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Institutional History of Watershed Research: The Evolution of ICRISAT's Work on Natural Resources in India

International Crops Research Institute for the Semi-Arid Tropics

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Abstract

In recent years international agricultural research centers had to respond to changed mandates with a more explicit focus on poverty reduction and environmental sustainability from an earlier focus on improved agricultural productivity. Natural resource management (NRM) research has been an important area that has witnessed several institutional changes within the CGIAR system for the fulfillments of these goals. Most research centers have sought and promoted innovations through concepts such as participatory research, partnerships and alternatives to the transfer of technology approach. In this report we argue that while these changes have indeed contributed to a greater poverty focus of the CG centers, there is a greater need to understand the practice of science amongst these centers and the underlying institutional constraints that hinder or enhance learning in the proposed transition of these research centers into learning organizations. In this study the institutional history of a CG center has been used as a tool to promote institutional learning and change. It demonstrates that research managers in the CG system have not adequately accessed the institutional innovations of its own scientists in facilitating changes under newer mandates. By tracing the various ups and downs of ICRISAT's thirty-year involvement in NRM research, this report points to the need for greater sensitivity in research design towards institutional constraints that prevent faster learning and the need for evolving mechanisms to enable real time learning in projects.

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Introduction

There is an increasing realization that traditional transfer-of-technology approaches to agricultural research can no longer keep pace with the complex, diverse, risk-prone and dynamic realities of poor farmers. Recent research on the poverty alleviating impacts of technology associated with the Consultative Group on International Agricultural Research (CGIAR or CG) has identified institutional learning and change as a key area for intervention if research is to be more efficient and pro-poor and has pointed to the need for research centers to transform themselves into learning organizations (Watts et al. 2003). This report uses institutional history as a tool to promote institutional learning and change. Institutional histories with their emphasis on inclusive narratives of technical and economic change and sensitivity to tacit lessons can lead to greater opportunities to learn from past successes and failures and thus future interventions can be designed in more effective ways. This report, a case study of watershed-based development initiatives at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), seeks to reveal the way scientists and development practitioners work and are shaped by the diversity of partners involved and thereby draw process lessons for ongoing and future work on watersheds in international agricultural research centers (IARCs).

The watershed work at ICRISAT in recent years has become one of its most visible activities with impact over several locations in the SAT (semi-arid tropics) region.[1] It is seen as a 'flagship project of the institute' and reflects a new organizational culture of strategic and applied research involving a large number of stakeholders under a common platform.[2] However, what has not been sufficiently understood is the evolution of these activities over a long period that is as old as the institute's history. In fact the earlier work does not figure in recent writings on NRM (natural resource management) research in the CGIAR. The Technical Advisory Committee (TAC) in its review of NRM in the CG centers views the development of the NRM concept as a phenomenon of the 1980s (TAC 2001).

This study traces the evolution of the watershed work at ICRISAT arguing that the present activities need to be seen as part of a larger narrative of several innovations, not all of them successful, by scientists over a thirty-year period. In fact the study shows how scientific organizations rarely forefront many of their institutional innovations in the same manner as they do for technical innovations. We argue that the work on watersheds has lessons not only for the scientists in watershed work but also for the larger scientific community both at ICRISAT and elsewhere relating to the nature of the public goods mandate of an international agricultural organization and the way this mandate is understood and shaped in practice. The institutional history shows that despite pioneering several innovations an excessive technical emphasis hindered learning of valuable lessons on processes and ICRISAT played a larger role in the evolution of NRM concepts in CGIAR. These process lessons are often generic and relate to problems of working in multidisciplinary teams, of negotiating a balance between strategic and applied research, of providing solutions for and impacts on SAT farmers in the locality where it is situated and yet maintaining an international focus, and to questions relating to the mandate of an international organization in an environment like India with a large national agricultural research system (NARS). To each of these broader questions the watershed work at ICRISAT has experiences to offer for analysis and understanding.

1. ICRISAT was established in 1972 and is one of the fifteen research centers across the globe that is part of the CGIAR. ICRISAT has its headquarters in Patancheru, India with regional hubs in Western and Central Africa (Niamey, Niger) and Eastern and Southern Africa (Nairobi, Kenya). This report, however, is restricted to developments in India.
2. Quoted in Dixit and Wani (2003).

The watershed work also provides a context for reflection on the role of social sciences in an international research organization. The conventional policy discourse in the social sciences with its strong economics tradition has lacked the tools to examine issues of process. The role of tacit learning and the importance of reporting failures are often inadequately appreciated. Ex-post evaluation of impacts of technology have contributed little to making agricultural research organizations less isolated and more connected and to be in closer touch with field realities and be able to learn better and change. There is a need for perspectives and analytical tools to construct a more rounded understanding of scientific practice especially in appreciation of those activities and processes that are not easily quantifiable. On one hand social science research needs to inform research design by reflecting on institutional learning and change and suggesting meaningful ways of collaboration with natural science scientists. On the other hand it also needs to aid critical reflection on the roles and the mandates of IARCs especially in their understanding of the innovation chain.

The approach for this study has been to use tools of science studies that have questioned the treatment of science as a black box of inputs and outputs. They have instead sought to unravel the black box by focusing on science as practice and analyzing the way scientists work. This has involved a combination of analyzing official documents (both technical and non-technical) at ICRISAT during the period with field visits to a few sites of research activity and interviews with scientists of the NRM team. This approach was preferred due to its greater analytic content and for the opportunities it provided for learning. It is worth mentioning here that the approach of institutional histories differs from process documentation in a few ways. Table 1 highlights some of the differences between the two approaches.

Table 1. Difference between process documentation and institutional history.

Particulars	Process documentation	Institutional history
Objective	Capturing or recording events and processes as they occur	Revealing development and evolution of institutional arrangements over time
Emphasis	Capturing the process, the official line	Recognizes existence of competing narratives and seeks to bring them together
Focus	Authenticity, facts	Learning, analytic content/different interpretation
Role of partners	Aligned with official understanding; hence, partners or collaborators view not included	Seeks to include viewpoint of all partners/ stakeholders
Seen as	Documentation of success, impacts and outcomes	Critical reflective learning
Time span	Short, particular event or project period or tenure of head	Long time spans, focus on pre-project and post-project institutional arrangements
Knowledge	Official or scientific knowledge	Tacit and institutional
Nature	Quantitative	Qualitative, drivers and constraints governing institutional development process
Methodology	Official records and interview with officials in the organization	This plus views and perspectives from outside through broader set of interviews and literature review
Users	Project or institutional leaders alone	All partners and stakeholders and people in similar circumstances

The report is divided into two sections. In the first section, the various phases of watershed activity at ICRISAT are charted. In this exercise greater emphasis has been placed on the earlier years as the recent phase has seen more documentation and analysis while the earlier phases of ICRISAT work have neither been sufficiently documented nor understood. In the second section the various phases of watershed work are summarized with discussions outlining key lessons and challenges for future work.

The thirty-year history of watershed work at ICRISAT can be broadly divided into five phases. The delineation of these phases is not meant to be chronologically rigid and is based on the thrust of the research activity of the period. There is inevitably some overlap.

Phase 1: Watersheds and Farming Systems – ICRISAT as a Pioneer

Watershed-based activity was initiated at ICRISAT through the Farming Systems Research (FSR) Program and indicates several significant institutional innovations that have hitherto been underreported within the organization. ICRISAT was the earliest of the CG centers to give formal recognition in its mandate to supplement research on individual crops with research into the integration of the various components of farm productivity, in terms of stable and socioeconomically viable farming systems. The constitution of research in the farming systems program at ICRISAT and the focus on watersheds is significant for two reasons. First, unlike the other programs that were essentially uni-disciplinary like plant breeding, biochemistry, entomology, plant pathology and physiology, the FSR Program was multidisciplinary right from the start. Second, unlike land development for research trials under other programs that involved disturbing the original lay of the land and soil profiles for creation of precision plots with irrigation, the watershed-based research (WBR) at ICRISAT consciously sought to maintain the natural terrain in its research work while using animals as the prime source of draft power. This made the watershed work closer to the actual conditions in a farmer's field in the SAT.

Heading the FSR Program were scientists from the Ford Foundation – Bert Krantz, an agronomist and Jacob Kampen, an agricultural engineer. In their earlier work, they had been exposed to conditions on India's black soils and it was their concern about the waterlogging problem in black soils, especially in Madhya Pradesh and Maharashtra that formed the basis of their research. Farmers of the region took only one crop in the *rabi* (postrainy) season and left the land fallow during the *kharif* (rainy) season leading to water runoff and severe soil erosion while the production of the dry season crop was limited by lack of moisture. Improper soil and water conservation and inadequate drainage, they believed, were the main constraints to farmers not growing a second crop. The watershed research work was thus aimed at developing a 'technology package' for black soils by demonstrating the feasibility of taking more than one crop. This would lead to increased productivity and also prevent soil erosion.

> "At ICRISAT we feel that land and water management, new varieties, cropping combinations, fertilizers, implements and other innovations should be presented to farmers in a coordinated package rather than as isolated inputs and fragmented knowledge. … To achieve a practical integration of technological innovations and sound practices, we have selected the watershed as a basic production unit. … Watersheds would be the focal point where new technology and innovations from ICRISAT and other programs will meet and be tested and demonstrated on a field scale." (ICRISAT 1974)

The use of the watershed as a framework for agronomic and NRM research and a pilot operational production unit was indeed a significant departure from the individual field and farm focus of almost all agricultural research centers then.

Work started in 1972 at the Patancheru campus to develop five natural watersheds on black soils (BW1 to 5) for complete monitoring of their water balance and erosion characteristics and intensive data collection on inputs and outputs of a wide range of cropping systems of variable compositions. These watersheds covered a total of 48 ha with individual watersheds between 3.6 and 19.1 ha. Out of the five, two watersheds would be maintained 'as is' while on another two (a third was added later), variations of different cropping patterns and soil/water management systems were to be simulated. The improved systems of farming were to be superimposed on the watersheds with the aim of developing 'models of approach' to farming systems for 'best use of soil, water and human resources'. Later three more watersheds were delineated (BW 6 to 8); they were primarily meant for operational-scale production research while the existing BW 1 to 5 were used for intensive experiments and observations especially on hydrological characteristics. Two watersheds, RW 1 and RW 2, were developed on red soils. A conscious effort was made to think in terms of integrated systems instead of a narrow focus on crop productivity improvement alone. This significant institutional innovation in the conception of research was followed up through research design that was sensitive to field-level constraints. Thus while the initial watershed development and tank construction was intensive using heavy farm equipment like tractors, scrapers and compactors, a conscious decision was taken to use only human and animal power in all subsequent farm operations. This was done to simulate actual field conditions on small farms in the SAT (ICRISAT 1973, 1974, 1975, 1976, Kampen and Krantz 1977).

One of the main technical interventions was the introduction of the broad-bed and furrow (BBF) system to control surface runoff and conserve soil and moisture that was based on the well-known concept of ridge planting and proposed as an alternative to the traditional bunding system in farmers' fields. It involved graded and narrow or broad ridges or beds separated by furrows with a grassed waterway and a possible runoff storage facility. These components were meant for effective soil and water management. Along with the BBF system parallel developments occurred in making an animal-drawn tool carrier known as the tropicultor, a versatile machine that could, with attachments, be used for harrowing, bed preparation, plowing, seeding, weeding and transporting the harvest. The evolution of the tropicultor was related to the need for speeding-up land preparation for timely planting and appropriate placement of seeds and fertilizer (Starkey 1988).

The watershed research on station showed promising results in comparison to traditional fields. Krantz (1981) reported a fourfold increase in rainfall productivity over traditional systems for a six-year period in the operational-scale watersheds. By the early 1980s, ICRISAT felt it had developed a 'Vertisol technology package'. The features of this package were summer cultivation (plowing land immediately after harvesting the postrainy season crop), BBF (for improved drainage), dry seeding (sowing crops before the monsoon rains), use of improved seeds and moderate amounts of fertilizer, proper seed and fertilizer placement, double cropping and plant protection measures (Ryan et al. 1982).

The translation of the promise indicated in the early work at ICRISAT into actual field potential seemed a natural step for the scientists and the management at ICRISAT. This, however, was no mere technical decision alone and involved the larger political economy of the SAT mandate and the emerging contextual environment of international agricultural research in India. Given the prevalence of an extensive NARS unlike in other parts of the world where CG centers operated, ICRISAT's institutional arrangement with the Indian farmer was to be through the NARS. Two very significant institutional initiatives were taken by ICRISAT in the later half of the 1970s that had a bearing on field-level activities concerning the transfer of technology of the watershed work. The first, the

"Village Level Studies" by ICRISAT Economists, started in 1975 that led to the socioeconomic characterization of certain groups of SAT farmers, provided a logical entry point for involvement in Indian villages. In fact the initial places for testing, adaptation and extension of watershed-based technologies were these study villages (Walker and Ryan 1990). The second was the commencement of two collaborative research programs with the Indian agricultural research establishment following initial discussions with scientists at the All India Coordinated Research Project on Dryland Agriculture (AICRPDA) coordinated by the Indian Council of Agricultural Research (ICAR) and the Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Dehra Dun in 1977.

Significantly, the work on resource management at ICRISAT provided the first opportunity for ICRISAT to be actively involved with the Indian NARS and the years of working together since represent an illustration of how scientists have had to negotiate cooperation for making their own work relevant and contemporary to the host country research programs. The farmer's 'field' was thus already shaped by these initiatives. Given the institutional arrangements then, ICRISAT scientists did not see a role for themselves in the actual selection of the location for field trials, a choice that was left to the NARS with its research centers and the state agricultural universities that were involved in the collaborative program. This resulted in the selection of some adaptive research sites and conditions where the resource management technologies could not be expected to express themselves in significant outcomes. This broader context needs to be appreciated before we look into the next phase of research at ICRISAT that sought to take the results from the proverbial 'lab to land'.

Phase 2: On-farm Trials of Vertisol Technology

ICRISAT's cooperative research with NARS on watershed-based technologies was on two themes. The first, 'Research on Resource Development, Conservation and Utilization in Rainfed Areas', was to test the BBF system of cultivation under several agroclimatic conditions and was implemented at Akola, Bangalore, Bellary, Hyderabad, Indore, Ranchi and Sholapur. The second, 'Hydrologic Studies to Improve Land and Water Utilization in Small Agricultural Watersheds', was started at Bangalore, Hyderabad and ICRISAT. In 1978, a preliminary on-farm research program on small watersheds was planned in the pre-monsoon period in cooperation with three agricultural universities and AICRPDA personnel. Three villages representing three different soil types, namely Aurepalle (Mahbubnagar district of Andhra Pradesh), and Kanzara (Akola district) and Shirapur (Sholapur district) (both in Maharashtra), where ICRISAT had collected baseline data for village-level studies were chosen for testing and possible introduction of the BBF system (ICRISAT 1978). As an international institute, ICRISAT did not have the mandate to take up extension activities directly, which was the responsibility of the existing state agricultural extension systems. ICRISAT, however, agreed to underwrite the scheme by guaranteeing farmers that yields would be at least double their normal profits. Inputs were made available to 19 farmers in the three villages.

The scientists realized in the first year that the number of experimental treatments of on-farm trials were too large with the cumbersome requirement of at least three replications for each treatment. This resulted in small plots and too much time – and land – was lost during field operations in turning animals and equipment. Farmers had thereby decreased their attention for the yield performance of successful treatments and at Kanzara they declined to participate. At Shirapur too the participation of farmers in the experiments was less than expected. Though the yields obtained with BBF technologies were generally higher than under the traditional system, none of the farms showed 'record' yields. Results on Alfisols (red soils) were discouraging and the suitability of BBF for Alfisols was uncertain.

In some areas participation of the NARS scientists in this research phase was less than expected because of prior commitments. Serious problems were also encountered in attempts to transfer new technology from the AICRPDA research centers – and ICRISAT – to the selected locations because of the dissimilarity of the agroclimatic environment on the farms compared to that of the adjacent centers. Scientists had clearly underestimated the time and effort required for verification, tailoring and extension of a technology, the 'technology introduction' period, and believed that the timeframe for the studies should be extended. Though the scientists realized the differences in performance of one system compared to another this does not seem to have changed the institutional environment of research as the reasons for the same – the 'why' – could not be determined from simple yield data alone. The first phase of on-farm collaborative experiments were completed by 1981 and scientists decided to concentrate on Vertisols (black soils) in dependable rainfall areas for their future work (Kampen 1980, ICRISAT 1981, 1982).

Consequent to the focus on Vertisols and building upon the experience of a similar soil type in the operational watersheds at ICRISAT where the maize/pigeonpea intercropping system had evolved as remunerative, it was decided to test this technology at Taddanpalle, 41 km from ICRISAT, on a 15.42-ha watershed with the Andhra Pradesh Department of Agriculture, the AICRPDA, Andhra Pradesh Agricultural University (APAU) and 14 participating farmers. The Taddanpalle experiment was to be used not only to verify the experience at ICRISAT with regard to the technology options but also to test the ability of the delivery systems to support the demands of the improved technology. It was to be a test of technical and economic performance of the options in real farm conditions (ICRISAT 1982). Subsidies in the Taddanpalle experiment were to be kept at a minimum and farmers were encouraged to use existing sources of credit. However, farmers were provided free of cost the wheeled-tool carriers and the improved implements that accompanied them, and provided assistance in the construction of a main drainage channel, in the use of power sprayers, in surveying of the watershed and in rodent control. ICRISAT provided intensive scientific and technical guidance to the project and a senior technician and field assistant were assigned full time apart from ad-hoc inputs from scientists estimated at a total of 1.4 person-years. Farmers also visited ICRISAT a number of times and ICRISAT guaranteed better returns than the traditional system. Farmers, however, could not be convinced to install the community drains required for watershed-based drainage and soil conservation. They also made their own choices on crops of which there were nine combinations. ICRISAT made calculations of rates of return that varied from 244% to 284% depending on grain prices; these outcomes compared satisfactorily with the experience on station (250%) (Ryan et al. 1982).

Thus all estimates pointed to a 'success' of the technology with the on-farm economic results closely matching the on-station results. Yet, the field reality was different. Despite encouraging agronomic and economic results during the first year of the project, seven of the eleven farmers decided not to continue with the technology package in 1982–83.[3] A study was therefore undertaken to ascertain the reasons for non-participation. The scientists believed that the overriding reason for farmers not taking a crop during the rainy season was the absence of field drainage but farmers' perceptions were different and varied. Farmers felt that the bullocks in their fields were not strong enough for the tool carrier and its attachment. The study also speculated on factors such as 'frequent visits by foreigners

3. It may be noted that the rather high failure in adoption of seven out of eleven that translates as 63.6% was not postulated against the rather elaborate calculations on rates of return.

in imported cars instilled greater expectation in farmers that they could extract a higher price to participate in the project' or to local factors such as the largest farmer strongly influencing his brothers to withdraw from the project (Sarin and Walker 1982). In short, the Taddanpalle experiment reiterated that the transfer of technology from the lab to the land was much more complex than what ICRISAT scientists had imagined. The selection of the site it appears was based on technical considerations alone. It did not involve knowledgeable partners who could have advised ICRISAT on places where there was a history of cooperation amongst farmers. Also, the project schedule did not include time for such consultation. Reflecting on the process with hindsight, a scientist remarked recently that 'the technical assistant had taken care of the village physical environment but not the social environment. The emphasis too was not on a real participatory approach, so when the organization withdrew the whole thing collapsed.' Another scientist remarked that the main focus of ICRISAT was more on evaluating the technology in on-farm research and not to make it a development strategy that required more continuous effort and involvement.[4]

Ideally it was possible for ICRISAT to learn from its first direct experience from the field, even if largely unsuccessful, and revise its approach to collaborative on-farm research and its conception of the technology development, adaptation and dissemination process. However, this would have meant more continuous and intense involvement in the field either at Taddanpalle or in some other location and this alternative was not persisted with. The institutional arrangements of the collaborative projects did not allow for it and the projections of the widespread suitability and impact of the technology package were optimistic. The cooperative projects with the concerned NARS institutions continued at several locations with the underlying assumption that the NARS had a superior delivery system and better access to the SAT farmer in India and hence more effective. Paradoxically, quite contrary to the outcome of the Taddanpalle experiment and despite not so encouraging results, the public projections of advantages of the technology created a continued demand for support to extension of watershed-based activities from other state governments.[5] Appendix 1 lists some of the not so successful cases of transfer of Vertisol technology from the field. These highlighted the difficulty of maintaining a BBF system, waterlogging as not a critical factor on many soils, problems with the tropicultor, difficulties in dry seeding, etc. Unfortunately, the separation of the field from the scientist both conceptually and physically meant that there was no mechanism wherein these critical field-level inputs could feed into improvements of the technology. Conceptually, the projection of a "technology package" did not encourage revisions and adaptation. It was also evident that in the package there was a lock-in to the hardware with the BBF linked to the tropicultor in all the places.[6]

Despite the 'failure' of the specific technology packages, ICRISAT's work on WBR had important effects on the thinking concerning agricultural development in a watershed context. ICRISAT organized three workshops related to watershed-based development in the early 1980s. Of these the workshop in 1983 was an innovative effort for it was the first time that banking and financial institutions were involved. This institutional innovation was in recognition of the critical role of credit in dryland farming. Nearly half of the 79 participants were from financial institutions, which ICRISAT believed would play a crucial role in the future watershed-based developments (ICRISAT 1984). The 'idea'

4. Interview with ICRISAT scientist in September 2003 and January 2004.
5. By 1984 tests were on at 28 locations involving 1406 farmers on 2122 ha. The governments of the states of Karnataka and Maharashtra were keen to push the watershed concept. Despite failure at Farhatabad in Karnataka, the Government took it up in other districts on 227 ha in 1983 and was keen to extend it to 1354 ha in the subsequent year. The state department of agriculture, Maharashtra had decided to select 5065 watersheds for future work.
6. The connection between the 'lock-in' to technologies has been pointed out by Robert Chambers, Institute of Development Studies, Sussex, UK (personal communication).

of watersheds moved to other institutions in India and ICRISAT contributed to it. ICRISAT was part of discussions with Indian government officials in the early 1980s and the participation of ICRISAT scientists in seminars such as those by the Indian National Science Academy led to the spread of the idea that rainwater management held the key to the development of dryland agriculture.[7]

The 1980s began to see a change in the organizational climate on NRM with multiple players. In the mid-1980s, ICAR decided to implement the findings of its dryland agricultural research in 47 model watersheds in the country. In 1984, the World Bank Pilot Project for Watershed Development in Rainfed Areas was initiated in Karnataka, Madhya Pradesh, Maharashtra and Andhra Pradesh. Karnataka was the first Indian state to constitute a "Dryland Development Board". ICRISAT could no longer see itself as the lone player pushing a technology package and had to see itself as part of a larger system. The 'field' was getting defined in various ways both nationally and internationally. With years of work in the area, ICRISAT could have been an important player; however, a fixation on technology packages overshadowed the real success of ICRISAT, which was in drawing attention to the importance of a watershed-based approach for sustainable farming in SAT regions. In the absence of an institutional mechanism to underline approaches as opposed to technologies, the research program at ICRISAT retreated towards on-station and strategic work.

Phase 3: Retreat to Strategic Research: Modeling for Generic Applications

Following the "failure" of the Integrated Vertisol Management Technology (IVMT), there was a reorientation of research priorities at ICRISAT with a shift away from on-farm research to the development of benchmark watersheds at ICRISAT as also a concentration on different soil types. In 1985, the FSR Program was renamed as the "Resource Management Program". There was a significant shift in emphasis from soil-centered to crop focused studies. It was felt that mechanisms were needed to tailor the components of technology more precisely. Computer models simulating physiological processes with environmental controls and site-specific statistical relations between treatment yields through these models were emphasized. Much of the research during the next decade was on developing "benchmark sites" and modeling (ICRISAT 1990).

The research program was clearly in need of change and reorientation given the adverse field results. However, the existing institutional arrangement and management views meant that the changes that were implemented were more in keeping with conventional research approaches involving on-station work with precision farms and mathematical modeling that traditional agricultural centers were used to. The retreat to on-station activities, however, also meant a separation from the on-farm setting. Simultaneously, there was a move away from continuous monitoring of farm and household activities in individual villages to periodic updating of records from benchmark sites. The new focus on adoption and/or rejection of ICRISAT technologies was in keeping with the new emphasis on impact assessment being propagated at all CG centers under pressure of donor agencies.

While some of these shifts could be traced to changes in external environments there was also significant opposition from within ICRISAT to the watershed-based work and associated research on

7. ICRISAT concepts of BBF found acceptance later in Africa and came to be known as "tie ridging". Within India, in the dryland project of ICAR the same concept was used as graded bunds, and dead furrow system using field boundaries (Kanwar 1988, JS Kanwar, Hyderabad, India, personal communication, 2004).

farming systems mostly from the crop improvement programs.[8] The leadership underwent changes from the earlier disciplines of agricultural engineers and soil scientists to a plant physiologist whose focus was on components of plant and cropping systems. Crop improvement had a simple yardstick for measurement, namely productivity per hectare, while at the time there were no developed methods to assess systems research such as the watershed-based work. Primary responsibility of the watershed-based activities was placed with the Cropping Systems Unit from 1985 onwards and the previous cropping patterns were changed. The long-term data of over a decade began to be quantified and assessed. There were two kinds of long-term experiments at the watersheds – the operational-scale watersheds or WBR and the steps in improved technology (SIT) studies. The WBR work was implemented mostly by the FSR land and water sub-program and involved hydrological studies, integration of new technology components into improved sustainable farming systems and economic evaluation of different production systems. SIT involved studying the effect of increases in yields with changes in technology arising out of the use of different varieties, fertilizer applications and soil and water management practices. The production agronomy unit carried out the SIT experiments. The SIT experiments were more amenable to statistical analysis than the watershed trials and were conducted on much smaller plots than the watersheds.[9]

Anders and Sharma (1993), analyzing the data of Vertisol watershed research at ICRISAT over a 15-year period, pointed to a difference between the projections made for the IVMT and the results from the field locations (see Appendix 1 for a summary of some of the field results). They argued that the interpretation of the data as published in ICRISAT's "Small Watersheds" pamphlet was incorrect as it underreported the field results while overemphasizing the yield and profit increases between 'improved' and 'traditional' management systems. Earlier, Anders had argued for the discontinuation of the use of the pamphlet (an internal memo in 1991). The overall effect of these findings was a major reorientation of research and the watershed-based work at ICRISAT was de-emphasized. There were indeed problems with the field data and the interpretations arising out of the WBR work. However, the potentials of the innovative approach of identifying watersheds as a focus for intervention proposed by the research team involved were not perceptible in the revision of findings and organizational changes.

Paradoxically the concept of watershed-based development rapidly gained greater recognition outside ICRISAT especially in India. In 1990, the World Bank had initiated development projects in four states on watersheds that were part of the SAT region. The Indian government had started taking note of some of the more successful watershed development experiments at Ralegan Siddhi and Sukhomajri and the severe drought of 1986–87 focused attention on the urgent need for better land and water management. This led to a series of initiatives beginning with the National Watershed Development Programme for Rainfed Areas (NWDPRA) launched in 99 districts in 16 states of India in 1987.[10]

These changes did create opportunities for ICRISAT as an international organization to capitalize on and offer its expertise gained in being a pioneer in pushing the watershed concept. However, the

8. Such opposition was not new; even at the time of ICRISAT's establishment in 1972, the question of including FSR vs an exclusive focus on plant breeding was seriously debated within the institute. This, however, does not seem to have been the case with the new changes.
9. See Binswanger et al. (1980) for more details.
10. In 1985, the Government of India established the National Land Use and Wastelands Development Council. Under this Council, two Boards had been set up: the National Land Use & Conservation Board in the Ministry of Agriculture and the National Wastelands Development Board under the Ministry of Environment & Forests. In 1992, the National Wastelands Development Board was placed under the newly created Department of Wasteland Development in the Ministry of Rural Development with the mandate to develop non-forest wastelands.

particular set of circumstances and the institutional settings of the late 1980s having only remote and indirect arrangements with the on-farm situation through the extension mechanisms of the NARS did not allow building on this. ICRISAT's overemphasis on technical innovations and the direct delivery of packages of technology in many ways undermined the Institute's larger and more important role in institutional innovations in agricultural research that related to approaches to research rather than any technical products; for example, the FSR Program and the crucial role of the watershed-based approach for the SAT region. We shall see later how ICRISAT in recent years has relied more on institutional innovation to again be an active player in the intervention climate concerning watershed development in India.

A few years before the reconstitution of Farming Systems into the Resource Management Program, ICRISAT organized a special in-house review in 1981 of the FSR Program. This was to look at the experience in FSR and to discuss and elucidate the concepts of FSR in relation to the Institute's organizational framework. It was a tempered celebration of the program that was one of the first CGIAR centers to carry out research experiments in an integrated interdisciplinary manner. The complexity of farming systems in the SAT and the risks that farmers face in testing and adopting innovations necessitated such an approach. The review pointed out that while the study of farming systems was not new in agriculture, the concept of multidisciplinary institutional research on farming systems was new and still evolving and that ICRISAT was a leader in these institutional experiments. The review raised several issues relating to the challenges of multidisciplinary research, the hierarchy of scientific disciplines and cooperation with NARSs. The scientists involved saw the review also as an effort in 'conceptual soul searching' and wondered 'if the work was ahead of its time'.

The scientists were clear that FSR was 'not a new science but a new approach'. The questions raised and conclusions reached indicate the robust internal discussions and debates that took place. Some of the questions that the scientists pondered were:

- FSR is seen as an applied arm of an agricultural research institution. How should FSR correct such perceptions?
- How should FSR scientists deal with the issue of peer recognition and career development when scientists are used to systems of publishing in disciplinary journals?
- What should be the hierarchy among disciplines, if at all, in FSR?
- Should the scientists be pioneering research methodologies to cope with the marked location specificity of technologies in the SAT?
- Industrial organizations have large research and development departments focused primarily on producing a marketable finished product. Should the scientists take this approach in evolving a package of improved technology?
- What should be the nature of the interaction with national research centers? Should FSR have the flexibility to undertake research in new crops such as safflower, which is not a mandate crop?

The review emphasized that *a lot of learning had occurred in the last 8 years, and that ICRISAT had made a substantial contribution to the world's thinking on farming systems, if not an impact on production systems* (ICRISAT 1983, emphasis added).

In the years after the review, many of the technical suggestions on future research directions were carried out but the lessons on 'approaches' were not drawn to the desired extent. The potential opportunity illustrated by the watershed-based work of developing new approaches towards uplifting the SAT farmer and the region that ICRISAT could establish through examples at several locations for replication by others, remained at the level of an idea. The work of the Resource Management Program brought out the dimensions of differences of working in Asia and Africa. While it was technically possible to classify SAT regions based on soil and rainfall type, making research relevant in the various regions had to take into account the variations of scientific and development cultures of the regions. The variance between research cultures of Asia and Africa was often overlooked in refocusing effort and organizational changes.

In 1992, ICRISAT, as part of celebrations marking its 20th year in India, organized a seminar titled 'CGIAR and India: Twenty Years of Fruitful Partnership'. Notable in the proceedings on accomplishments by the six CGIAR centers including ICRISAT that followed was the rather brief mention of the resource management work at ICRISAT. It was clear from the note that ICRISAT saw its breeding work as its main contribution to Indian agriculture. The report also spoke about the way ICRISAT reaches the Indian farmer:

> "The resource poor farmer, who is the principal target of ICRISAT's research, is reached *through* the scientists and extension agencies of the national research systems that make up the SAT. National scientists are ICRISAT's principal client group: they receive the Institute's latest research information and seeds of its improved varieties and hybrids, test them, and adapt them to local conditions. The Institute *does not work directly with the farmer*, although it evaluates on farmers' fields the technology developed in the research station. The Institute does not directly engage itself in extension work involving direct contacts with the farmer but encourages and supports adaptive research through the national agricultural research systems." (CPR 1991, emphasis added)

While such a method for technology transfer is likely to be effective for the release of varieties or a product made at an ICRISAT station, it is a moot point if this mode of accessing the farmer in the case of watershed-based work which in many ways is about an approach and not a product would be effective.[11] ICRISAT's own experience with the Vertisol technology package did point to the need for a different way to achieve effective technology transfer. One of the important lessons that could have been learned from the watershed experience had to do with the need for a different relation to farmers and their fields especially in the case of approaches and practices of farming as compared to technological "products".

Another issue about the assessment of impact of ICRISAT's work relates to the conceptual issues about the way the institution sees itself and its means to look at non-quantifiable lessons. In 1992, ICRISAT brought out a publication – "ICRISAT in the Media" – that carried news reports of ICRISAT's work. The collection implicitly gives a misleading picture about the watershed work for it finds no mention. However, at the same time ICRISAT's work was contributing to the larger debates on watershed-based approaches. In 1991, the Indian Journal of Agricultural Economics carried a special issue based on papers at its annual conference that was organized under three main themes of which watershed development was one (IJAE 1991). Scientists from ICRISAT too participated and shared their experiences on watersheds (Kshirsagar and Ghodake 1991). Outlined in the preface to the issue were five kinds of programs on watershed development in India – the Operational Research Projects

11. Douthwaite in his recent book on innovation has remarked that the only agricultural example that he could find of (successful) top down methods working was in the production of new seeds for farmers in areas where the growing conditions could be controlled by the use of irrigation, fertilizers and pesticide sprays (Douthwaite 2001).

of ICAR, the World Bank program with the active participation of agricultural universities, the initiatives of state governments of Karnataka and Maharashtra, the National Watershed Development Programme (NWDP) of the central government and several others implemented by voluntary organizations. A conspicuous absence in the list was ICRISAT's own work on watersheds including that in collaboration with the NARS. The technological mindset at ICRISAT resulted in a situation where the Institute's useful lessons concerning approaches to watershed development and farming continued to be underreported by ICRISAT's own scientists. At about the same time, the report of the Third External Program Review mentioned that 'perhaps this (watershed-based) package approach was over-ambitious, but ICRISAT's watershed technology is the basis of the NWDP of the Government of India' (TAC 1991). This vital role and opportunity of contributing to the larger debates on watershed development was completely missed out in the way ICRISAT projected itself at the time.

A case in point is the establishment of a critical link between the farmer and the watershed concept, a link that was more often than not missed in the soil and water conservation (SWC) efforts by state departments but that was recognized at ICRISAT early on. In January 1991 ICRISAT organized a workshop on 'Farmers' Practices and Soil and Water Conservation Programs'. Researchers, government and non-government organization (NGO) officials, and farmers met to discuss and document indigenous SWC practices and to share experiences of participatory SWC programs. Recommendations were made for change intended to bring more flexibility, relevance, financial viability, and adaptability into SWC programs, and to introduce indigenous knowledge and participatory methodologies into education curricula. Leading the initiative was John Kerr, the leading natural resource economist, then an ICRISAT scientist, in collaboration with NK Sanghi, a senior scientist from the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. Kerr was later involved in studies to look at the watershed development in India as part of the World Bank team, a report that has since played a major role in the institutional acceptance of the participatory approach in watershed work in India in recent years (Kerr et al. 2000). The work by Kerr on NRM and the work on common property resources by Jodha (1991, 1992) are significant contributions by ICRISAT scientists that helped shape the debates on SWC in India. The success of Kerr, Jodha and Starkey in using their experience at ICRISAT to contribute to the broader development thinking on natural resources raises an important question: "What were the key institutional constraints that did not allow for ICRISAT as an Institute to be effectively involved in these larger debates whilst individual scientists were able to make pioneering contributions to the subject?" The individual scientists were able to draw several important insights through their work with ICRISAT especially in some of the villages where the watershed was undertaken, but the organization was unable to build on these insights in its own programs. ICRISAT often remained passive in the sense that these important insights were formulated in the context of its programs but used elsewhere without any pro-active involvement by the Institute. In fact as we shall see in the next section, instead of being an important leader in the debates on natural resources, the work at ICRISAT began to be led by the international focus on natural resources following the 1992 Rio Summit.

Phase 4: Re-emergence of NRM through Internationalism

The Rio Summit of 1992 is often seen as a landmark event for launching the concept of sustainable development. It led to a rethinking of the research agenda at several international research centers and environment and natural resources assumed prominence. ICRISAT was no exception. The difference though was that ICRISAT has substantial institutional knowledge on the subject at least on NRM and should ideally have been contributing to the definition of the agenda. It was instead being led by a new internationalism that had little to learn from local innovations of its centers. Organizational changes in the wake of debates on sustainable development within the CGIAR system led to the framing of agroecological regions and production systems suited to these. ICRISAT, like most other CG centers, was forced to respond to external environment changes and pressures of reduced and uncertain core funding. ICRISAT went through an organization and management review that reworked research programs under the matrix approach with the agroecological region on one axis and global research themes on another. Production systems replaced research themes.

The international mandate and the growing importance of work in Africa began a shift in focus to Africa in which the donor agencies played a big part. The External Program Review recommended that there was greater scope for coordination of economics with agronomists and soil scientists. The resource management program also underwent a review; the three regional centers at Patancheru, the Sahelian center at Niger and in Southern Africa were restructured. Despite the perceived effectiveness in addressing region-specific needs of NRM research in the SAT it was felt that these centers were not effective in capitalizing on opportunities for global spillovers and synergies between research actors in similar agroecological environments (ICRISAT 1994a).

The project was to be the basic unit of research. If the earlier integration of disciplinary research (soils, agroclimatology, agronomy and socioeconomics) occurred within regional research management units, in the new structure this was to occur globally under interdisciplinary research projects.[12] The annual reports of the early 1990s have surprisingly little mention of watershed-based work of ICRISAT. The Fourth External Program Management Review in 1996 proposed a new model wherein research on management of natural resources would be concentrated in Africa with the germplasm-related work on SAT crops housed at Patancheru. Crop improvement and release of varieties was seen as the only real focus and competitive advantage of the Institute and it played up its work in this area almost in response to the comment in the External Program Management Review that expressed concern 'that ICRISAT was underselling its achievements'. While the King Badouin Award for pearl millet in 1996 was recognition of its achievements in crop improvement, there seemed to be no mechanism to 'sell' or even speak of its achievements on the non-technical sphere in the watershed context.

Despite increased demands for shifting the resource management program to Africa, it was the work in Asia that started opening new vistas for research and development. The work with the Indian NARS had over a period of time helped change ICAR's perception of ICRISAT. The series of collaborative projects facilitated the process (see Appendix 2 for a list of ongoing projects in 1993). In 1996, in recognition of the work by ICRISAT scientists, the Government of India invited SM Virmani to be part of a national working group on dryland and rainfed agricultural production. A few years prior to this, ICRISAT scientists had made a significant shift in their research efforts by concentrating on Vertic Inceptisols in contrast to Vertisols generally as part of their Multicommodity Research Project.[13] This decision was taken in recognition of the fact that this area covered 60 of the 72 million ha of black soils in India and was thought to have good potential. Concomitant to this was

12. There were to be four of these projects for various ecoregions of the world. ISP 3 dealt with production systems 7 and 8 in Asia that were related to the earlier work in India and was titled 'Strategies for enhanced and sustainable production in low and intermittent rainfall production systems (90–150 days) in the SAT'.

13. Vertic Inceptisols, which occur in association with Vertisols in a toposequence, occupy about 60 million ha area in India. These soils have similar physical and chemical properties as the Vertisols, except that these are shallower and somewhat lighter in texture and occur on slopes not exceeding 5%. (www.icrisat.org/text/research/nrmp/researchbriefs/resbrief_piara.asp) This shift was in keeping with the External Program Management Review recommendations as well.

also a significant shift in looking at crops like soybean that were not part of the five mandate crops of ICRISAT but yet had become important crops of the SAT in India. Though watershed-based work found little mention in ICRISAT's annual reports it was agreed with the NARS that 'the watershed is to be the loci of integration of dryland technologies' (ICRISAT 1994b). The Integrated Systems Project (ISP) work was to be carried out at benchmark sites and on farmers' fields in collaboration with NARS. In collaborative meetings with CRIDA, ICRISAT scientists decided to organize joint planning sessions and reviews with the NARS scientists in that manner seeking to be part of the planning process and not just the execution of plans. The partnership was to be a learning partnership for all the collaborators involved on an equal basis. ICRISAT saw partnership research as involving the sharing of inter-institutional arrangements leading to increased research efficiency (Virmani and Wani 1995).

On-farm research at the BW7 benchmark watershed at ICRISAT and at Indore pointed to soybean-based farming systems as highly suitable for sustainable production on Vertisols and associated Vertic Inceptisols. The watershed-based studies allowed for a broader and more flexible operation and ICRISAT was able to extend its research fields beyond the mandate crops by now looking at all available opportunities in the SAT region and not be restricted to the five crops alone. At another level despite the continued emphasis in several review committee reports on having the NRM division to focus more on or even entirely shift to Africa, new donors started seeing the potential of ICRISAT's watershed-based research in Asia. The Japan International Research Center for Agricultural Sciences (JIRCAS), Tokyo, Japan provided support to ICRISAT scientists on satellite imaging. Research in Anantapur district showed severe soil erosion despite increases in cropping intensity between 1973 and 1995. In 1997, ICRISAT, Bharatiya Agro Industries Foundation (BAIF), Pune, the Deccan Development Society, Hyderabad and the National Remote Sensing Agency (NRSA), Hyderabad joined hands to develop a watershed in Zaheerabad district of Andhra Pradesh and in Vidisha district in Madhya Pradesh. The initiative was significant for it was also the first time that ICRISAT was working with non-science partners and grassroots level organizations.

Phase 5: Consortium Approach and 'Adarsha' Watershed

The NRM program of ICRISAT had a rebirth. The Soils and Agroclimatology Division (SACD) was renamed Natural Resource Management Program in 1997 and watershed-based work was back in the research agenda of ICRISAT in a more explicit manner. The Annual Report of 1999 for the first time spoke of the watershed work as a continuous effort for 25 years. The Asian Development Bank (ADB) supported a project for evaluation of an integrated technological approach, which was tested by a multidisciplinary scientific team involving ICRISAT and the Indian NARS (participating institutions were CRIDA in Hyderabad and agricultural universities in the states of Andhra Pradesh, Maharashtra, Madhya Pradesh and Karnataka). Slowly but surely there was a shift in emphasis in ICRISAT's research. Scientists responded to the debates on participatory watershed management and reoriented their research from 1999 on the basis of a new integrated natural resources management (INRM) focus.

The year was significant for watershed-related activities. ICRISAT initiated work on projects with IBSRAM (International Board for Soil Research and Management) in Thailand in close interaction with ADB. The mode of functioning of these projects was significantly different from the earlier phases and reflected the new emphasis on 'partnerships in research for development' and a focus on developmental as opposed to strategic research. The new projects at ICRISAT and IBSRAM began to emphasize networks and consortiums. This has since become the mainstay of ICRISAT work. IBSRAM and ICRISAT highlighted the network or consortium approach as a mode of operation that could be adopted to overcome problems of fragmentation of appropriate mixes of technologies because of location specificity of research on many land management problems, and on the promotion of a partnership approach focused on the needs of NARSs and building their research capacity (IBSRAM-ICRISAT 1999).

There was also a new openness to include NGOs as important stakeholders. Earlier, NGOs, even those that had done significant work on watersheds like MYRADA (Mysore Resettlement and Development Agency) or community leaders such as Anna Hazare (work in Ralegan Siddhi) were never part of ICRISAT's watershed work. This changed with the collaboration by ICRISAT with BAIF in Madhya Pradesh and M Venkatarangaiah Foundation (MVF) in Andhra Pradesh. The collaboration with MVF led to the model watershed at Kothapally. BAIF had been involved in rural development activities since the late 1960s and had extended its range of work to include watersheds. ICRISAT chose to strengthen its association with BAIF in its integrated watershed program at Lateri block of Vidisha district in Madhya Pradesh. BAIF's approach to extension of technology focused on the delivery of services to the farmers' doors instead of waiting to be approached and it involved indirect extension or 'entry point activities' like livestock development for other programs such as watershed development. The Lalatora watershed was chosen as one of the five watershed projects to be assisted by ADB and BAIF believed that the new multi-institutional project would help in extending the 'best benefit' to small farmers in the watershed area expeditiously. BAIF, however, wanted the scientists to keep an open mind and respect the opinion and knowledge of the farmers and field workers while planning and testing field research developed at the research centers like ICRISAT, CRIDA, the Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur and the Indian Institute of Soil Science (IISS), Bhopal. Based on the closer understanding of field realities and farmers' knowledge and mind set, BAIF scientists cautioned that social acceptance was as important as technical soundness and economic viability of a project (Rangnekar 1999). This new institutional arrangement significantly affected the mode of working at ICRISAT and there was more openness to knowledge emanating from other sources. One illustrative example is ICRISAT's popularization of the pest management knowledge of an 80-year-old farmer named Bitchappa in Mahbubnagar district, Andhra Pradesh. The technology was identified by a local NGO, REEDS (Research in Environment, Education and Development Society) and was fine-tuned at ICRISAT. ICRISAT scientists have in recent years also used the watershed as the basis for several collaborative experiments with farmers on integrated pest management.[14]

A more direct involvement of ICRISAT in the field was with the Kothapally watershed in Ranga Reddy district. This was one of the on-farm benchmark sites for the ADB-assisted project and involved MVF, an NGO that worked on mobilizing the community, the Drought Prone Area Programme (DPAP) of the Government of Andhra Pradesh, and national agricultural research organizations such as CRIDA and NRSA. The choice of Kothapally was based on a combination of technical and non-technical factors. The Government of Andhra Pradesh, the state where ICRISAT is located, appealed to ICRISAT to take up a location in the state where the technologies and approaches of ICRISAT could be tried out. The organizational climate for ICRISAT's work in India had changed substantially since the early years when it was viewed with some suspicion by the NARS. Significantly, this was perhaps the first case of ICRISAT's direct field involvement without the NARS or the line departments of agricultural universities. It was this changed scenario that was behind the confident re-articulation

14. http://www.icrisat.org/text/news/2000/ipm_research.htm

of the Director General on the role of ICRISAT wherein he saw ICRISAT as using "its international character to act as a trusted broker between NARS and various other stakeholders in dealing with technology transfers to find win-win solutions" (Dar quoted in Venkataramani 2000).

It was the work at Kothapally involving intensive studies by ICRISAT in partnership with CRIDA, NRSA, MVF and DPAP, which led most of the subsequent research. The involvement of diverse partners that included an NGO provided a conducive atmosphere and with a more receptive participatory approach towards technology, the results were favorable. ICRISAT developed the watershed as a model and even named it *Adarsha* ("ideal" or "model" in Indian languages) and pushed it as a major success story. The proximity to ICRISAT (40 km) helped in that it was possible to show to donors – government and international – that the work on-station had been translated on-farm successfully. Scientists used the promising experiment at Kothapally to leverage extension to other areas and as a result two major projects, one with the Andhra Pradesh Rural Livelihoods Programme (APRLP) titled "Improved Livelihood Opportunities through Watersheds" and another with Sir Dorabji Tata Trust titled "Combating Land Degradation and Increasing Productivity in Madhya Pradesh and Eastern Rajasthan" came into being. The efforts of the watershed team were recognized by ICRISAT and it received the 'Best Resource Mobilizer Award' in 2002. The work at Kothapally was covered by the BBC in a documentary and has recently been chosen by the Interim Science Council as one of the successful cases of partnership in NRM under the CGIAR (Wani et al. 2003). The scale and spread of the activity since 1999 has been quite extensive and is beyond the scope of the present report to discuss in detail (Wani et al. 2001, 2002, Shiferaw et al. 2002). As indicated earlier, there are several publications about the recent watershed work and it has been rather well documented. In recent planning meetings with consortium partners the scope and scale of activities have been increased significantly in all the watershed projects. What merits mention though is that the watershed work has almost come full circle at ICRISAT occupying an important place in the institute's activities.

What is it that one can make out of this long involvement in watershed research? Could learning have happened faster? If so, what were the lessons that enhanced and hindered institutional learning? These issues are addressed in the following section.

Summary and Discussion

The above narrative of the various phases of watershed research at ICRISAT clearly demonstrates that the recent work has been part of several initiatives undertaken over a long period of time at the Institute. Watershed-based work has had several ups and downs over its 30-year-old history. Like other instances of complex systems and multi-faceted reality there seems no case here of a textbook linear progression of success in the laboratory due to scientific inputs leading to a trickling down of technologies to the farmer as outputs through the pipeline of the extension mechanisms of the state agricultural departments. Table 2 below summarizes some of the key directions of the watershed effort at ICRISAT. A more detailed institutional timeline of watershed-related events is provided in Appendix 3.

Table 2. Phases of ICRISAT's research on watersheds.

Phase	Research focus	Key features of research	Institutional lessons
Pioneer in farming systems and watershed research (1972–78)	Development of an integrated technology package	• Watershed as focal point of new technologies in other programs • Multidisciplinary teams • Work on 'imprecise' fields with "farmers' resources" • Village-level studies as possible entry point for watershed • Watershed as site for first collaborative project with NARS	• Willingness to learn through bold experimentation, seeking opportunities to move towards farmers' fields • Better understanding of resource constraints of SAT regions
On-farm trials of Vertisol technology (1979–84)	Evaluation and adaptation of technology package through NARS	• Enthusiastic projections by economists with high rates of return estimates • Partners and the experiences from the field raise questions on the universal application of package	• Underestimation of technology introduction period • 'Perfected' on-station rejected at 'field' • Reflection by scientists (of what farming system means) and social scientists (farmers' perceptions and reasons for non-adoption)
Retreat to on-station strategic research (1985–91)	Modeling of generic packages for use across regions	• Shift to crop and resource-centered research • Farming systems renamed as Resource Management Program • Less mention of watershed, demand for more work in Africa • Development of benchmark sites	• Watershed out of institutional memory of ICRISAT despite being factor in larger climate • Individual scientists players in larger debate, organization out
Re-emergence of NRM internationally (1992–98)	Developing experimental plans and impact analysis	• Renewed NRM interest following Rio Summit in CG centers • Organizational reorientation towards global projects • New vistas in Asia not seen by CG external reviews • Establishment of benchmark sites, model watersheds	• Externally induced changes; ICRISAT being led instead of leading • Negotiations by scientists using opportunities for growth in Asia • Extension of boundaries (physical as well as crop) • Emergence of stronger 'local innovation system' with diverse partners

continued

Table 2. *continued*

Phase	Research focus	Key features of research	Institutional lessons
"Consortium approach" (1999 onwards)	Integrated watershed management through model and satellite watersheds	• New partnerships • Wider linkages to livelihoods • Watersheds as ICRISAT "flagship"	• Direct contact with farmers and bringing together various players acting as bridge, broker and catalyst • ICRISAT again as important player, enlargement of mandate beyond technical • Proliferation of watersheds, newer challenges

The WBR program at ICRISAT has gone through several stages beginning with promises of being a pioneer innovator in the early years, a promise that was tempered, somewhat drastically, with not so favorable on-farm results. The retreat into strategic research on-station then led to the institution and the scientists responding to the changing mandate internationally with natural resources re-emerging in the agenda. Through a gradual process of learning the watershed-oriented work has in recent times become one of the most important activities of the institute and the basis of ICRISAT's outreach to farmers. Our attempt in this report has been to capture this process with all its complexities and derive lessons for research design and strategies from them. We first begin by summarizing some of the key institutional developments of the watershed work.

A systems approach to farming

As highlighted in the internal review of farming systems at ICRISAT, scientists believed that what they were offering was not a new science but **a new approach** to research in agriculture. As one of the first of the CG centers to experiment with such an approach, ICRISAT scientists showed remarkable vision both in identifying the SAT as in need of critical attention by researchers, the importance of soil and water management for SAT and for a different approach in tackling the most crucial problems. The deliberate choice of the watershed as a basis for research and the consequent choice in not using heavy farm equipment indicate sensitivity in research design to actual farm conditions. Though not specifically articulated in that manner, the watershed was conceived as a halfway house between precision fields on-station and actual farms in villages of SAT.

Scientists at ICRISAT were also involved in multidisciplinary research teams right from the start that had agricultural engineers, agronomists, soil scientists and social scientists seeking to work together. This approach was ahead of its time and before the need for it was articulated in agricultural research following the environmental debates on sustainable development in the late 1980s and early 1990s. Thus in practice the scientists had to face problems of the hierarchy of scientific disciplines and the lack of journals that were sensitive to these new demands. This was in contrast to the rather well defined and quantifiable parameters of crop improvement research.

Collaborative work with the Indian NARS and other partners

The watershed-based work was also the site for important institutional initiatives for ICRISAT. It was around this research that the first collaborative program with ICAR was conceived. CG centers had prior to ICRISAT never worked actively in countries with a strong NARS and the research experience in India with a strong and relatively well-developed NARS is undoubtedly of significance. This partnership as we have seen was not without its difficulties. However, the decision to engage in long-term studies with the NARS helped shape and define the role of an IARC in India. This partnership helped ICRISAT redefine its strategies and indicated for instance very early that the IVMT would not work on all soils. The role of ICRISAT too changed with time from an earlier institutional conception of being the main innovator using the comparative advantage of NARS in extension activities to a more humble and equal collaborative partnership. The experience with NARS through the watershed work led to important institutional lessons that were however underreported.

In later years there has been greater openness by ICRISAT to include dissimilar partners in its work. The involvement of non-specialist partners such as NGOs and farmers' groups (eg, watershed committee members) has helped change the character and the effectiveness of research. These partners have brought their own agendas and networks and have facilitated better technology uptake, an issue that ICRISAT was grappling with for several years.

Joint problem solving with social scientists

If the work with the NARS had to do with work outside the institute, the engagement by natural scientists and social scientists over a long period of time had important lessons for collaborative work within the institute. As most CG centers, ICRISAT too had a fairly significant portion of its staff from the social sciences, nearly 15%, and the years of work on watershed development issues indicate cases of important complementarities (the village-level studies helped ICRISAT scientists with an entry point for testing and adaptation of their technologies), critical reflections [as in farmers' perceptions varying from those of the scientists (Sarin and Walker 1982) or studies on social organization and group action (Jodha 1975, Doherty and Miranda 1980)] and projections on rates of return (Ryan et al. 1982). The watershed work involved at least a few scientists (like Jodha on common properties, Kerr on NRM and Starkey on lessons in technology transfer) who contributed to the larger debates on natural resources and development though ICRISAT, as an organization was not able or interested to do so. They had pointed out that watershed research at ICRISAT needed to be more broad based and had to include other components of farming systems such as livestock, pastures and associated agronomic practices. However, this went unheeded. As will be evident in the discussion to follow the potential of action research involving teams of social and natural scientists has remained unexplored. This has partly to do with the composition of social scientists in the CGIAR which has been largely quantitative economics based. A sensitivity to farming systems and complex problem solving that it entails necessitates a broader social science outlook involving other disciplines such as anthropology, social studies of science, development theory and public management.

The case study indicates that the potential of all these significant institutional initiatives were not fully realized. The reasons for these were not related to individual failures of the scientists themselves but due to factors relating to institutional constraints of research. In the following discussion we discuss in greater detail the institutional and process lessons that need to be unraveled for a better understanding of the constraints hindering faster learning.

Lessons and Challenges for Future Work

Some of the broad lessons from the above institutional history of WBR relate to the understanding of the roles of scientists, of their work and of its relation to society, the underlying concepts of technology transfer, the relation of scientists to the field and the way they shape it, and the underlying processes that may restrain and/or enhance learning.

1. Conception of work – linear vs systems:

There were some early lessons in technology transfer in the 1980s that were not learned or learned only gradually. Apart from the technical constraints of the package attempted there were constraints in the design of the process of transfer of technology. One of the significant barriers to learning was the institutional arrangement in place in the late 1970s that believed in a linear model of innovation from international CG centers to produce a technology that would be then transferred to the field through the NARS and its extension mechanisms. As observed earlier, such an arrangement is at best effective only in standard crop improvement programs where a variety developed on station could be transferred to the field through the NARS, extension departments of the government or the seed industry and then to the ultimate clients, the farmers. Such an approach in more complex systems such as those involved in the watershed-based work was bound to face difficulties. More importantly from the scientists' point of view, this linear discontinuation between the scientist and the field did not allow for learning and reworking of the design or the technology input. The process was conceptualized as a linear process with no possibility of a feedback from users.[15] More recently Reece (1998, 1999), in the context of a detailed historical case study of the Centro Internacional de Agricultura Tropical (CIAT), has argued that while the CG centers were successful in achieving their original aggregate productivity goals for well defined products, such as wheat and rice, they have become singularly unsuccessful when attempting to deal with "poorly defined problems" such as the degradation of a natural resource base and the inadequate livelihoods provided by low-resource agriculture. He argues that while well-defined goals are amenable to a "pipeline" research methodology, most modern issues for poor farmers need a more systemic approach.

Research lessons drawn by Starkey (1988) in his study on animal-drawn tool carriers are equally applicable here. Starkey observed that there was a lack of realism of on-station research. The 'failures' of research and extension programs have often been due to professionals who did not really understand the local farming systems, and tried to impose on them technology that the farmers considered inappropriate. It was important for ICRISAT to work with farmers in different ways, a lesson that it learned in its later work especially when it worked directly with them as in Kothapally, or through arrangements with organizations such as BAIF that urged its scientific partners to 'respect the opinion and knowledge of the farmers and field workers while planning and testing field research'. There is also the need for recognizing, as in the case of the Taddanpalle experiment, that there could be a difference in perceptions of problems and solutions between farmers and researchers. Unfortunately this insight was not treated as crucial feedback to reconceptualize research design. A greater openness and a systems view on technology transfer that does not create hierarchical relations amongst actors involved in a system could lead to better technology uptake.

2. Role of ICRISAT – technology provider vs validated approaches to problems:

One of the key lessons that emerge from the study is the over-emphasis placed by scientists and research managers on technological packages like the IVMT. This undermined ICRISAT's larger role

15. "The path which the Vertisol technology development at ICRISAT has followed is essentially one which from component research to package and system design remained within the research station in Patancheru and then entered the farmers' fields, with the effect that many constraints were understood only at the stage where farmers were confronted with the technology" (von Oppen et al. 1985).

in institutional innovations in agricultural research where ICRISAT had some original contributions to make. Scientists believed that they had made a substantial contribution to the world's thinking on farming systems. ICRISAT's work on watersheds was an important factor that contributed to the Indian government's NWDP in 1991 but neither of these achievements figured in ICRISAT's own projections of its work. This was due to the organizational mindset of being cast in the mold of a technology provider. This possibility of changing the thinking or paradigm of research with a robust farmer validated approach should have been the focus of efforts. In recent years in the CGIAR system, FSR has evoked a renewed interest with several scholars identifying the origin of the INRM approach as having arisen from FSR (Douthwaite et al. 2001).

The gradual replacement of technology packages to integrated watershed management in recent years does indicate a shift in thinking. However, it appears to be more a representation of a changed reality rather than a conscious attempt to shape existing thinking. A broader view of its own work would necessitate a reflection on ICRISAT's mandate on a continual basis. Such exercises can help provide greater contemporary meaning to the institute's work that reflects both changes in the external environment and the tacit internal institutional knowledge. It is possible for an organization such as ICRISAT to reframe its target of research as not just the farmer or the NARS researchers but changing the thinking of actors in the system that includes the farmer, the NARS as well as itself.

3. Local innovation system vs international public goods mandate:

The watershed case study also indicates some of the tensions within a CG center keen to realize its international public goods mandate. In its attempt to find universal solutions that could be applied across regions of the globe, it loses out on the possibility of it being a player, and often an important one at that, in improving local innovation systems. Several organizational and management changes at ICRISAT in the late 1980s and 1990s failed to recognize the importance of local innovation systems. It is being increasingly realized that the actual practice of science in different settings is influenced by organizational cultures (Pickering 1992, Feller 2002). In its NRM work, ICRISAT underestimated the role of organizational cultures and sought to develop uniform models across Asia and Africa, often pushing the work in Africa at the cost of possibilities in Asia. What was not realized though was the fact that there was no clear institutional mechanism for ICRISAT to work its NRM strategy from the bottom up looking at existing work at its centers and combining it with the new mandates brought about by the Rio Summit and demands for sustainable development. The new organizational changes in the late 1980s and early 1990s unfortunately were not based on the learning and institutional knowledge of years of work at ICRISAT since the 1970s. Research managers also did not account for the possibility of scientists from India at ICRISAT negotiating the meaning of work related to watershed research and opportunities in the place where the center was located and their being important players in the local innovation system in watershed-related work. That an international center can be 'local' without diluting its mandate is often missed out. CG centers like ICRISAT are under increasing pressures to 'deliver impact' in Africa, an agenda that is seen as being opposed to continued work in Asia. An innovation systems framework can help re-conceptualize the role of these centers and go beyond the dualism of the Asia-Africa debate. Understanding the local innovation systems and their distinct dynamics in Asia and Africa can help ICRISAT situate its global focus better following the popular adage of environmental consciousness 'think globally – act locally'.

Given this underplaying of the role of the local innovation system it is not surprising to find that in a recent review of NRM concepts in the CGIAR, the TAC did not mention ICRISAT's activities in a review of NRM before 1996 (TAC 2001). There was much learning both for ICRISAT and the CG system on the experiences of ICRISAT but this was not the basis of their research plans.

Given the above broad considerations that were factors hindering learning in watershed-based work, we now suggest factors that need to be recognized so as to enhance learning.

1. Research as a social process:

One of the important lessons that the watershed work illustrates is the social process of research wherein scientists are constantly involved in a process of negotiating with other actors, donors included, the meaning of their work. Research is an inherently social process where learning and institutional innovations are part and parcel of technology development and promotion. Scientists are often the source of this learning, derived from their own experience of trying to get research products to technology users. There are also several instances wherein they use opportunities and negotiate newer meanings of their work. A classic case illustrating this is the expanding work in Asia wherein scientists have been able to negotiate and use opportunities that were not foreseen by external program reviews of ICRISAT. It is also a recognition that research needs to be linked to developmental issues that have been behind the success of the watershed effort in more recent years.

2. Institutional context of research:

Research approaches and outcomes are intimately related to institutional contexts and it is these contexts that determine to a large extent the way science is practiced. The underpinning mandate of scientists having to reach the farmer through the NARS was facilitative but hindered learning. This mandate, however, was slowly changing through practice by scientists through several partnerships. The watershed case is a good instance of learning for ICRISAT to review and broaden its mandate, and to view its contribution in systemic terms instead of the linear model of improved productivity through inputs from international centers, validated in national research centers and extended to the farmer through public extension mechanisms.

The watershed case study also illustrates the fact that there were no enabling mechanisms at ICRISAT to 'sell' or even speak of its achievements on the non-technical sphere. This did not allow for learning many of the lessons on approaches in contrast to the more easily accessible technical lessons. Enabling this change of institutional mandates relates closely to the importance of process lessons.

3. Process lessons for institutional learning and change:

One of the interesting facets of the research work at ICRISAT was the robust and open discussion by farming systems scientists in the early years on what their work meant. These discussions were, as is to be expected, not pushed by or for donor agencies but part of an attempt to reflect and learn from their involvement in WBR. The internal review of ICRISAT's FSR being a classic case where there were questions raised on the challenges of interdisciplinary work vis-à-vis peer recognition and career development of scientists, on the appropriateness of viewing farming systems (WBR as well) as an applied arm of the research institution, if it was a new science or a new approach, etc. The kinds of questions that were raised as part of this review were generic and are as relevant today as they were 20 years ago. These internal debates and reflections on projects and processes of the organization reveal key insights towards tacit or institutional knowledge that is crucial to achieve change.

Process lessons require constant reflection on roles and mandates and different documentation procedures that enable the articulation of tacit knowledge. One of the key elements towards this is the possibility of reporting failures. Mechanisms exist in most research centers for collation of success stories but none to document 'failures' or non-success. In his lessons for research design from the case study of animal-drawn tool carriers, wherein much of the work was done by ICRISAT, Starkey commenting on this practice of portraying success alone observed:

> "There has been less learning from each other's experiences, less efficient utilization of human and financial resources and consequently less overall progress. There have been few attempts to publicize or evaluate disappointing results, presumably because the various reference groups might interpret this as "failure". Yet it cannot be too strongly stressed that negative lessons are not in themselves failures, they are only failures if the institutions and individuals fail to learn from the experience. … Institutions funded by national and international aid agencies must be willing to view 'negative lessons' constructively, and not regard them as 'failures' of which they should be ashamed. Learning involves both positive and negative experiences and if such institutions are only prepared to release positive information, then the world is losing a major chance to learn from their experiences. It is therefore most important that professionals can feel as proud of a well-presented negative lesson as a positive one." (Starkey 1988)

Unfortunately process lessons continue to receive little attention in research centers and are seen as qualitative intangibles instead of key elements in institutional knowledge that can affect the impacts of research.

Related to this is the role of social sciences in the watershed-based work in particular and research design in general. The long history of watershed-related research at ICRISAT has shown several ways by which natural and social scientists have responded to each other. These have included creating entry points for application of technologies, explicating the wider socioeconomic context that enables the situation of this research, critical engagement on why technologies have not worked at the field and also research that has quantified the research benefits such as from Vertisol technologies. Some of these later studies have been justificatory in that they have sometimes followed uncritically the projections by the scientists without questioning the assumptions. The wheeled-tool carrier being an example where the projections of impact attracted donor interest but were ineffective in uptake by the important end user – the farmer. Kerr and Chung (2001) have argued that many of the early studies on adoption rates of WBR results were overly optimistic.[16]

Over the years the diversity of perspectives that social science research could provide and produce on WBR became restricted to impact assessment alone. The application of tools of economic and impact analysis – impact assessment research, it has been argued recently, has not made much difference because the measurement of the economic impact has poor diagnostic power. In particular it does not provide research managers with critical institutional lessons concerning ways of improving research and innovation as a process (Hall et al. 2003).

A conventional argument of social science looking at natural science has been to blame the latter for pursuing uni-disciplinary research. However, this has not been the case with the watershed-based

16. These studies (of soil and conservation measures) focused on heavily supervised projects with subsidies of 90–100% awarded to adopters of the prescribed packages. As such, the estimates of adoption rates were not meaningful. Also, the benefit-cost studies were conducted before the actual outcomes could be known. They estimated net project benefits using yield impacts based on experimental data and assuming adoption and maintenance rates by farmers. *Ex post*, however, some evidence suggested that many farmers abandoned watershed measures once the project subsidies ended (Kerr and Sanghi 1992). Taken together, these factors suggested that many of the early, favorable evaluations were overly optimistic" (Kerr and Chung 2001).

work. The real challenge for social science at CG centers and elsewhere is to engage with the natural scientists in newer ways so as to provide real time learning lessons. Unfortunately these have been insufficiently explored and remain a big challenge. There is clear indication of newer trends where social science can engage with natural science on equal terms in joint problem solving. Scholars such as Gibbons and Nowotny have argued the potential for trans-disciplinary research as an effective way for managing complexity as the way forward. They argue that the thrust of innovation in the new mode of knowledge production is from new links between traditionally segmented producers and users of knowledge. This necessitates a new contextualization of research around the interests of stakeholders fostering a more 'socially robust' knowledge (Gibbons and Nowotny 2001). Broader patterns of partnership as evidenced in recent watershed development work necessitate such changes for greater effectiveness. It is important, however, to recognize that there is a lurking danger in the successes of recent efforts. Replication of success is not a mere extension or scaling up factor and it is only a learning environment that would be sensitive to the newer challenges that the new consortium approach phase brings in its wake.

To conclude this study we would like to highlight that the present institutional history of watershed-related research at ICRISAT presents us with insights on research design. We argue that while NRM research has been one of the significant areas that has witnessed several institutional changes within the CGIAR system for the fulfillment of newer goals and mandates relating to poverty reduction and environmental sustainability, most research centers have sought and promoted innovations through concepts such as participatory research, partnerships and alternatives to the transfer of technology approach. This report argues that while these changes have indeed contributed to a greater poverty focus of the CG centers, there is a greater need to understand the practice of science amongst these centers and the underlying institutional constraints that hinder or enhance learning in the proposed transition of these research centers into learning organizations. In this study the institutional history of a CG center has been used as a tool to promote institutional learning and change. It demonstrates that research managers in the CG system have not adequately accessed the institutional innovations of its own scientists in facilitating changes under newer mandates.

We provide no blueprint for future action; in fact such an approach would be self-defeating in an action research context. Our purpose has been to illustrate that the future of WBR and most other such projects at agricultural research centers needs an enabling environment that is sensitive to tacit or 'situated' knowledge that is often hidden in the memories and files of individual innovative scientists. Access to such institutional knowledge is predicated upon organizations innovating by introducing institutional changes that provide incentives to formalize learning as part of the practice of research, recognizing capacity development as an important outcome and purpose of research and accepting the need to embed *evaluation as learning* in the day-to-day procedures of research staff and administrators. A broader social science outlook we believe can play an active role in enabling this process of institutional learning and change.

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Appendix 1: Select Field Performance of Integrated Vertisol Management Technology Package

Experiences in Karnataka and Madhya Pradesh

- In 14 locations in Karnataka the number of participating farmers was less than four.
- The agriculture department purchased a number of tropicultors but many of them were lying idle due to lack of maintenance and repair. Reasons included high draft for small- and medium-sized bullocks owned by majority of SAT farmers, unavailability of seed plates for all seeds particularly groundnut, convenience and efficiency of interculture with local implements, unplowed land left on turning points during plowing, difficulty in repairing punctures or other mechanical faults in villages, no tool kit or manual supplied by manufacturers and the prohibitive price of the implement for an average dryland farmer.
- Dry sowing has been risky and the farmers in Gulbarga, Bellary, Dharwad and Bijapur are not ready to adopt dry seeding practice. Dry seeding of soybean is not very dependable; sowing in wet soil by tropicultor poses problems.
- Cultivation of land immediately after harvesting had not been easy especially in Dharwad where cotton crop extends up to March end. In Madhya Pradesh the harvesting of wheat extended till April end with similar difficulties.

Source: Sangle and Sharma (1993), Yaoi et al. (1993).

Other field observations

- Though the Integrated Vertisol Management Technology (IVMT) expressed a 31–45% increase in gross profits above the traditional system the reasons for the increases were variable and confounding. In general the IVMT plots were managed better and more care was taken to ensure good crop yield.
- Observations indicated that the BBF system operated well in fields that were well laid out. The farmer would employ these methods only in areas of severe waterlogging and will not necessarily develop all of his land. The gradient of 0.4–0.8% slope was for ICRISAT conditions alone; evidence suggests that the range could be from 0.2 to 0.8% depending on the rainfall.
- Most of the sites selected for the implementation do not suffer from waterlogging and therefore an absence of waterways and main drains has not caused any serious problems.
- Preparation of BBF is symbolic of IVMT projects and all efforts have been made to make BBF structure either by tropicultor or by opening furrows by local implements. However, maintenance of BBF during the crop season and interculture operations was not possible, as subsequent operations were by local implements.
- Though farmers appreciated the role of BBF, they could not maintain it throughout the season. There was considerable resistance to waterways that passed through farmers' fields.
- The BBF system does not contribute towards increased productivity and profits in a soybean system.

- Cropping systems are location and area specific and land and water treatments need to be determined according to the soil and land characteristics, rainfall patterns and crops to be grown. Sorghum/pigeonpea and maize/pigeonpea which gave high profits at ICRISAT Center, Patancheru were not popular at Begumganj.
- Comparison of individual cropping systems showed that higher economic profitability of the improved watershed was mainly due to absence of fallowing and the practices of intercropping or double cropping. The improved watershed was intended for double cropping, the point missed by uni-disciplinary evaluation.
- Maintenance of field to field grassed waterways has not been possible since farmers do not like to lose the land involved, and tend to cultivate and plant a crop in the marked waterways.

Source: Collated from Anders and Sharma (1993).

Appendix 2: List of Collaborative Projects of CRIDA-ICRISAT Resource Management Program (RMP)

Project	Title of project	Year	Recommendations
RMP 1	Agroclimatological research and training	1991–1994	ICRISAT on modeling aspects of disease and CRIDA on field experiments
RMP 2	Use of weather-disease relations for advice on foliar disease of groundnut	1992–1995	Project to be extended to large sites
RMP 4	Agroforesrty systems for rainfed drylands	1992–1995	Methodologies for live fences to be developed
RMP 5	Resource characterization for dry farming regions of India	1992–1994	Very broad focus to be sharpened
RMP 6	Run-off collection storage and optimum use of supplemental water	1992–1998	Project to be linked with watershed plan
RMP 7	Farmer level production constraints in groundnut	1992–1994	Project be linked to gender project
RMP 8	Nature and extent of crop establishment problem in farmers' fields	1992–1994	Debate on crop selection and sowing implements
RMP 9	Gender analysis of select technologies in SAT agriculture	1992–continuing	Debate on increased work load on women and improved technology
ICAR-ICRISAT	Behavior of phosphorus in Vertisols	1989–1995	Efforts must be made to publish results
New Project 1	Soil and water management for crop production on SAT Alfisols	1993–1999	15 ha of Alfisols to be used for watershed study as well as four other sites

Source: Collated from CRIDA-ICRISAT (1993).

Appendix 3: Institutional Timeline of Watershed at ICRISAT

Year	Activity
1970	• All India Coordinated Research Project on Dryland Agriculture (AICRPDA) initiated in India.[1]
1973	• Farming Systems Research (FSR) Program starts work to develop five natural watersheds on 48 ha for monitoring of water balance and intensive data collection on cropping systems.
1975	• Village Level Studies started by the economics program of ICRISAT. • Two studies initiated: 'Steps in Technology' and 'Operational Scale Demonstrations' on Vertisols and Vertic Inceptisols.
1975–76	• FSR renamed as RUR (Resource Utilization Research). Decision to develop a representative small watershed and to identify benchmark locations. • Initiation of two cooperative proposals with AICRPDA and the Central Soil and Water Conservation Research and Training Institute (CSWCRTI) at Dehra Dun.
1977	• Discussions with ICAR (Indian Council of Agricultural Research) leads to cooperative research at several locations.
1978	• Decision to involve AICRPDA and three state agricultural universities. Several additional research centers participate in the collaborative program. • On-farm experiments initiated (as part of the Village Level Studies) for information on suitable cropping systems and appropriate land management methods.
1977–78	• Articulation of watersheds being an operational testing ground for principles and methods tested in other sub-programs. • AICRPDA requested to work on watershed development on 4 Alfisols.
1978–79	• Shift in focus from evaluation of graded BBF (broad-bed and furrow) system to work on natural resource development. • Testing and adoption of the tropicultor, animal-drawn tool carrier and commercial manufacture in India.
1979	• Land and water development on a watershed basis at Aurepalle initiated. • International workshop on socioeconomic constraints to development of semi-arid tropics (SAT) agriculture. First workshop by ICRISAT with collaborating research centers of NARS. • Collaboration with the National Institute of Agricultural Engineering, UK to develop an alternative to the tropicultor.
1979–80	• On-farm watershed in Aurepalle, Kanzara and Shirapur. Thirteen research centers as part of program under FS1. The Central Institute of Cotton Research asks ICRISAT for FS1 type experiment with cotton as main crop.
1980	• Doherty and Miranda seek to understand the relation between development of small watersheds and the potential for cooperation.
1981	• Taddanpalle village selected in collaboration with APAU (Andhra Pradesh Agricultural University), ICAR and Andhra Pradesh state agricultural department and watershed farmers of the village. • Special in-house review of FSR Program in relation to institute's organizational framework.

continued

Year	Activity
1982	• Study by Sarin and Walker on perception of farmers in Taddanpalle watershed.
1983	• Workshop on watershed based dryland farming in black and red soils of peninsular India. First workshop that involved banking and financial institutions. • Sarin and Ryan make economic assessment of improved watershed technologies in on-farm experiments.
1984	• Initial work on deep Vertisols, now directed at soils with less assured moisture regimes. • Formalization of work on intensive program on soil and water conservation and identifying priority areas for FSR at ICRISAT Sahelian Center, Niger with much harsher environments. • On-farm evaluations now tested on 28 locations; 1406 farmers involved on 2122 ha. • Active participation discontinued in Taddanpalle, the first benchmark site. • World Bank clears four projects in Karnataka, Maharashtra, Madhya Pradesh and Andhra Pradesh for developing agriculture on watershed basis. Karnataka was the first state to constitute the Dryland Development Board.[1]
1985	• Resource Management Program formed out of Farming Systems and Economics and Policy programs that seek to integrate research over wide range of physical sciences through engineering and agronomy to economics and sociology. • RK Bansal brings out the Agribar manual. • Management of Vertisols for improved agricultural production: proceedings of an IBSRAM Inaugural Workshop, 18–22 Feb 1985.
1986	• Ghodake and Lalitha look at credit and Vertisol technology; whole farm model in Madhya Pradesh.
1986–87	• National Watershed Development Programme for Rainfed Areas (NWDPRA) launched in 99 districts in 16 states.[1]
1988	• Workshop on role of small watershed hydrology in rainfed agriculture by ICRISAT. • Queensland Department of Primary Industries (QDPI) collaboration work on Alfisols as the basis for the new Australian Centre for International Agricultural Research (ACIAR) modeling project on sustainable soil management on semi-arid farms.
1989	• Shift in emphasis from soil centered research to crop-resource centered research.
1990	• Wightman and Doppler look at the resource availability, impact of water management and decision mechanisms at Aurepalle watershed.
1991	• Whole issue on watershed in the Indian Journal of Agricultural Economics.[1] • Anders sends internal memo questioning data used for small watershed pamphlet and requests its discontinuation. • Workshop on Farmers' Practices and Soil and Water Conservation Programs.
1993	• Proceedings of Planning Meeting of CRIDA-ICRISAT Resource Management Program Collaborative Research Projects. • New Organization and Management for ICRISAT; shift to global research themes; adoption of the matrix approach. • Research Evaluation and Impact Assessment Workshop.

continued

Year	Activity
1995	• Development of experimental plans of selected benchmark sites for ISP 3 in Asia workshop. • Teamwork for NRM first initiated in BW7 watershed.
1996	• Virmani invited by the Government of India to be part of the working group on dryland and rainfed agricultural production.
1997	• ICRISAT, the Bharatiya Agro-Industries Foundation (BAIF), Deccan Development Society and the National Remote Sensing Agency (NRSA) had chosen to develop watersheds in Vidisha district of Madhya Pradesh and Zaheerabad district of Andhra Pradesh.
1998	• ADB project to ICRISAT for 3 years on improving management of natural resources for sustainable rainfed agriculture.
1998–99	• 'Shake- down' technique of farmers for pest control evaluated at ICRISAT in 15 ha research watershed.
1999	• Sustaining Asian Rainfed Agricultural Production by Improved Management of Natural Resources IBSRAM-ICRISAT Planning Meeting. • ICRISAT-led consortium team on watershed starts functioning.
2000	• Mini-symposium on Watershed on 18 January 2000 at ICRISAT, Patancheru to discuss long-term watershed experiments. • Traveling Workshop-cum-Field Visit to Benchmark Watersheds during 27 August–12 September 2000 at the Vietnam Agricultural Science Institute (VASI), Vietnam, Khon Kaen University, Bangkok, BAIF, Bhopal, IISS, Bhopal and ICRISAT, Patancheru.
2001	• Brain Storming Workshop on Policy and Institutional Options for Sustainable Management of Watersheds during 1 and 2 November 2001 at ICRISAT, Patancheru.
2002	• ADB project completed, new ADB project on participatory watershed management approved. Nuclear watersheds for scaling-up the consortium model for integrated watershed management established in Andhra Pradesh, Madhya Pradesh and Rajasthan with support from APRLP-DFID (Andhra Pradesh Rural Livelihoods Programme–Department for International Development, UK) and Sir Dorabji Tata Trust. • Team wins Best Resource Mobilizer Award for 2002 at ICRISAT. • International workshop on methods for assessing impacts of NRM research. • Review and Planning Meeting of ADB Project during 23 February to 3 March 2002 at Vietnam and Thailand. • ICRISAT-IWMI (International Water Management Institute) jointly initiated the study on Socioeconomic and Policy Research in Watershed Management in India: Synthesis of Past Experiences and Needs for Future Research. • Tata-ICRISAT Project Launching and Planning Workshop "Combating Land Degradation and Increasing Productivity in Madhya Pradesh and Eastern Rajasthan" during 26–27 March 2002 at ICRISAT, Patancheru. Subsequently State-level Project Launching Workshops in Madhya Pradesh and Rajasthan involving State leaders, Government Departments, NGOs and consortium partners were held.

continued

Year	Activity
	• Review and Planning Meeting for the Convergence in APRLP Watersheds on 19 August 2002 at ICRISAT, Patancheru. • Brain Storming Workshop on Coping Strategies for Drought Management during 19–21 November 2002 at ICRISAT, Patancheru. • APRLP-Orientation Workshop at ICRISAT, Patancheru on 11–12 February 2002.
2003	• Team Building Workshops on 18 January, 28 January, 29 January, 31 January and 1 February 2003 at ICRISAT, Patancheru. • State-level Institute's Farmers Day on 1 October 2003 at Govardhanpura in Hindoli Block of Bundi District of Rajasthan in partnership with Rajasthan State Government. • ADB Project Inception and Planning Workshop on Participatory Watershed Management for Reducing Poverty and Land Degradation in SAT Asia [RETA 6067] during 7–9 April 2003 in Bangkok, Thailand. • Project Inception and Planning Workshop on Water Scarcity and Food Security in Tropical Rainfed Water Scarcity Systems: A Multi-level Assessment of Existing Conditions, Response Options and Future Potentials during 11–12 September 2003 at ICRISAT, Patancheru. • Tata-ICRISAT Project Review and Planning Workshop on Combating Land Degradation and Increasing Productivity in Madhya Pradesh and Eastern Rajasthan during 29–30 April 2003 at ICRISAT, Patancheru. • NRM Team wins Best Resource Mobilizer Award for 2003 at ICRISAT.
2004	• National Workshop on Drought Management Strategies: Lessons from the APRLP-ICRISAT Project during 18–19 March 2004 at ICRISAT, Patancheru. • Tata-ICRISAT-ICAR Workshop on Combating Land Degradation and Increasing Productivity in Madhya Pradesh and Eastern Rajasthan during 21–23 April 2004. • ADB Review and Planning Workshop on Participatory Watershed Management for Reducing Poverty and Land Degradation in SAT Asia [RETA 6067] during 6–8 May 2004 at ICRISAT, Patancheru. • Team wins Doreen Margaret Mashler Award for 2004. • Team wins CGIAR Outstanding Support Team Award for 2004.

1. Developments outside ICRISAT.

Acronyms

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AICRPDA	All India Coordinated Research Project on Dryland Agriculture
APAU	Andhra Pradesh Agricultural University
APRLP	Andhra Pradesh Rural Livelihoods Programme
BAIF	Bharatiya Agro-Industries Foundation
BBF	broad-bed and furrow
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CRIDA	Central Research Institute for Dryland Agriculture
CSWCTRI	Central Soil and Water Conservation Research and Training Institute
DFID	Department for International Development, UK
DPAP	Drought Prone Area Programme
FSR	Farming Systems Research
IARC	international agricultural research center
IBSRAM	International Board for Soil Research and Management
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IISS	Indian Institute of Soil Science
INRM	integrated natural resources management
ISP	Integrated Systems Project
IVMT	Integrated Vertisol Management Technology
IWMI	International Water Management Institute
JIRCAS	Japan International Research Center for Agricultural Sciences
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya
MVF	M Venkatarangaiah Foundation
MYRADA	Mysore Resettlement and Development Agency
NARS	national agricultural research system
NGO	non-government organization
NRM	natural resource management
NRSA	National Remote Sensing Agency
NWDP	National Watershed Development Programme
NWDPRA	National Watershed Development Programme for Rainfed Areas
QDPI	Queensland Department of Primary Industries
REEDS	Research in Environment, Education and Development Society
RUR	Resource Utilization Research
SACD	Soils and Agroclimatology Division
SAT	semi-arid tropics
SIT	steps in improved technology
SWC	soil and water conservation
TAC	Technical Advisory Committee
VASI	Vietnam Agricultural Science Institute
WBR	watershed-based research

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political, international organization for science-based agricultural development. ICRISAT conducts research on sorghum, pearl millet, chickpea, pigeonpea and groundnut – crops that support the livelihoods of the poorest of the poor in the semi-arid tropics encompassing 48 countries. ICRISAT also shares information and knowledge through capacity building, publications and information and communication technologies (ICTs). Established in 1972, it is one of 15 Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

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