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Restoring lands and livelihoods in rain-fed areas through community watershed management

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Ensuring food security and reducing poverty for a global population that will grow to 9 billion by 2050 is a challenging task.[1] Increased food production has to come from available, limited water and land resources.[2] Water scarcity is acute, particularly in developing countries like India, China and Thailand where population pressure is high, physical scarcity of water is expected and countries are struggling to eradicate poverty and improve quality of life.

Blue water availability in most of the river basins is declining as available water resources are already allocated among various sectors and no scope exists to harvest it further.[3,4] Moreover, significant uncertainty is arising on future water and food availability due to increased vulnerability of drylands. Extreme events like flash floods or longer dry spells; more dry or wet years; temperature change and pest/disease infestation are among the characteristics driven by climate change.[5] Use efficiency of land and water resources must be enhanced, especially in rain-fed systems which hold huge untapped potential to address present and future food security.[6,7,8,9,10]

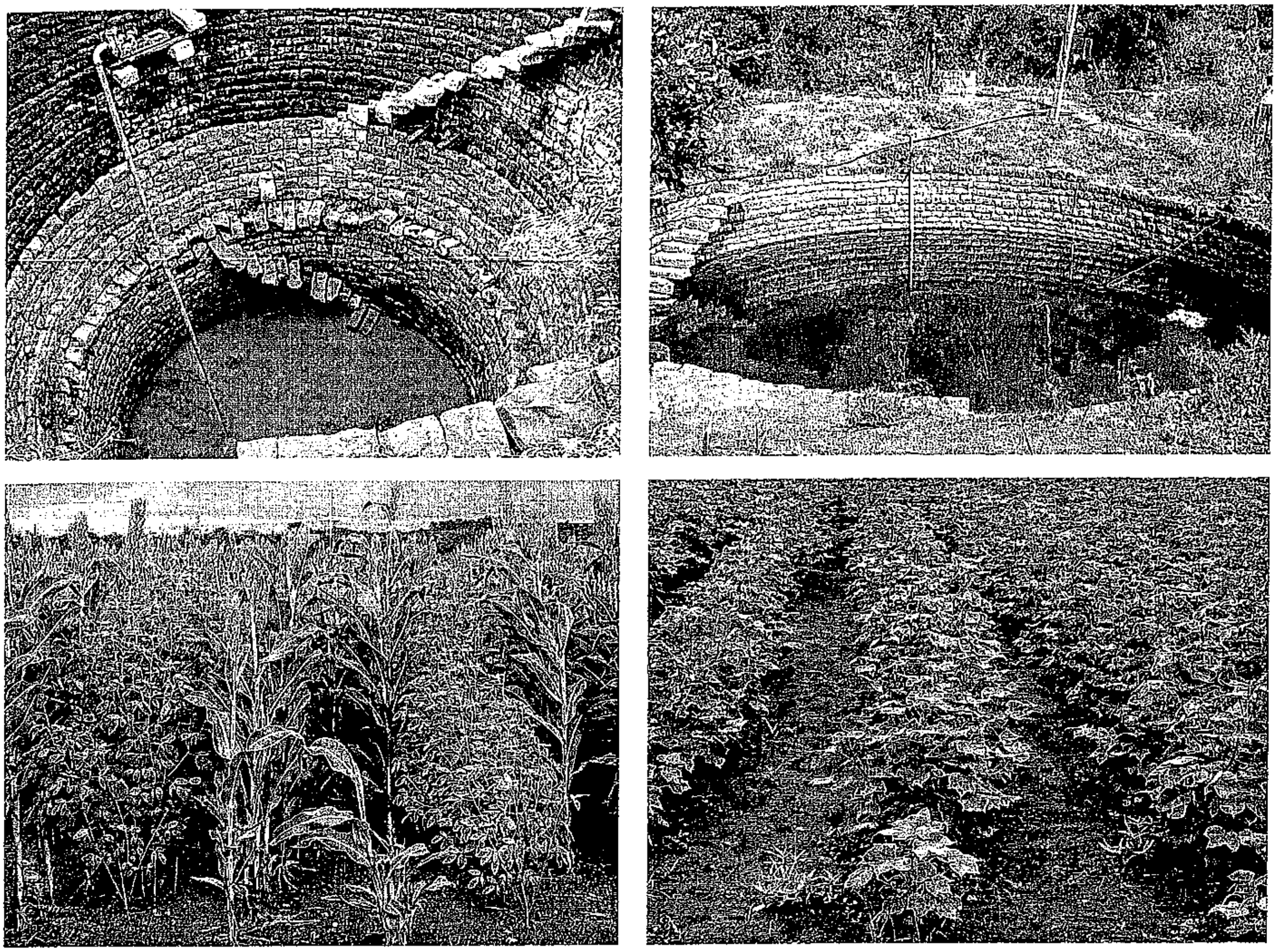
A large percentage of rural families in Asia (60 per cent) and Africa (70-80 per cent) is largely dependent on agriculture and allied sectors. There are a number of challenges such as fragmentation of farmlands, low crop yields, water scarcity, land degradation and inability to access credit and markets.[11] However, crop productivity of these farms is two to five times lower than the achievable potential. Per capita availability of land is declining continually with the growing population.[12] Further, most of the cultivated lands as well as common property resource lands are degraded and continue to degrade further, particularly in Asia and Africa. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and its partners have been working to develop various natural resources management technologies to bridge the yield gaps and to harvest the potential of rain-fed areas since 1976. For example, various *in-situ* and *ex-situ* soil and water conservation technologies to enhance/maintain land capability and green and blue water availability were developed at farm and community scale; their suitability was evaluated for different soil types and cropping systems; and they were demonstrated through on-station research experiments at ICRISAT and on-farm farmers' participatory trials along with consortium partners.[8,9,10] Based on the lessons learned from different evaluation studies, an ICRISAT-led consortium has developed a farmer participatory integrated watershed management approach adopting a holistic integrated genetic and natural resource management strategy to increase productivity, production and profitability through building partnerships. ICRISAT later expanded and strengthened the Inclusive Market Oriented Development strategy to link smallholder farmers to markets and ensure profits through innovative collective action using new information and communication technologies.

ICRISAT and its partners have established sites of learning (500-2,000 ha scale) in different rainfall and ecological regions, demonstrating the potential of rain-fed system through an integrated watershed management approach. The following case studies from India, China and Thailand represent different ecosystems, demonstrating the suitability of the integrated watershed management approach to minimize land degradation, overcome water scarcity and harness the potential of rain-fed agriculture in Asia.

Adarsha Watershed, southern India

The Adarsha watershed in Kothapally is located in the Shankarpally mandal of the Ranga Reddy district of Telangana (previously Andhra Pradesh). Before 1999, this village suffered acute water shortage, land degradation and poor agricultural and livestock productivity. Eighty per cent of its 462 ha of agricultural land was rain-fed with a monocropping system. The main crops were cotton, maize, sorghum and pigeonpea with productivity of 1,000-1,500 kg ha^{-1} of sorghum/maize and 200 kg ha^{-1} of pigeonpea. There were 62 open wells. Most of these dried up soon after monsoon and the women walked 2-3 km to fetch drinking water from February until the monsoon arrived.

At the request of the district administrator and the government Drought Prone Area Programme, ICRISAT and its consortium partners (the Government of Andhra Pradesh; MV Foundation, a non-governmental organization; the Central Research Institute for Dryland Agriculture; and the National Remote Sensing Agency) started implementing watershed technologies between 1999 and 2004. Various soil and water conservation practices, productivity enhancement, crop diversification and intensification work along with knowledge-based entry point activities were introduced. Groundwater availability increased from 3.5 m to 6.0 m due to various soil and water conservation interventions. Due to increased availability of water resources, the entire watershed transformed from degraded to more productive. Cropping intensity increased from 85 per cent to 150 per cent and large numbers of farmers shifted from low-value crops to high-value crops (Bt. Cotton and vegetables). Average crop yields of sole maize increased by 2.2



Images: ICRISAT

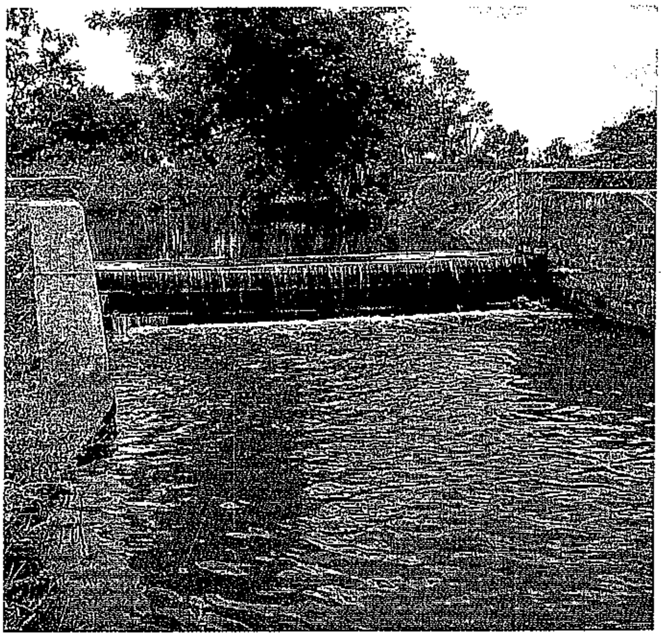
Top: Post-monsoon water levels in one of the wells of Adarsha watershed, (left) before and (right) after the watershed intervention
Bottom: Farmers in the Adarsha watershed adopted intercropping as an improved management practice and many moved to high-value crops such as cotton

to 2.5 times (3,800 kg ha^{-1} compared to 1,500 kg ha^{-1}); intercropped maize pigeonpea with improved management produced 6,000 kg ha^{-1} compared to 2,900 kg ha^{-1}; and pigeonpea yields increased to 900 kg ha^{-1} against 200 kg ha^{-1} in 1998. Moreover implementing such interventions has strengthened a number of regulating and supporting ecosystem services such as reduced soil loss (10 t ha^{-1} to 2 t ha^{-1}), reduced surface run-off (30-40 per cent), increased base flow, improved water quality (pesticide residue-free), increased green cover and carbon sequestration.

Parasai-Sindh, central India

The Parasai-Sindh watershed, comprising three villages covering 1,250 ha, was developed as a benchmark site in Jhansi district of Bundelkhand, being a hot spot of water scarcity, land degradation, poverty and vulnerability to the impacts of climate change. This watershed receives nearly 850 mm of rainfall with about 85 per cent from June to September. Agriculture and allied sectors are the main sources of livelihood for the rural people in this region who are largely dependent on groundwater resources for domestic and agricultural use. Due to hard-rock geology, groundwater recharge mainly takes place in shallow and unconfined aquifer which is characterized by poor specific yield. Water level in open/dug wells depletes very fast after the monsoon and communities suffer from water scarcity especially in summer. Women and girls were spending significant time and energy collecting water for domestic use, while men would migrate to nearby cities in search of livelihood during and after the monsoon. This left women and livestock further exposed to a number of socio-economic stresses and exploitation.

From 2012 onwards, ICRISAT along with national partners, Central Agro-Forestry Research Institute (CAFRI), district administration, government of Uttar Pradesh and local community started implementing watershed interventions in Parasai-Sindh watershed. Regular interactions with the community contributed to a strong trust resulting in effective planning and implementation of watershed activities. The village and the watershed committees identified potential locations where different soil and water conservation practices such as check dams and gully control structures could be made. *Ex-situ* water harvesting structures together developed 125,000 m^3 of storage capacity by the end of June 2015. Through state-of-the-art monitoring, it was estimated that these structures harvested around 250,000 m^3 of surface runoff and facilitated groundwater recharge in every monsoon season with the groundwater table increasing on average by 2.5 m compared to non-intervention stage. This has increased cropping intensity



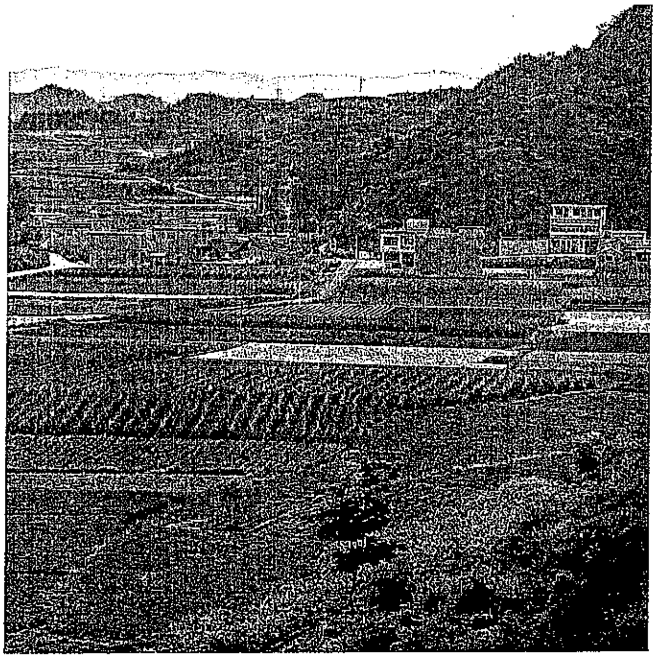

Parasai-Sindh watershed, Bundelkhand region, central India: (left) over and base flow from a check-dam indicates increased groundwater and surface water availability; (right) farmer cultivating vegetable as cash crop

by 50 per cent especially during post-monsoon season (*rabi* season). Productivity of post-monsoon crop especially wheat has doubled after the watershed interventions. Wheat yield before the watershed interventions ranged from 1,500 to 1,800 Kg ha^{-1}. Despite the good establishment of crop, there was high chance of crop failure due to depleted water resources between January and February and supplemental irrigation was not possible due to drying wells. After implementing the watershed programme, farmers began harvesting wheat yield ranging from 3,000 to 4,000 kg ha^{-1} resulting in significant improvement in their income and livelihood. Farmers have shifted cropping pattern from low-income crops (chickpea and mustard) to high-income crops (vegetables and wheat) and fodder availability has increased significantly. Agro-forestry has strengthened by promoting tree plantation on farm bunds and wasteland with community participation. Improved varieties of chickpea and wheat were introduced and crop yields increased from by 30 to 50 per cent. In addition, various income-generating activities such as vermicomposting, nursery raising and other micro-enterprises helped farmers to earn additional income. Watershed interventions enhanced average annual family income from 50,000 INR (US$830) to 125,000 INR (US$2,080) in a period of three to four years clearly indicating the potential of science-led interventions to address the food security and rural livelihood issues in drylands.

Lucheba, China

Lucheba village in Pingba County, Guizhou province in southern China comprises a cluster of six villages with 340 households and 1,373 people. It was selected in 2003 for integrated watershed interventions by ICRISAT and its partners. Before this, the cropping system was largely maize, rice, soybean, sunflower and rapeseed. There was high pressure on women as they had to travel long distances to fetch drinking water due to water scarcity even for domestic use. Migration levels were high as people sought other livelihood options and men were largely engaged for labour work in the construction sector. In 2003, based on discussions with the village communities, two drinking water schemes were undertaken as an entry point activity with project funds and partial contributions from villagers. Spring water from the hilltop was tapped and brought down to the village through a pipeline system. Further watershed interventions such as soil and water management, improved cropping systems, crop diversification, integrated nutrient and pest management practices, along with other income-generating activities such as poultry and pig rearing, were introduced. Altogether 151 rainwater harvesting/irrigation water storage tanks of 5 m^3 capacity were constructed; nearly 133,000 trees were planted on 100 ha of wasteland, and a 4.8 km village approach road was built from the main road. Later a 6 km-long field road was also constructed with government support. Crop diversification was undertaken with high-value vegetable crops. More than 260 biogas plants were set up in village households to reduce pressure on fuelwood and protect the forests. Micro-enterprises for women were promoted along with forage production on bunds.

Watershed interventions completely transformed the livelihood of the people. Average annual income from agriculture has increased threefolds (from US$500 to US$1,650). The benchmark crops (rice, corn, rape, soybean, sunflower and kidney bean) were replaced with high-value crops like watermelon and vegetables like tomato, pumpkin, cabbage, chilli and eggplant using hybrid seeds and improved agronomical practices. Lucheba now boasts two animal health centres, an Internet-enabled farmers' training centre and one Vegetable Growers' Association. The whole village currently has biogas-powered street lighting. The migration level has been drastically reduced and those who had migrated to cities have returned to villages as the quality of life is better than the city with more opportunity to work in the village itself. The village's average per capita income is twice that of the province.



Images: ICRISAT

Lucheba watershed, China: (left) the landscape shows a large area under vegetable and cash crops; (right) Scientist observing staked tomato plants

Tad Fa, Thailand

Tad Fa watershed is located in Phu Pa Man district in the Khon Kaen province of Thailand. It was developed as benchmark site to address the issues of land degradation and poor agricultural productivity in 2003. The Department of Agriculture, the Land Development Department, Khon Kaen University and ICRISAT, along with the rural community, formed the consortium for implementing the programme. The watershed receives a good amount of rainfall (1,300 mm) but due to uneven distribution and lack of water harvesting structures, the village was suffering water scarcity even during the monsoon period. Nearly 80 per cent of the total agricultural area was rain-fed, having one crop per year. Farmers in upland areas with high to medium slopes were cultivating maize along the slope (up and down cultivation), triggering heavy soil erosion, as well as cash crops and rice on the lower lands for domestic use. The watershed faced severe soil erosion and crop productivity was declining year by year due to land degradation.

Several soil, water, nutrient and integrated crop management interventions were introduced in 2003. In consultation with the farmers, the Land Development Department constructed 17 farm ponds each of 1,260 m^3 storage capacity to facilitate supplemental irrigation to crops, fruit trees and vegetables, particularly in the post-rainy season. Field bunds were constructed along with vetiver grass largely in uplands. Sowing through hand dibbling was promoted on steep slopes; and cultivation using tractor-mounted implements was promoted in farms with moderate to mild slopes. About 70 per cent of the area was promoted under contour cultivation. Relay and sequential cropping systems were promoted to use green water efficiently and improved varieties of seeds were introduced. Fruit tree cultivation was promoted and improved plantation methods were introduced to enhance the land and water use efficiency.

Maize yields increased by 30-40 per cent compared to the conventional system due to the increased availability of green water resources. Surface run-off (60 per cent reduction) and soil loss (40 t ha^{-1} to 8 t ha^{-1}) were reduced drastically and crop productivity increased. Areas under fruit tree cultivation increased in and around Tad Fa watershed within three years of the project implementation. This has helped in controlling soil erosion and provided better and more sustainable income to farmers which significantly contributed to enhancing rural livelihood.

The way forward

Integrated watershed management is an important strategy for strengthening resilience to drought, especially in uplands which are hotspots of poverty, water scarcity and land degradation. Soil and water conservation practices have resulted in higher groundwater recharge which enables supplementary irrigation of the monsoon, bridging of dry spells and scope for irrigation of a second dry-season crop. Moreover, *in-situ* water harvesting has resulted in enhanced green water use efficiency in rain-fed agriculture. Productivity enhancement, crop intensification and diversification further helped farmers to utilize available resources effectively and earn more. Watershed interventions are also helpful in strengthening various ecosystem services such as reduced nutrient and soil loss, which is expected to have positive impacts on in-stream river ecology and run-off generation for other downstream water uses. Under the changing climatic scenario with reduced annual rainfall and higher rainfall intensities, watershed development programmes are increasingly important for securing agricultural yields in upland areas to achieve food security and improve the livelihoods of small and marginal farmers and, most importantly, for building the resilience of systems to the changing climate. Scaling-up of these initiatives is urgently needed to achieve the desired level of impacts and outcomes for food, nutrition and water security for the growing population through sustainable development.