions. These risk prone areas exhibit a wide variation and instability in yields. Gap between yield potential and actual yields are very high compared to the irrigated areas. All areas where rainfed farming is predominant, whether in central plain, hill, and semi-arid or coastal lands will need to contribute more to poverty alleviation and augment food security by producing marketable surpluses more reliably.

The relationship between Indian agriculture and climate is well known. Droughts, which have been frequent in different parts of India all through the history, have been responsible for many famines, rural poverty and migration despite development of impressive irrigation potentials. Similarly temperatures, wind velocity and humidity during critical stages are known to significantly effect food production due to their effects on various crop growth and yield processes; pest incidences and epidemics and demand on irrigation resources. Although the contribution of agriculture in the national GDP has now gradually reduced, the climatic variability still plays a very important role in India's food security and economy.

Impact of Climate Change on Agriculture

The earth's climate has been evolving continuously over many millennia. The last two centuries, however, have witnessed the development of the greenhouse problem, which threatens to change climate in an unprecedented manner. It is also clear now that an increase in global mean surface temperature over the past twenty years is undoubtedly real and is substantially greater than the average rate of warming during the twentieth century. Since the industrial revolution, anthropogenic activities have been increasing, the atmospheric concentration of greenhouse gases [CO_2, CH_4, N_2O, sulphur hexaflouride (SF), hydrofluorocarbons (HFCs) and per-fluorocarbons (PFCs)], etc. beyond their natural levels, resulting in enhanced greenhouse effect.

This causes an increase in the global temperature, which is known as global warming. The Inter-governmental Panel on Climate Change (IPCC), in its Third Assessment Report finalized in 2001 has projected that global average surface temperature may increase by 1.4°C to 5.8°C over the period 1990 – 2100 (Anonymous,2001). This projected warming is greater than that experienced over the last 10,000 years. The IPCC report has specifically considered agriculture as highly vulnerable to impacts of climate change in the south Asian region. Crop production and aquaculture would be threatened by thermal and water stresses, sea-level rise, increased flooding, and strong winds associated with intense tropical cyclones.

There is considerable uncertainty in the magnitude of global warming and its impact on agricultural production. The specific effect of global warming on Indian agriculture would depend upon the actual change in temperature and other climatic features together with adaptation and mitigation strategies. These findings are of major concern for India, where agriculture accounts for 25% of GDP, but more importantly, provides livelihood to nearly 67 % of the people.

Environmental Considerations in the National Agriculture Policy

Recognizing the increasing population in the region and limited availability of land and water, productivity of agriculture, forestry, horticulture, agro-forestry, grazing lands and other biomass based production systems need to continuously increase to meet the growing demand of food, firewood, fodder, fibre and fruits despite the adverse impacts of changing climate. Fortunately, considerable capacity for adaptation exists in agriculture. Activities required for enhancement of adaptive capacity are essentially equivalent to those promoting sustainable development. The policy challenge, therefore, lies in identifying opportunities to facilitate sustainable development with strategies that make climate-sensitive sectors resilient to climate variability. The national strategies for sustainable development, particularly of the countries in the arid and semi-arid regions, should include appropriate measures to address mitigation and adaptation issues in agriculture and related sectors.

The National Agriculture Policy of India (Anonymous, 2000) aims at promoting technically sound, economically viable, environmentally non-degrading and socially acceptable use of country's natural resources - land, water and genetic endowment – to promote sustainable development in agriculture. It seeks to actualize the fast untapped growth potential of Indian agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate the growth of agri-business, etc. and face the challenges arising out of economic liberalization and globalization.

Ongoing Resource Conservation Programs ("No Regret Measures") Promoting Sustainable Agriculture and Helping in Adaptation to Climate Change

After enjoying self-sufficiency in food during the last three decades, India is once again at the crossroads, facing tremendous new challenges because of continued population growth, globalization, environmental degradation and stagnation in farm productivity in intensive farming areas. The rapid economic expansion has increased tremendously the demands on land and associated natural resources for agriculture, urban settlements, infrastructure, and industry. The big challenge for the agricultural research and extension is, therefore, to develop, disseminate and implement better practices and technologies for sustained food production without causing damage to the environment.

Conservation has been an integral part of India’s ethos and culture, reflected even in the ancient scriptures. A review of the AGENDA 21, prior to World Summit on Sustainable Development, Johannesburg indicated that India is well towards the path of sustainability. However, an integrated vision to facilitate inter-ministerial coordination and the mechanisms to involve voluntary organizations and private sector in developmental efforts could perhaps accelerate the process of sustainable development.

Various resource conserving programs are under implementation to promote efficient utilization of water, land, nutrients and pesticides etc. for sustainable farm development in the country. These programs taken as “no regret measures” help, to some extent, in mitigation and adaptation to climate change (Gupta, 2002). These need to be continued, strenghthened and converged in the areas vulnerable to adverse climatic changes. Some of the important programs are as under:

i) Integrated watershed development programs.
ii) Reclamation of alkali soils and other problem soils.
iii) National project on development and use of biofertilisers.
iv) Promotion of integrated pest management.
v) National project on organic farming.
vi) Promotion of zero tillage.
vii) Anticipatory programs and contingency plans for disasters such as drought, flood and climate change.
viii) Promotion of drip and sprinkler irrigation to ensure efficient utilization of water.

Among various resource conserving programs and practices, integrated watershed development is considered the most effective approach in augmenting water supply for enhanced productivity in the rainfed farming areas. The watershed approach has ensured better coordination and convergence of inputs / technologies and has revolutionized the quality of life of the watershed people.

Integrated Watershed Development Programs

Increasing water scarcity is a major challenge confronting agriculture sector in the Asia-Pacific Region. In India agriculture is the single largest user of water. Increasing dependence on water for irrigation depletes aquifers and watercourses and inefficient use of irrigation water puts pressure on other users and imposes environmental costs. Over 90% of the run-off in Indian rivers occurs in the four monsoon months of the year. Regions of harmful abundance co-exist with areas of acute scarcity. Since water resources are finite and demand from the various sectoral users is rising rapidly, prudent management of water resources are required to overcome the inefficiencies that currently plague the water sector. For efficient use of water, India is implementing one of the largest watershed development programs in the world.

Watershed, as we know, is a hydrological unit of an area draining to a common outlet point, is recognized as an ideal unit for planning and development of land, water and vegetation resources. Watershed concept has been used extensively because of importance of water balances in the study of ecosystems. National Agriculture Policy being followed in this Ministry accords high priority for watershed development to improve production and productivity of rainfed areas. The policy says that management of land resources on watershed basis will receive special attention. Areas of shifting cultivation will also receive particular attention for their sustainable development. All spatial components of a watershed, i.e. arable land, non-arable and drainage lines will be treated as one geo-hydrological entity.

The importance of watershed development programs has been emphasized in the National Common Minimum Program adopted by the Government. This says that watershed and wasteland development programs will be taken up on a massive scale. Water management in all its aspects, both for irrigation and drinking purposes, will receive urgent attention.

Rainfed Farming with a Watershed Approach

Food grain production in the country accrues from 142 million hectares of cultivated land, of which 85 million hectares are rainfed. Low levels of productivity and low input usage characterize the rainfed agriculture. Vagaries of monsoon result in vide variation and instability in crop yield. Integrated watershed development has emerged as an effective approach in augmenting water supply through conservation of rainwater in dry and arid (rainfed) farming systems, taking into account various kinds of land-use.

The activities undertaken in the watershed program include soil and moisture conservation measures like construction of check dams, water harvesting structures, desilting of village ponds, treatment of drainage lines/gullies, land levelling, bunding of farms, treatment of problem soils, agro-forestry, agri-horticulture, silvi-pasture, organic farming, use of bio-fertilizers, value addition and marketing of produce through farmers groups, training and capacity building of staff and beneficiaries etc.

Major centrally sponsored watershed programs being implemented by various ministries of Govt. of India during the 1980's and 1990's are as follows.

Ministry of Agriculture

- National Watershed Development Project for Rainfed Areas (NWDPRA).
- Soil Conservation in the Catchments of River Valley Projects and Flood Prone Rivers (RVP & FPR).
- Watershed Development Project in Shifting Cultivation Areas (WDPSCA).
- Watershed Development Fund (WDF).
- Externally Aided Projects (EAP's).

Ministry of Rural Development

- Drought Prone Areas Program (DPAP).
- Desert Development Program (DDP).
- Integrated Wasteland Development Program (IWDP).

Planning Commission

- Hill Area Development Program (HADP).
- Western Ghat Development Program (WGDP).

Perspective Planning for Degraded/ Rainfed Area Development

Through various watershed development programs, about 30 million ha of land has so far been developed at an expenditure of Rs.9343 crores upto the end of IX Five-Year Plan. During X Five-Year Plan about 11.4 million ha is proposed to be developed at an outlay of Rs.7440 crore. Besides, an area of 1.24 million ha is likely to be treated under watershed programs at a cost of Rs.1872 crore through external funding (Planning Commission, 2001).

Planning Commission, in its working group report, has proposed to develop all the rainfed areas (88.5 million ha) in a period of 20 years (i.e. upto XIII Five-Year Plan) at a cost of Rs.72750 crore with peoples' participation. The Government of India has accorded a high priority to the holistic and sustainable development of rainfed areas through integrated watershed development approach. At the present pace of watershed development, it will take over 50 years to develop the entire degraded lands and rainfed area.

Common Approach/Principles for Watershed Development

Watershed development schemes have been thoroughly restructured by retaining the technical strengths of the older programs and incorporating the lessons learnt from successful projects, especially on community participation. In the new guidelines, it is mandatory for watershed development to be planned, implemented and maintained by the watershed communities by themselves. Moreover, to bring about uniformity in approach between the watersheds based programs being implemented by various agencies, Ministries of Agriculture and Rural Development formulated a Common Approach/Principles for Watershed Development.

The NWDPRA has been radically restructured for implementation during IX Plan in conformity with this common approach. The restructured NWDPRA allows a much greater degree of flexibility in choice of technology, decentralization of procedures, provision for sustainability and ensures active participation of the watershed community in the planning and execution, encouraging location specific and low cost indigenous technologies, convergence of on-going production programs, strong mechanism for monitoring and evaluation of the programs through concurrent and impact evaluations of watershed development.

National Watershed Committee

Keeping in view the requirement of Common Approach/Principles for Watershed Development formulated by Ministries of Agriculture and Rural Development, the National Watershed Development Policy and Implementation Committee (NWDPIC) was formed. This committee is renamed as National

Watershed Committee and has members from concerned ministries, organizations and state governments to review the progress of various watershed development programs annually and to provide policy directions to the program.

Impact of Watershed Programs

Impact evaluation studies conducted in treated watersheds reveal that there has been: (i) recharge of groundwater aquifers as evidenced by increase in water levels and rise in number of wells, (ii) reduction in soil erosion, (iii) increase in cropping intensity, (iv) change in cropping pattern leading to higher value crops, (v) increase in crop productivity, (vi) reduction in rural and urban migration, and (vii) rise in overall bio-mass in the watershed. However, an element of lack of sustainability and of community participation was also noticed in some of these watersheds.

Operationalizing Mitigation and Adaptation through Watershed Development

Considering the potential of integrated watershed development as an adaptation strategy and mitigation option, efforts to strengthen the program and expand its scope manifold becomes an even higher priority than before. This would imply :

- Assessment and quantification of integrated watershed projects as adaptation and mitigation source.
- Awareness generation about the impact of climate change on agriculture.
- Highlighting the adaptation and mitigation benefits of integrated watershed.
- Expanded capacity building campaign including building climate change issues into training curricula.
- Major resource mobilization both from the Government of India as well as the international agencies.
- Identification of vulnerable regions to enable priority setting.

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Integrating Watershed Management for Land Degradation and Improving Agricultural Productivity in Northeast Thailand

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Abstract

Thailand's northeastern region accounts for one third of the country's population and land area, but generates only 15 percent of the gross domestic product. Most of the region's inhabitants have small holding, are low income farmers who face diverse agricultural and resource problems related to extreme environmental variability, an adverse climate, poor soils and limited, often unreliable water resources. Due to these problems the current agricultural productivity and income is very low. The deforestation and other agricultural practices have led to the changes in the hydrologic environment and caused widespread land degradation problems. To tackle these problems several watershed management programs have been implemented by various government departments and organizations. This paper reviews the various watershed development management works in northeast Thailand and discusses their approaches and impact on agricultural productivity and natural resources.

The impact of small-scale water resources (SSWR) development program implemented by the Thai Royal Irrigation Department and Ministry of Agriculture and Cooperatives, on the socio-economic conditions of the farmers in NE Thailand was studied. It was found that the farmers in SSWR area earned more income from agriculture, than farmers outside SSWR area. Farm profitability and source of farm cash income of SSWR farmers were closely related to dry season cash crops rather than wet season rice. Area under double cropping was found to be higher in SSWR area than those outside SSWR area. In terms of productivity, profitability and equity the weir type SSWR system was found to be the most appropriate for northeast Thailand. Overall the study indicated that the small scale water resources can play very significant role in increasing the productivity and income of small rainfed farmers in northeast Thailand. The Department of Land Development approach of watershed development and management gives greater emphasis to small farm ponds and control of soil erosion. This program is being implemented on large scale in Thailand. The Kingdom Watershed Management Program for small, medium and large scale watersheds is also discussed.

The results from integrated participatory watershed management project implemented jointly by the Department of Agriculture, Land Development Department and Khon Kaen

University in close collaboration with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) are discussed in detail. This project is being carried out at two benchmark sites, viz., Tad Fa in Phuphaman district and Wang Chai in Phuwiang district in northeast region of Thailand. Results shows that with proper land use planning and use of integrated soil, water and nutrient management (SWMM) and crop management options the land degradation can be controlled (soil loss of 5 t/ha/yr in improved system vs soil loss of 37 t/ha/yr in the traditional system). The project interventions significantly increased the water availability and crop yields. Promising watershed management technologies developed at the project sites provide a good framework for increasing productivity and income of farmers on sustained basis, while improving the soil and water resources.

Introduction

Northeast Thailand is situated between 19° and 14° N latitude, and 101° and 106° E longitudes. It encompasses 17.02 million hectares, roughly one third of the entire country and is the poorest region of Thailand in terms of resources, economy and per capita income. Most of the region's inhabitants are small holding, low income farmers who face diverse agricultural and resource problems related to extreme environmental variability, an adverse climate, poor soils, and limited, often unreliable water resources.

Northeast Thailand has a monsoon climate similar to other parts of southeast Asia, but the region's geophysical characteristics create special conditions. Annual rainfall normally averages between 1300 and 1400 mm for the entire region, but with considerable variation. More than 90 percent of the annual rainfall occurs between May and October (i.e. rainy season). The western half of the region is substantially drier (1100 mm/year) as a consequence of the rain shadow effect. In contrast, annual rainfall in the extreme northeast corner of the region is about 1800 mm. The actual amount and pattern of rainfall are often extremely erratic and unpredictable. This creates considerable risk for agricultural production, 80 percent of which involves rainfed cultivation.

Soils in the northeast region are generally loamy sand or sandy loam, both having low fertility and a poor moisture retention capacity. Through deforestation, the cultivable area has expanded rapidly during the 1960's. The deforestation and other practices have led to the changes in the hydrologic environment and caused widespread salinity problems. Also, the soil erosion and soil fertility deteriorations are some of the serious problems coming up in many areas. In rainfed areas, the water is becoming one of the major constraints for increasing and sustaining productivity. Many regions of Thailand have suffered from longer than usual drought periods, higher temperatures and unusual rainfall anomalies which have devastated rural economies in rainfed areas. In Thailand, 46 out of its 76 provinces are currently suffering from water shortage. Due to these problems, a vicious cycle of soil degradation, low yields, poverty and low investment has gripped the rainfed agriculture.

To address these problems several watershed management programs have been implemented in Thailand during the past two decades by various government departments and institutions. Most of the initial watershed programs by Thai Royal Irrigation Department, Ministry of Agriculture and Cooperatives, and Kingdom Watershed Management Program were primarily focused on increasing the availability of water for agriculture. Several other watershed programs by Agriculture Development and Research Center (ADRC) and Land Development Department (LDD) were focussed on reducing land degradation and improving soil quality. More recently, the Integrated Watershed Management Project implemented by consortium of the Department of Agriculture (DOA), the Department of Land Development, Khon Kaen University (KKU) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is focussing more on increasing the productivity and improving livelihoods of farmers through better management of natural resources. This paper reviews the various watershed management programs in Thailand with particular emphasis to rainfed areas in northeast region and discusses their approach, problem, and impact on agricultural productivity and natural resources.

General Background of Northeast Thailand

Landscape of Northeast Thailand

Northeastern region of Thailand is a plateau, which is gently sloping from the western toward the eastern part bordering PDR Laos or the Mekong river. There are numerous streams and rivers, some of them drain directly into the Mekong river but the majority of them drain into two main rivers, the Chi and Moon. These two rivers also drain into the Mekong river. In terms of agricultural development, there are two main agro-ecological basins, Sakon Nakon basin on the northeastern corner and the inner and larger Korat basin.

Soil Features and Management

Soil features: Land is gently undulating (nearly 80% of NE landform), covered by Mesozoic and Paleogene Tertiary sedimentary rock formation (ADRC, 1989). The soils are characterized by sandy textured topsoils. A skeletal soil owing to shallow laterite layer is widespread in Sakon Nakon Basin and comprises 13 percent of NE. Saline and sodic soils commonly occur in plateau and cover about 17 percent of the region. The alluvial plain, a fertile soil, are distributed along the Mekong, Chi and Moon rivers and their tributaries but comprising rather small area of only 6 percent of total NE area. Thus sandy top-soils, salt-affected soils and skeletal soils are three major problem soil in the northeast. Low soil fertility caused by these soils on the plateau as well as erratic rainfall are closely responsible for the low agricultural productivity of the northeast as a whole.

Soil erosion and nutrient loss: Increasing population in Thailand is putting strain on the natural resources such as land and water. The increase in population causes encroachment of forest area for agricultural land. The run-off that is loaded with the sediments impoverishes the soil and also causes reduction in the storage capacity of the water bodies.

Soil erosion is the main problem in degradation of natural resources. The sediment load and the extent of soil erosion in NE Thailand are shown in Table 1.

Sedimentation is secondary process after soil erosion, consequently, transported to streams or reservoirs. Soil erosion causes huge soil nutrient loss through transportation of sediments to other regions (Table 2).

Table 1. Sediment load in the run-off water in northeastern Thailand watersheds

Watershed	Mean annual suspended sediment (MCM)	Depth of erosion (mm)
Mae Khong	9.36	0.16
Chi	1.04	0.02
Moon	1.00	0.01

Source: Montien Somabhi and Peaingpen Sarawat.

Table 2. Nutrient loss (tonnes/year) through soil erosion in different regions of Thailand

Region	Nitrogen	Phosphorus	Potasssium
North	38.29	4.47	75.59
Northeast	18.90	1.21	91.64
Eastern	17.89	1.07	30.86
Southern	17.31	0.45	13.45

Source: RID, Thailand.

Crop Production and Socio-economic Conditions

According to archeological excavation at Ban Chiang and Udon Thani, the region's agriculture has been developed more than 3000 year ago. The lowland areas were first utilized for the cultivation of rice, the staple food of the early inhabitants. The upland area has only been significantly utilized since the last 40-50 years for additional family incomes. The first major upland crop was kenaf, followed by cassava in low fertility areas, and maize along the fertile land tracts. Other major upland crops introduced into the area were sugarcane, cotton, peanut, soybean, castor, mungbean and sesame. Kenaf has experienced a continuous decline due to competition with cheaper synthetic products and marketing problems. Cotton has also rapidly decreased in planting area due to pest-control problems. At present the cassava area has slowly decreased because of market problems and the replacement by sugarcane. The sugarcane areas have rapidly expanded in recent years due to the relocation of many sugar mills from other parts of country. At the same time most local mills also improved their equipment and increased the crushing capacity. The fruit trees were slowly introduced into the cropping systems of the northeast. Since only in the last two decades, the commercial fruit-tree production has been initiated and in recent years many large plantations were established because of the availability of cheap land and labours.

The majority of the northeast farmers are still dependent on the cultivation of crops. Crop incomes account for more than 60 percent of the total family's farm income and livestock and agricultural employment account for about 32 percent. However, the off-farm income of the average northeast farm family was slightly larger than the agricultural incomes. This fact implicate that the low agricultural income is not sufficient to support the family and seeking employment outside the farms is necessary for the majority of NE farm families.

The economic and social conditions of the country have changed dramatically and rapidly during the past two decades. The NE agricultural production has also been affected by these changes. The farm labours were drawn into the industrial and service sectors in other parts of the country. The NE agriculture production needs proper adjustment in order to improve family incomes, adapt to reduced-farm labour regime, and lead to a sustainable production system.

Soil management: Several research inputs to improve problem soils (sandy, saline, erosion and skeletal) aiming to increase crop production had been developed. Various kinds of maps such as agro-ecological zone map, land suitability map, saline soil map, erosion status map, underground water and land suitability for small scale water resource development map have been produced. Innovation of new hypothesis of soil salinization that saline groundwater originates from rock salt and moves up through the fractured zone and contaminates shallow aquifer and further moves to surface during dry season. Vetiver grass (*Vetiveria zizanioides*) and Ruzi grass (*Brachiaria ruzizensis*) planted contour-strips were useful to prevent soil loss and water run-off. *Sesbania rostrata* showed high potential as a promising green manure crop for supplying both nitrogen and phosphorus in infertile soil of NE rainfed lowland rice. Similarly, Hamata (*Stylosanthes-hamata*) and sunhemp (*Crotolaria juncea.)* are well suited for upland green manuring crop rotation. Application of biofertilzers such as mycorrhiza, blue green algae and azolla enhanced the efficiency of chemical fertilizers. Use of 1.5 m wide ridges associated with 14-day irrigation interval gave highest irrigation efficiency for soybean cultivation. Eucalyptus trees planted in upper part can suppress severe salinity in lowland paddy. These research findings are extensively used for reclamation of problematic soils in NE Thailand.

Land development technology transfers: The Land Development Department plays major role in both soil improvement and soil conservation through the conventional concept of extension and technology transfer that clearly covers all three areas of technology development process-researcher, extension staff and the farmers. The soil conservation has been receiving less attention in the past. The mobile units helped farmers build terraces on sloping land. This approach did not prove effective as farmers considered the terraces as the government properties and did not maintain them (Samran, 1995). This was an example of common failure of public resources land management. The information flew in one direction from researcher to extension staff and to farmers with little or no interaction and, seldom had good understanding of the farmers' environment and constraints. The concept of 'People-Centered' and 'Farmers' Participatory' concepts are now generally accepted that soil conservation program must work in close collaboration with land users right at the initial stage. The 'Soil Doctor' nowadays well known as 'Soil Doctor Volunteer (SDV)' is established in each Land Development Village (LDV) programs, which are being practised countrywide. SDVs are considered as good agents for land development which help in cost-sharing of various on-farm conservation measures, farm inputs, job contraction such as the award of contract to produce seedling or work on project activities, infrastructure for better village farm road, education such as field trips and vocational trainings and ensuring people's participation in project activities. However, some concerns are again emerging about this LDV programs in which government pays almost the total cost of establishing soil and water conservation measures, whether it could be as effective without such subsidies.

Water Resources Development for the Northeast

Strategy of water resources development: The water resources development strategy for the northeast follows two-pronged water policy. Firstly, it emphasizes proper distribution system for the existing sources of reservoir and rivers. In zone I (2.1 million rai, 8-9 % of farm families), farms are irrigated by large reservoirs, while in zone II (1.9 million rai, 10% of farm families), farms are irrigated by pumping water from reliable rivers. The second challenge is to meet basic requirement in every village which can be classified as zone III which have no access to reservoir and reliable rivers and support 80 percent of farm families. In these areas small scale water resources (SSWR) development may be possible to meet basic domestic water needs and minimal supplementary irrigation requirements.

The potential effectiveness use and alternatives of SSWR development projects to meet the basic requirement of villages can be visualized as summarized in Table 3.

Table 3. The potential use of alternatives (types) for small-scale water resources projects

Village use & requirement	Alternatives for small scale water resources projects						
	Weirs	Rehabi-litation	Village tanks	Dug ponds	Deep wells	Shallow wells	Roof run-off
Drinking					x,?	x, ?	x
Domestic use	x	x	x	x	x	x	?
Animal	x	x	x	x	x	x	
Wet season crop	x	x	x	x	x, ?	?	
Dry season crop	x	x	x	x,?	x, ?	?	
Fisheries	x	x	x	x,?			

Note:x = Indicates potential use, ? = Questionable or limited use.

The first three types, weirs, rehabilitation of natural streams (*Huay*) and swamps (*Nhong*), and small reservoirs or village tanks are typically found in NE watersheds in common lands. Dug ponds or farm ponds are built by excavating the earth below the water table or higher ground with some sorts of seepage prevention which are relatively smaller than village tanks and usually dry out through seepage in the dry season. The deep (tube) wells are dug down to a confined aquifer and require pumping. The shallow (open) wells are usually dug manually by villagers down to the water table. And the last alternative is collection of run-off rainwater from household roofs for drinking purpose.

Agencies for water resources development: Electricity Generating Authority of Thailand (EGAT) is concerned with construction of the major/mega dams for electricity production only. For agricultural purposes, several departments of the Ministry of Agriculture and Cooperatives (MOAC) are responsible in various contexts. The

Royal Irrigation Department (RID) plays important roles in agricultural water resources development associated with irrigation system facilities. It has divided the whole Kingdom into 25 main river basins and NE Thailand shares only 3 main river basins, namely, Mekong, Chi and Moon river basins (Table 4). The Royal Irrigation Department is responsible for construction and maintenance (large and medium schemes) of reservoirs associated with main irrigation systems. These supply main water resources for 15 percent of the irrigated area of the country. It also constructs small scale schemes such as village tanks, rehabilitation (dredging) of natural streams and swamps, levee for flood protection, and mobile pumping for emergency cases (drought relief program, in particular).

Table 4. Main river basins, drainage area, run-off, and RID water resources development in northeast Thailand

Main river basins	Drainage area (*1000 km^2)	Mean annual run-off (*billion m^3)	RID water resources development schemes			
			No. of large & medium	No. of Small & others	Stock (m.m^3)	Irrigable area (m. rai)
Kingdom (25)	511.48	213.42	694	694	9362	37.45
Northeast (3)	165.85	44.03	178	5184	6.02	2.90
Mekong	46.67	13.29	na	na	1.16	na
Chi	49.48	11.24	75	2025	1.79	1.24
Moon	69.70	19.50	109	3159	3.07	1.66
NE (%) share	32.4	20.6	25.7	55.4	15.9	7.5

Source: Consolidated from RID.

In sub-river basin defined as Zone III with sloping undulated upland, mini-watersheds are formed. Major responsibility of Land Development Department (LDD) is soil conservation. Water resources projects are included as part of soil conservation needs. In terms of SSWR development, the LDD is focusing on on-farm level in the watershed, for instance, on-farm ponds, shallow wells, dredged waterways, and earthen bunds. Up-to-date, LDD has completed construction of 1,807 number of SSWR (LDD, 2004). Similarly, the Office of Land Reform (OLR) has responsibility of land reform and consolidation, but is also empowered to construct water resources projects as a part of agricultural land development. The Office of Permanent Secretary (OPS) is launching integrated farming program, under King's New Theory Farming Initiation, which also stress farm pond as a key component of all pilot farms. The Department of Agricultural Extension (DOAE) has also initiated deep well pumping project as part of extension promotion program.

The Community Development Department has major responsibility in community development and generally takes over the RID-SSWR projects for further development but, the department also develops its own water resources as part of the program. The drillings program of Department of Mineral Resources is for mineral exploration, however, the wells where good groundwater is encountered are developed for use. The rural water supply development program of the department in Ministry of Public Health is aimed to provide good drinking water for rural community. National Energy Authority (NEA) develops groundwater irrigation of medium and large scale. The results were very promising, but unfortunately NEA is not authority in line agency for executing the pumping schemes.

The three main types of SSWR of RID such as weirs, tanks and natural stream rehabilitation which are typically located in lowland, indicated that water availability in dry season has boosted upland crop and vegetables production. The impact on socio-economic conditions of the farmers in NE Thailand was found that the farmers in SSWR area earned more income from agriculture than farmers outside SSWR area. Farm profitability and source of farm cash income of SSWR farmers were closely related to dry season cash crops rather than wet season rice. The area under double cropping was found to be higher in SSWR area than those outside SSWR area. In terms of productivity, profitability and equity, the weir type SSWR system was found to be most appropriate for the NE Thailand. Overall the study indicated that the small scale water resources can play very significant role in increasing the productivity and income of small rainfed farmers in NE Thailand.

This can be implied that the productivity of rainy season paddy in zones I and II watershed (20% irrigable farm families) may not need much of supplemental irrigation water, however, water is required during dry season in contrast to Zone III watershed (80% rainfed farm families) where SSWR played important role for both rainy season paddy security and obtaining extra farm income from dry season crop cultivation.

Integrated Watershed Development Experiences

An earlier overview showed that independent activities on soil improvement, land development, water resources development, crops and livestock production are executed by individual departments without any coordination. It has now been realized that more of the integration of multi-disciplinary partnerships is required for holistic management. Generally, the term 'Watershed' refers to a sub-drainage area of a major river basin (Dixon and Easter *et al.,* 1991), whereas the Integrated Watershed Management Approach is the process of formulating and implementing the course of action involving natural and human resources in the watershed to achieve specific social objectives. This means developing proper linkages between the upland and lowland in both biophysical and socio-economic context.

Integrated Watershed Management for Enhancing the Livelihoods of the People

The concept of integrated watershed management with holistic approach for increasing the agricultural productivity and enhancing people's livelihoods is relatively new in NE Thailand. In 1999, an integrated watershed management program was initiated at Tad Fa village in Phupaman district of Khon Kaen province. A new farmer participatory consortium model for efficient management of natural resources and reducing poverty has been adopted. A consortium of institutions, as opposed to a single institution, was formed for project implementation and technical backstopping. The Department of Agriculture (DOA), the Land Development Department (LDD), Khon Kaen University (KKU), along with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) formed the consortium for implementation and technical backstopping at two benchmark sites, viz., Tad Fa wateshed in Phupaman district and Wang Chai watershed in Phuwiang district.

Tad Fa Watershed, Phupaman, Khon Kaen

Tad Fa watershed is part of a large basin of Chi river, which is located at latitude 15° 30′ N and longitude 101° 30′ to 140° 30′ E and is about 150 km northwest of Khon Kaen. It is a junction of three big watersheds, namely, Chi in east, Mae Khong in the northeast, and Pasak in the southwest. Tad Fa watershed falls in two provinces: the eastern part of the river Tad Fa comes under Khon Kaen province, which has nearly 700 ha, while the western side comes under Petchabun province. This watershed project was carried out in the eastern part of Tad Fa watershed of Khon Kaen province.

Mean annual rainfall at Tad Fa watershed is about 1300 mm with 1900-2000 mm evaporation and in terms of temperature regime the area is tropical (26-30°C). Topographically it has high to medium slopes and soils are mostly Ustults. The land use mostly comprised field crops, horticulture, and vegetables. The cropping systems under rainfed condition include maize as a cash crop on high and medium slopes and upland rice on the lower slopes. The fruit trees and vegetables are usually grown close to supplementary water resources on the lower slopes. Sometimes, legumes and cereals are rotated with maize. Some of the major research and development activities carried at Tad Fa watershed are discussed.

Watershed development: In consultation with the farmers, the Land Development Depatment has constructed about 17 farm ponds each of 1260 m^3 capacity. This provides much needed supplemental irrigation to crops/fruit trees/vegetables, particularly in the post-rainy season. In large areas the field bunds have been constructed along with vetiver grass. This is necessary for controlling soil erosion, which is one of the major problem in Tad Fa watershed. The annual soil loss of 40-60 tonnes/ha is quite common in this watershed.

Soil and water management: In order to reduce tillage on very steep slopes, which result in high soil loss, minimum tillage is being tried. On mild slopes contour cultivation or cultivation across the slopes is being popularized in the watershed. During 2003-2004, about 68 percent area was planted on contour on mild slopes. The cultivation increased the maize yield by 30-40 percent compared to conventional up and down cultivation. It also significantly reduced the soil loss.

Integrated nutrient management: Most of the farmers in northeast Thailand apply chemical fertilizers for their cash crops in order to harvest decent yields. Chemical fertilizers are one of the costliest inputs and there is a need to search other alternatives or supplement sources to overcome nutrient constraints. There is not much scope to use farmyard manure (FYM) as farm animals have been replaced by tractors for draft purposes. The use of legumes in the cropping system would certainly help to reduce the amount of chemical N fertilizer. Several legumenous crops viz. rice bean (*Vigna umbellata*), black gram (*Vigna mungo*), sword bean (*Canavalia gladiata* (Jacq) DC) and sunnhemp (*Crotolaria juncea*) were evaluated. Based on the N-difference method, N_2 fixation varied from 20 to 104 kg N/ha and net N benefit expected to the succeeding crop was expected in the range of 2 to 51 kg N/ha. Following legume crops, a maize crop was grown with 40 kg N/ha along with the organic matter from the legume residues. Grain yield of succeeding maize crop was significantly higher by 27 to 34 percent in case of treatments following black gram, rice bean and sumhemp over the yield of control maize crop (Table 5). Although N_2 fixation was highest in case of sword bean (104 kg N/ha), the benefits were not translated in terms of increased maize yields. These results demonstrated that it is not only the quantity of N_2 fixed that determines the benefit to the succeeding crop but the quality of organic matter and N release pattern from the legume residue. However, in long-term for sustaining land productivity the sword bean crop could play an important role.

Table 5. Dry matter of maize grown after five different crops at Ban Koke Mon in the rainy season of 2000

Treatment	Dry matter (kg/ha)			
	Stover	Cob	Seed	Total
Rice bean	7.069	816	4,541a	12,425
Sunnhemp	6,634	786	4,720a	12,141
Sword bean	6,689	659	3,642b	10,991
Black gram	6,786	875	4,488a	12,149
Maize (fallow)	5,560	697	3,525b	9,781
F-test	NS	NS	*	NS
CV (%)	14.57	14.41	13.36	13.13

* The maize crop received N from crop residue as mentioned plus 40 kg N/ha in the form of chemical fertilizer.

It was found that for quick benefits for succeeding maize crop, farmers would be benefitted by growing legumes such as rice bean, sunnhemp and black gram. In another experiment, the effect of groundnut stover management on growth and yield of upland rice was studied. The stover of groundnut grown in many areas is left unattended after the final pod harvest. Generally no attempts are made to use it for the succeeding crop production. The study included two parts i.e. preceding crops and succeeding crops. Preceding crops were local groundnut and non-nodulating groundnut. Succeeding crop was glutinous rice (*Pla Ziew Maew*, a local variety).

Data in Table 6 shows dry matter production of upland rice grown after different treatments at final harvest. It clearly shows that stover removal results in lower growth and yield of rice. The treatments where the stover is returned either as incorporated or mulched increased growth and yield of rice. Treatments where groundnut stover was returned could supply sufficient N for rice as N application at panicle initiation period did not significantly increase rice growth and seed yield.

Table 6. Grain and dry matter yields (t/ha) at final harvest of upland rice grown after groundnuts with different treatments (Ban Koke Mon site, 2003)

Treatment	Grain dry weight	Total dry matter weight
-S**+N_0+P_0+K_0 (Control)	2.56bc	5.98bc
+S(incorp.)+P+K	3.63ab	8.62ab
+S(mulch.)+P+K	3.94a	9.25a
+S(incorp.)+P+K+NPI*	3.75ab	9.84a
+S(mulch.)+P+K+NPI	4.21a	9.99a
-S(non-nod)+P+K	2.02c	5.60c
-S+(½N)+P+K	3.56ab	7.89abc
-S+N+P+K	3.02abc	7.20abc
-S+(2N)+P+K	3.48ab	8.57ab
F-test	**	*
C.V.(%)	22.64	22.31

* Nitrogen at panicle initiation stage, ** Groundnut stover, N : Nitrogen, P : Phosphorus, K : Potassium

Diversifying land use system: Cultivation of fruit trees is being popularized in the Tad Fa watershed. This assists in controlling soil erosion and provides better and more sustainable income to the farmers. During last 2-3 years the area under fruit trees cultivation has increased in and around Tad Fa watershed. Several new fruits and varieties have been introduced to increase the productivity and the survival of fruit trees. Several new systems, viz., intercrop banana with other fruit trees, mulching, inter-row water harvesting and growing annual crops along with fruit trees have been introduced.

Improved crops and cropping system: Several new crops and their varieties have been introduced in the watershed. New relay and sequential cropping systems have been identified and tested. A large numbers of farmers have adopted these new crops and varieties.

Empowerment of community: Empowerment of communities, individuals and the strengthening of village institutions were done through concerted efforts. It was observed that when people are empowered to take decisions and execute the activities, they own the program very well. They run the watershed activities according to local, social and cultural systems.

Hydrological measurements: An automatic weather station has been installed in the watershed to monitor rainfall, temperature, sunshine, humidity, wind velocity, and soil temperature at fixed intervals. Two digital run-off recorders along with automatic pumping type sediment samplers are installed at two sub-watersheds to monitor the run-off and soil loss from the two land use management systems. Sub-watershed I has land under the horticultural tree-based cultivation with some areas under annual crops. Sub-watershed II has most of the areas under annual crops and cropping systems. The run-off and soil loss from the two sub-watersheds during 2003 are shown in Table 7.

Table 7. Rainfall, run-off and soil loss from two watersheds (Tad Fa, 2003)

Land use systems	Rainfall(mm)	Run-off(mm)	Soil loss (t ha^{-1})
Annual crops	1650	256	32.5
Fruit trees	1650	142	6.3

Wang Chai Watershed, Phuwiang, Khon Kaen

Wang Chai watershed is part of a Nam-Phong basin and is about 75 km northwest of Khon Kaen city. Wang Chai village falls under the Phuwiang district in Khon Kaen province. Mean annual rainfall is about 1000 mm. About 90 percent of the annual rainfall occurs between May and October. Often the actual amount and pattern of rainfall are extremely erratic and unpredictable. This creates considerable risk for agricultural production since most of the watershed area is under rainfed cultivation. The soil in the watershed is mostly sandy or sandy loam with very low water holding capacity. The organic matter content is also very low. Major crops grown in the watershed are rice, sugarcane, cowpea and groundnut. Small areas are also under fruit trees and vegetables. The average productivity of most of the crops is quite low

The biophysical and socio-economic base line data from the Wang Chai watershed have been collected and analyzed. The major constraints for increasing the agricultural productivity were identified. The topographic, land use and soil maps have been prepared. Most of the areas in the watershed have moderate to low slopes.

Major research and development activities: In consultation with the farmers, 39 farm ponds each of about 1250 m^3 storage capacity were constructed. In large areas the field bunding has been done and total 9 km village roads have been constructed. To protect the bunds and roads from erosion, the vegetative barriers were planted. Drains were constructed for safe disposal of excess run-off water. The rainfall, run-off and soil loss have been monitored.

During the last two years various research and development activities on integrated nutrient management, water management, crops and cropping systems were taken up. Several self-help groups were formed. Farm and community based activities were initiated to enhance the agricultural productivity and income. New crops and varieties were introduced in the watershed. Village based pure rice seed production farms were established. Training was given to farmers for value addition to field crops products. The farmers are quite happy with the various watershed activities. The construction of farm ponds has significantly increased the cropping area in the post-rainy season. Some of the activities have already resulted in increased agricultural productivity and income.

Lessons Learnt

Integrated watershed management project is only 5 years old. Some of the initial lessons which could be drawn from this integrated watershed management project are:

- Consortium approach consisting of various research and development organizations, University and farmers helped to effectively plan, implement and monitor the watershed. This model of bringing the key organizations (DOA, LDD and KKU) together needs to be replicated in other watersheds for their success.
- The integrated watershed program resulted in tangible economic benefits to individual farmers through improved soil, water, nutrient and crop management options on their lands.
- Participatory planning with the farmers for deciding the location of the water ponds was found highly beneficial.
- Adoption of improved technologies (new crops and fruits, new varieties, tillage systems, land and water management, water harvesting, etc) substantially raised productivity and augmented farm income. Some of the watershed activities such as cultivation of fruit trees were found highly successful in attaining the livelihood and environmental objectives of the watershed.
- It was found that most of the farmers come together for immediate and private gains rather than the long-term social gains. As long as the collective action yielded sufficiently higher private gains, farmers participated actively in watershed programs.
- The formation of self-help groups was found to be highly beneficial. Particularly the self-help group formed in the watershed for fruit trees cultivation was highly successful. Farmers were able to share the various information about the new technologies, new varieties, insects and pests problems and possible solutions.
- A strong network of information is found necessary for increasing the effectiveness and sustainability of watershed program. In the changing economic regime, the technologies are changing rapidly and affecting competitiveness, markets, consumer preferences and prices.
- The integrated watershed management is relatively new in NE Thailand. There is need to address the second-generation watershed problems. The policy, institutional arrangement and problem of scaling up need to be taken up in future.

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Efficient Management of Water Resources for Improving the Livelihoods through Integrated Watershed Management Approach

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Abstract

Southwest China, administratively covering the provinces of Yunnan, Guizhou, Sichuan, Chongqing Municipality, and Tibet Autonomous Region is characterized by mountainous topography, multi-ethnic residents, and poor eco-environmental conditions. Except some parts of Sichuan province, the rest of the region consists of hills and mountains, which occupy more than 90 percent of the land area. Therefore, the cultivated land is very scarce. Most of the non-cultivated as well as cultivated lands are subject to severe soil erosion. Agriculture is a major dependency of livelihoods for the majority of the people in the region, especially in Yunnan, Guizhou and Sichuan provinces. The annual rainfall in this region varies from 1000 to 2000 mm and its distribution is erratic causing frequent droughts because most of the cropping is rain-fed. Agriculture is also the major source of revenues in the river valley areas in the southwest China, with a 44 percent of the social production values, and 54 percent of the Gross Domestic Product (GDP). Watershed management is one of the important schemes of the Chinese Government in the West Development Strategy. Economic development and improvement of eco-environmental conditions are two main goals of this strategy. The major constraints in this region are severe soil erosion, water scarcity for crop production and land degradation. The National Agricultural Research System (NARS) of China in recent years have developed and evaluated technologies like vegetation restoration, rain water harvesting, and control of soil erosion by different interventions in the research station to overcome the constraints. Since 2003 a collaborative project between International Crop Research Institute for Semi-Arid Tropics (ICRISAT) and Yunnan Academy of Agricultural Sciences (YAAS) and Guizhou Academy of Agricultural Sciences (GAAS), funded by Asian Development Bank (ADB), is being implemented in two benchmark watersheds representing two eco-regions, hot-arid valley region in Yunnan province and Karst region in Guizhou province. The major emphasis of this work is harvesting rainwater and its efficient use, control of soil erosion as also by various soil conservation measures in farmers' fields. As a part of integrated watershed management, many other interventions are being evaluated in order to improve the income of the farmers along with soil and water management interventions.

Introduction

Southwest China, administratively covering the provinces of Yunnan, Guizhou, Sichuan, Chongqing Municipality, and Tibet Autonomous Region is characterized by mountainous topography, multi-ethnic residents, and poor eco-environmental conditions. Agriculture is a major source of livelihood for majority of the population in the region. Arid valley areas are the major agricultural areas in the region, especially in Yunnan, Guizhou and Sichuan provinces. Agriculture is also major source of revenue in the river valley areas in southwest China, with a 44 percent of the social production values, and 54 percent of the GDP. However, most of the agricultural activities in the arid river valleys are rainfed agriculture. Watershed management is one of the important schemes of Chinese Government in the West Development Strategy. Economic development and improvement of eco-environmental conditions are two main goals of the strategy.

Two eco-regions in the southwest China are described below representing hot-arid valley regions in Yunnan province as well as other similar areas of Jinshajiang river basin and the Karst region of Guizhou province, which are both within Yangtze River drainage area.

Yunnan province is characterized by large areas of hills and mountains. The total area of the province is 383,390 km^2 (84% are hills and mountains, 10% are undulating lands, 6% are flat and valley lands), with only 2.93 million ha of arable land, of which 0.95 million ha (32%) is paddy field, 1.98 million ha (68%) is upland; irrigated land is 1.18 million ha (44.6%) and rainfed area is 1.75 million ha (55.4%).

The average annual rainfall is about 1300 mm ranging from 500-2900 mm in different parts of the province, distributing 85-90 percent from May to October About 38.2 percent of the total area (146, 000 km^2) has erosion problem. The yearly erosion modules range from 5-180 t f ha^{-1}, mostly from 5 -50 t f ha^{-1}. Severe erosion mainly occurs during July to September.

Yunnan is an agricultural province where 87 percent of its population depends on agriculture. Farmers are small holder with about 0.07 ha farmland per capita, which makes about 0.28 ha per household and the land holding is always fragmented. The major crops of the province are rice, corn, wheat, beans, tobacco, sugarcane, potato, sweet potato, oil seed crops, tea, vegetables, fruits, etc. Diversified crop systems found in the province are rice-based system: rice-wheat, rice-beans; and tobacco-based system: tobacco-wheat, tobacco-faba bean or pea.

Guizhou province is located in the east slope of Yun-Gui plateau with a total population of 37 million. The average altitude is 1100 m asl. The total land area is 176,152 km^2 of which 97 percent is mountains and hills. It is characterized by sub-tropic monsoon climate with annual mean temperature of 14-16°C and the average precipitation of 1100-1300 mm. Abundant sunshine and rainfall provide suitable condition for various plants to grow in the province.

Soil erosion is the major problem in Guizhou province. About 41 km^2, accounting for 44 percent of the total territory of the province is eroded causing serious landslide and debris flow. Nearly 0.28 billion tonnes of soil flows down into Yangzte river and Zhujiang river and creating decline in reservoir capacity. Another result of soil erosion in this eco-region is stone exposure. In this province, around 73 percent of the total land are Karst areas with 23-thousand km^2 land with stone exposing.

The arable land in Guizhou province is more than 1.86 million ha. The arable land per capita is only 0.05 ha. The major crops of the province are rice, corn, wheat, beans, tobacco, potato, sweet potato, oilseed, tea, vegetables, fruits, etc.

The major constraints for agriculture production are:

- *Water scarcity:* Due to inadequate and erratic distribution of rainfall, frequent droughts occur.
- *Soil erosion:* A severe problem in both eco-regions leading to large gullies and 'earth forest' in Yunnan, and Karst exposure of large tracks of cultivated land in Guizhou
- *Degradation of land:* Mainly due to soil erosion and improper crop management.

A participatory integrated watershed management approach is being evaluated since 2003 with the collaboration of ICRISAT, YAAS and GAAS which is funded by ADB. The objectives of the approach are: (i) reducing soil erosion, (ii) rainwater harvesting and its efficient use; and (iii) improving crop management systems to sustain the present productivity in an efficient manner, in order to enhance the economic conditions of the farmers.

Previous Research

The Yunnan Academy of Agricultural Sciences (YAAS) and Guizhou Academy of Agricultural Sciences (GAAS) in recent years have conducted research to overcome the above constraints. Many interventions were developed and evaluated in the research station. Some examples of such work are:

1. Vegetation restoration in hot-arid valley regions:
   - Fruit production under supplemental irrigation condition, such as mango (*Mangifera indica*), litchi (*Litchi chinensis*), longgan (*Mimocarpus longgan*), jack fruit (*Artocarpus heterphyllus*), banana (*Musa nana*), papaya (*Carica papaya*), etc.
   - Participatory forest establishment for conservation of soil and water and/or for fuel wood such as *Eucalypts camaldelensis, Leucaena lecocephala*, and native shrubs.
   - Rainfed high value woody species: tamarind (*Tamarindus indica*) and neem trees.
   - Participatory pastures restoring, such as tropical grasses, *Stylosanthes guianensis* and native grass species, etc., and livestock rearing.

   Results show that all these methods have good effect on increase of vegetative covers and promote diversification of crops production to generate higher incomes for the farmers. Use of agro-forestry to plant different fruit trees can improve 12-30 percent of water use efficiency, and increase income by US$ 150 per ha.

2. Technology of rainfall harvesting and its utilization in rainfed agriculture in hot-arid valley regions:
   - Establishing earthen moon ridge interditches with native grasses belt to harvest rainwater for rain-fed cash crop production. This technique can enhance soil moisture by 30-40 percent.
   - Constructing water cellar inside the fields to harvest run-off.
   - Using cement pitcher for pitcher irrigation. It can save 60-70 percent of water than flood irrigation.

3. Farming land construction of farm infrastructures and soil amelioration. The objectives of this intervention are to reduce soil erosion, improve soil moisture and soil fertility. Interventions include:
   - Terracing: This is a long-term measures to control soil erosion (supported by government).
   - Use of contour cropping to reduce soil and water loss.
   - Soil water conservation (mulching with litter, sand, plastic film, etc.).
   - Planting leguminous crops to improve soil fertility.

4. Select and use of drought resistant and/or high value species or varieties. These selections enable farmers' to have larger options to generate incomes from their lands.
   - Fast growing fuel wood trees, e.g, *Eucalypts camaldelensis*.
   - Industrial raw materials, such as medicinal plants and essential oil crops.
   - Fruits (high value, harvesting in winter), forages and off-season vegetables.

Approach

Participatory integrated watershed management approach is being adopted. Two benchmark watersheds to represent the above mentioned two eco-regions were identified. Xiaoxincun in Yuanmou county, Chuxiong prefecture of Yunnan province represents the hot-arid valley regions in Jinshajiang basin. Lucheba in Pingba county, Anshun prefecture of Guizhou province represents the Karst region. The brief descriptions of these two benchmark watersheds are given in Tables 1 and 2.

Table 1. Agriculture characteristics of two benchmark watersheds

	Xiaoxincun	Lucheba
Size (ha)	186.70	720.40
Population	316	1,350
Households	86	365
Land use system		
Cultivated lands	39.60	307.10
Paddy lands	5.20	102.20
Irrigated uplands	0.03	48.80
Rain-fed lands	34.10	156.10
Waste lands	133.40	17.42
Forest lands	11.30	390.40
Others	2.30	5.48
Cultivated lands holding (ha/hsd)	0.46	0.84
Major crops	Rice, watermelon, sweet potato corn/maize, groundnut, beans and chilli pepper	Rice, wheat, corn, soybean, rapeseed, sunflowers, vegetables
Cropping systems	Rice + vegetables, vegetable + maize, and/or fruits / maize sweet potato + seeds watermelon	Rice + rapeseed, corn + rapeseed or other oil seed soybean / corn, Rotation between vegetables, watermelon + rapeseed
Net income (USD/capita)	17.7	175.75

Table 2. Average yields of major crops in the benchmark watersheds (kg ha^{-1})

Crops	Xiaoxincun	Lucheba
Rice	6,000	6,000~7,500
Corn	3,000~4,500	5,000~7500
Sweet potato	12,000~15,000	—
Rapeseed	—	1,125~1,875
Watermelon	8,000~10,000	30,000~45,000
Seed-watermelon	750~1200 (seeds)	—
Potato	—	15,000~22,500
Groundnut	1,650~1,800	1,500~2,250
Sunflower	—	375 (intercropping)
Pigeon pea (pods)	450	—
Soybean (pods)	4,500~7,500	375 (intercropping)
Chinese cabbage	—	60,000~75,000
Tomato	70,000~90,000	45,000~75,000
Chilli pepper (fresh)	30,000~45,000	15,000~22,500
Beans	9,000~15,000	—
Onion	4,500~ 6,000	—

Xiaoxincun Watershed

Xiaoxincun watershed, a natural village of Jinlei village group, Julin town with the total area of about 186.7 ha is located in the middle-north of Yunnan Province belonging to Yuanmou County, Chuxiong Yi Minority Autonomous Prefecture.

Xiaoxincun watershed is about 1 km away from Longchuanjiang river, an important branch of Jinshajiang river, which is the first body-river of Yangtze river and passes through Yuanmou County in the north part from the west to the east. Qinlinghe river, the first order branch of Longchuanjiang river is also very close to the project watershed. Due to erosion, huge gullies have developed in the watershed. These gullies cover 71.45 percent of the total land area. According to statistics (1990), the average soil erosion modulus of Yuanmou was 43.33t ha^{-1} yr^{-1}, highest in Yunnan province.

Xiaoxincun watershed is a typical hot-arid valley area with slopy lands of hills and the altitude of 1068-1100 m asl. Due to fohen winds the climate is dry and hot with plentiful sunshine. During 1956-1990, the annual average temperature was about 21.9°C, annual mean rainfall 612.3 mm, annual mean evaporation 3600mm, average relative humidity 32 to 70 percent; and the average annual sunshine hours up to 2766. In the last 6 years (1997-2002), the annual average rainfall increased to 781mm.

Xiaoxincun is a new village, which emigrated from the semi-montane area in 1965 due to severe drought. All of the population which is Yi people is of 25 minorities in Yunnan Province.

As shown in Table 4, farmers' per capita net income in Xiaoxincun watershed is much lower than that of the farmers in the whole country and those settled in the irrigated-land areas. Moreover, of the total gross income of about 138 USD per capita, 46.4 percent come from off-farm work and open grazing livestock rearing.

Lucheba Watershed

Lucheba watershed is located in middle-low hilly areas, centre of Guizhou province and belongs to Karst landform. The average altitude is about 1350 m above sea level. The annual average precipitation is about 1200 mm and average temperature of 13.8°C. The soils in the watershed belong to yellow soil, paddy soil and limestone soil groups. The watershed is located near the branch of Yangtze river.

After the selection of these benchmark sites, participatory rural assessments (PRAs) were conducted at both the sites to identify and prioritize the constraints. Table 3 gives various constraints at both sites.

Table 3. Constraints for crop production at benchmark watersheds

Xiaoxincun	Lucheba
Soil erosion	Poor transportation
Low rainfall and water scarcity	Stone exposing (Krast)
Huge gullies, expanding	Water scarcity
Soil degradation	Small land holding
Small land holding	Low literacy
Low literacy	Poor income condition
Poor income condition	
Diseases and pests	

The income of farming households in these benchmark watershed are very low as compared with the national average, in spite of the fact that farmers are getting very high crop yields (Table 4). The agriculture output in the watersheds depends primarily on the holdings of irrigated land. Fox example, in Xiaoxincun watershed, paddy land holdings control the income of farming households because of the high profits of off-season vegetables grown in paddy lands in autumn and winter. The main reasons for low income are: (i) small land holdings, (ii) high inputs on fertilizer and farm chemicals to their crops, and (iii) undependable off-farm jobs. In order to improve the income of the poor farmers on sustainable basis, alternative options are needed like growing more of cash crops, such as vegetables, fruit crops, etc. Since most of the cultivated lands are rain-fed, more water is needed to grow alternative crop options. Therefore, rain water harvesting and its efficient utilization is a top priority. Secondly, in order to check the soil erosion and land degradation, interventions are needed. Both these can be achieved through an integrated watershed management.

Table 4. Gross incomes of farming households (USD/capita per annum)

Income	Xiaoxincun (Gross)	Lucheba (Gross)
Farming	73.8	137.2
Off-farming	30.5	18.3
Livestock raising	33.5	27.4
Total	137.8	182.9

Interventions

Xiaoxincun Watershed

Community groups and farmers activities: In August 2003, three community groups were set up, namely, scientific group, women group and leading people group, and each group composed of 5 members: 4 farmers and 1 researcher from the project.

In spite of various constraints to access all the farmers, farmers' activities at the level of community groups or households or individuals have been quite satisfactory from the beginning.

Rain water harvesting: With the participation of all the 86 households an agreement has been made to repair and make use of the existing three water tanks as well as the channel system to harvest the rainwater. The costs will be shared 50% each by farmers and the project. Channel system construction shall be completed in 3 months. The project will also facilitate to construct small water tanks in volunteer farmers' fields to use the harvested rainwater. In order to improve the water-use efficiency of harvested water, drip irrigation system will be evaluated in 10 farmers' fields.

Crop diversification: Crop diversification mainly focussed on home yard-horticulture. After more than 15 years of on-station research, jackfruit as a long-term profit crop and papaya as a short-term profit crop were planted in farm households. So far, three advantages have been supporting yard-horticulture in the watershed. Firstly, it can enhance the use-efficiency of water from open wells in farmers' yards. Wastewater from household activities was used in the yards, to irrigate the horticulture plants. Secondly, fruits, particularly short-term profit fruits can improve very quickly the nutrition level of the households, for example vitamins, and/or give more options to make marketing profits. Finally, yard-fruit-tree, especially, those arboreal trees like jackfruit in every household can provide shading for farmers' houses as well improve the environment of the village.

Crop variety evaluation: Major crops in the watershed are sweet potato and watermelon. The farmers have used very few varieties for long time causing crop degradation characterized by declined resistance to disease and pests, low yield and poor quality of the products, less marketing condition, and finally low income from farming. After three years of research in the station of ITSCC, new varieties of watermelon, muskmelon and sweet potato are introduced in farmers fields. In spite of the extreme drought conditions last year, the result showed good performance of all the sweet potato varieties. However, muskmelon and watermelon varieties did not perform well.

Integrated plant protection management: As previously mentioned, high cost of farm chemicals is one of the major reason for low income of the farm households. Crops resistance to disease and pests has declined in the watershed even in the whole eco-region. Furthermore, frequent droughts exacerbate this problem. Integrated plant protection management (IPM) is adopted with bio-pesticides, e.g., tobacco waste extract is being evaluated on watermelon and rice on 20 farmer's fields covering an area of 0.67ha. It was used in rice with three methods: (i) put in with basal fertilizer; (ii) extracted and sprayed on crops; and (iii) dissolved at the entrance of water in paddy fields. Only basal fertilization with the wastes was tried on watermelon. The results from all trials of pests control on rice and watermelon are very encouraging. Rice paddy borer and rice hopper were completely under control. Damages by soil insects on watermelon such as cutworm, white grub, wireworm and ground beetle, etc. were reduced to the extent of about 50 percent. Encouraged by this performance, farmers want to try this pesticide also on their vegetable crops.

Also, 4 light-traps have been installed which cover 4 ha paddy lands used for vegetables production during autumn and winter. This method has been approved as an efficient countermeasure against insects in this eco-regional scale during the past three years.

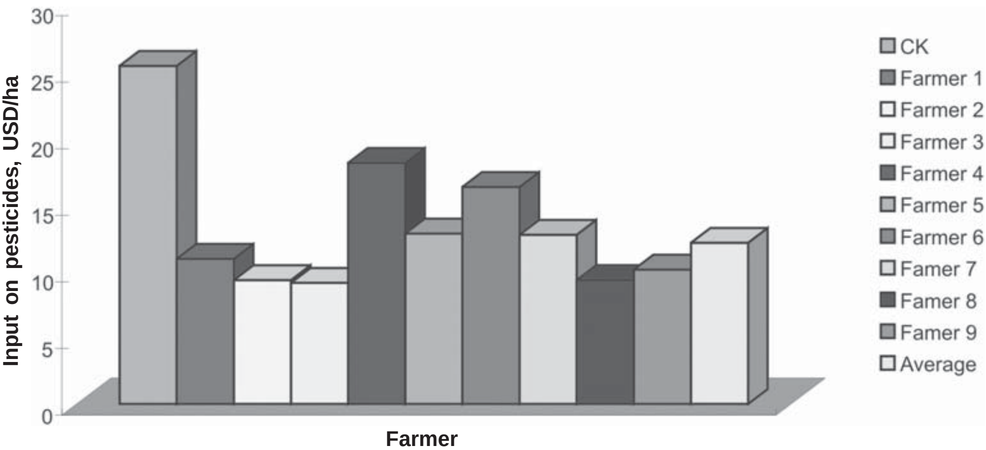

Figure 1. Input on pesticides for rice protection by using tobacco wastes bio-pesticides (USD/ha)

Forage crop evaluation: Overgrazing is considered by scientists and extension staff as the crucial factor contributing to land degradation and soil erosion in this eco-region. Stall-fed animal raised for land conservation was proposed and demonstrated by the project. Although this approach is gradually accepted by some households in the watershed but it gives rise to the shortage of appropriate forage supply. In the past five-year-on-station research and some extension cases several perennial forage species like *Panicum maximum* cv Reyan No 9, Neonotonia wightii spp. *Stylosanthes guianensis* cv Reyan 2, *Cajanus cajan* cv. spp. have been found to have good yield and quality. These species are major fodder resources in summer, autumn and winter, and annual *Medicago sativa* cv. sandili as an option of supplementary fodder in late winter and early spring have been planted in 5 farmers' fields. *Panicum* is also planted on hill slope to check soil erosion.

Gliricidia: Gliricidia was introduced into the watershed as an attempt mainly to provide more green manure to the degraded soils. Long-term surface soil loss, leaching, severe drought and continuous cropping result in severe soil degradation. *Gliricidia* was planted on farmers fields as field bunds and cross-slope intercropping. It was also planted on the sides of a live gully inside the farming field. The performance in all plots was very encouraging.

Training of farmers and leaders: Traditionally, cash crops especially fruit trees were not planted in the watershed due to the shortage of water. Since more open wells were constructed, some fruits and vegetables have been introduced into the watershed. *Zyziphus,* a popular fruit crop in places under appropriate irrigation condition in the eco-region has shown wonderful profit but nobody tried it in Xiaoxincun watershed till 2001. Two farmers grew this fruit crop on the irrigated upland and produced the pleasant results. Since 2003 about 20 farmers successively followed. However, their hopes are frustrated by high input, low yields and inferior quality of the fruit. Also, watermelon, especially, seeds watermelon has brought supportive income to the farmers in the past five years. But the profits have been declining due to disease and pests. In order to encourage these alternative crop options, the project took up the responsibility for training farmers and leaders on *Zyziphus* and watermelon crop management.

Lucheba Watershed

Drip irrigation: Besides introduction of forage crops (alfalfa, ryegrass, buckwheat) and providing balanced nutrition to all the crops, drip irrigation was demonstrated in Lucheba watershed. Several small size water tanks were constructed near farmlands to store water in dry season and harvest rainwater for supplementary irrigation. Each tank can store 3 cubic metres' water, which can be supplemented. About 2.5 ha of upland were protected against drought, that seriously affected yield of upland crops.

Road construction for transportation: Under the support from township government, a 4-metre wide, 1.7 km-long road was constructed for transportation to the market. Farmers put more hopes to the road construction for better movement and marketing of agricultural produce. Another road construction took place under the project support. It is about 1.5 km long, 4 metre wide connecting Zhangjiaba village to main highway (total is about 3.5 km). Cost of road construction was equally shared by farm households and the project.

Alley cropping: Alley cropping is a sustainable technology for sloping lands and was introduced by IWMI project and expanded at many places of Guizhou province. This technology could effectively control soil erosion and increase income on sloping land. After discussions, farmers selected the hedgerow crops themselves. Farmers preferred peach+ wild buckwheat or pear+ wild buckwheat. The fruit tree will have high income and the wild buckwheat is a good forage grass for raising pigs. Total 261 peach and 259 pear trees have been planted and 49 kg of wild buckwheat seedlings were transplanted at the Liujiazai village of the watershed.

Farmers' training: Keeping in view the farmers interests, following three trainings were held at the watershed:

- 50 farmers were involved in the low-pollution vegetable production.
- 57 households participated in the training on solid-media rice seedling techniques. Due to serious drought last year, the water level at the reservoir declined and many farmers did not have enough water for rice seedling. Experts from GAAS suggested farmers to adopt this technology and about 15.6 percent of total households in the watershed accepted it. This technology was helpful not only in saving water at rice seedling stage, but also produced higher rice yield by avoiding cold weather effect at rice flowering stage (the disaster takes place every year and about 10-70 per cent of yield is lost).
- 100 farmers got trainings on technology of fruit tree plantation and management, contour alley fruit trees cropping, varieties selection, and other management technologies.
- 150 farmers took the courses on forage selection and planting. Most of the farmers showed great interest in selecting suitable varieties for their farmlands.

Author Index

Our vision is that in 2008, IWMI is a world-class knowledge resource center on water, food and environment. It generates knowledge on better water and land management in developing countries, through strategic research alliances with a set of core partners throughout Asia and Africa, and with advanced research institutes in developed countries.

This knowledge is held and maintained as global public goods for the benefit of mankind.

Watershed Management Challenges

Improved Productivity, Resources and Livelihoods

Edited by

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Watershed management has emerged as a potential concept, which harmonizes the use of natural resources for their long-term sustainability and optimal productivity. It has also been accepted as a sound development paradigm by the local governments and donor agencies for upliftment of the rural masses living in rainfed and fragile ecosystems. Though sound on hydrological and biophysical principles, the approach is confronted with several challenges related to equity, effective participation, scaling-up, water rights, conflict resolution, cost sharing and subsidies, public and private gains and crafting of suitable policies and institutions. This publication is an attempt to effectively address these and related issues from scientific, socio-economic, institutional and policy perspectives through integration of Indian and international knowledge and experience.

This book is also an attempt to broker the Indian and international experiences on watershed management to the researchers, policy makers, donors and program implementing agencies in the African continent. It will be of significant interest to those working in the areas of hydrology and engineering, land and water management, development studies, knowledge management, and policies and institutions.

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