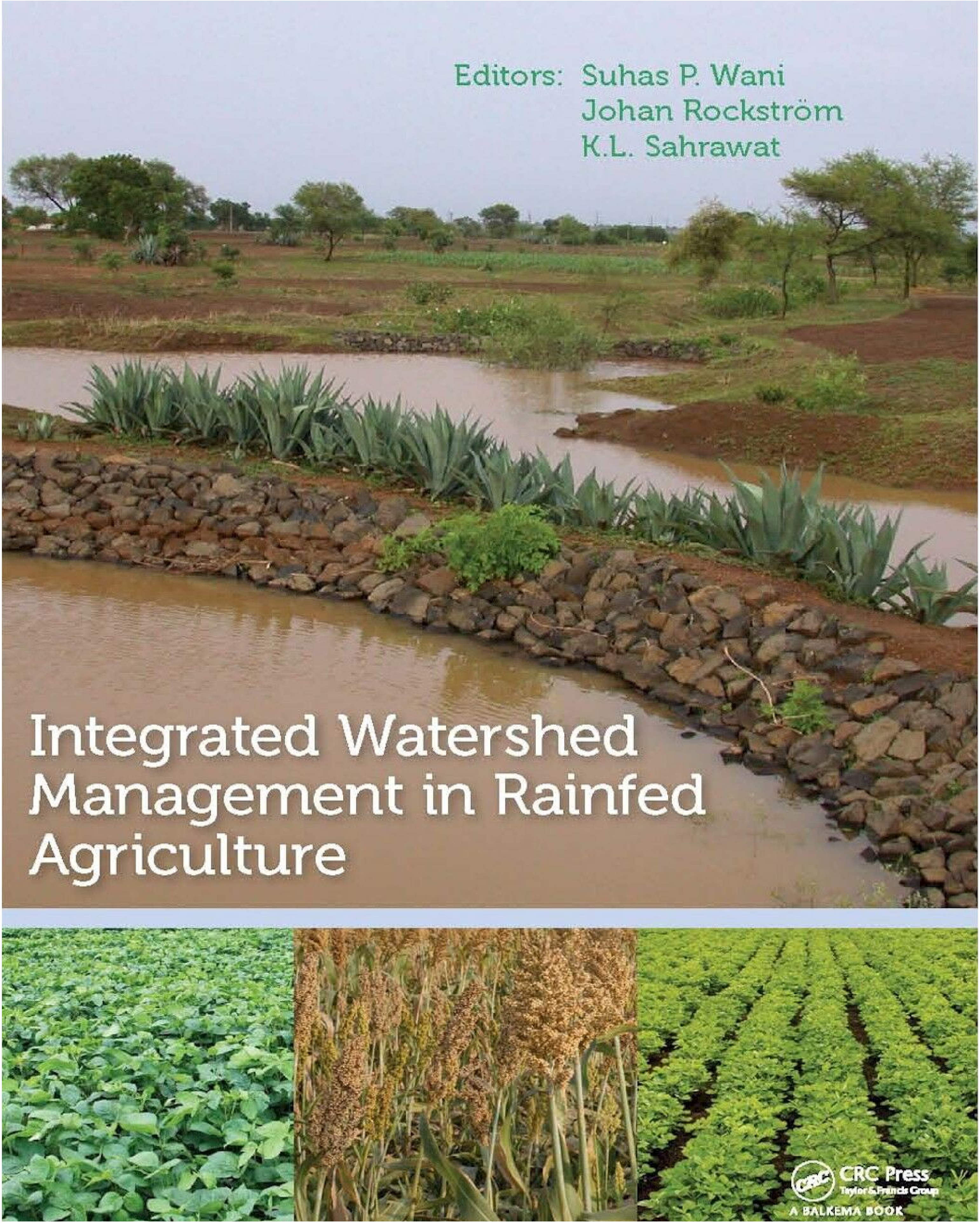
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Chapter 3

Watershed development for rainfed areas: Concept, principles, and approaches

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3.1 INTRODUCTION

Land, water, and vegetation are the natural resources, which provide food, feed, fiber, and fuel needs for the survival of human beings. However, the growing biotic pressure and overexploitation of the natural resources are leading to their accelerated degradation, resulting in reduced productivity. The sustainable management of natural resources is the key for the sustenance and well-being of human beings. Water is a finite resource and an elixir of life; however, water is becoming scarce due its overexploitation to meet the demands of the ever increasing demographic pressure. Agriculture is a major consumer (75–80%) of water for food production globally. For meeting the food demand of the growing global population by 2025, it is estimated that additional 2000 km^3 water will be required with the current practices of food production (Falkenmark 1986). An integrated approach to rainwater management is necessary, where the links are addressed between investments and risk reduction, between land, water, and crop, and between rainwater management and multiple livelihood strategies. The conservation linked development of vital natural resources on a sustained basis without impairing its productivity for the future generation is the need of the hour. In this context, watershed scale becomes very effective and handy to manage water and land resources effectively, particularly in the drought-prone rainfed areas, which are the hot-spots of poverty, malnutrition, and water scarcity and are prone to severe land degradation (Wani *et al.*, 2003a, 2009; Rockström *et al.*, 2007, 2009, 2010). For sustainable development of rainfed agriculture in tropical Asia and Africa, small catchment or watershed management approach is recommended for the sustainable development and to achieve food security through enhanced green water (rainwater stored as soil moisture) and blue water (runoff water harvested in tanks and groundwater) use efficiency (Wani *et al.*, 2002, 2009; Rockström *et al.*, 2007, 2010).

3.2 WATERSHED CONCEPT

A watershed is a catchment area from which all water drains into a common point, making it an attractive hydrological unit to manage water and soil resources through science-based technical management options. Along with water and soil, biodiversity also can be effectively managed at the watershed scale to harness the agroecological potential on a sustainable basis (Wani and Garg 2009). Watershed is a spatial unit that includes diverse natural resources (soil, water, trees, biodiversity, etc.) that are unevenly distributed within a given geographical area (Knox and Gupta 2000; Johnson *et al.*, 2002). The water flowing in a watershed interconnects upstream and downstream areas, and provides life support to rural people holding unequal use rights, making people and animals an integral part of watersheds (Wani *et al.*, 2010). Activities of people/animals affect the health and sustainability of watersheds and vice versa. Clearly, watersheds are geologically, ecologically, and socially complex geographical units characterized by temporal and spatial interdependence among resources as well as resource users. Watersheds are also inhabited by socially and economically heterogeneous groups of people located at different points along the terrain, creating potential conflicts in the resource use among those on the upper, middle, and lower reaches of the catchment. This implies that the effectiveness of the watershed interventions will depend on the ability to treat the entire hydrological landscape, following the ridge to valley approach and not just a part of it. In a watershed, along with the on-site impacts, there are off-site impacts also. The quality and status of land, water, and vegetation vary as per the toposequence position; and appropriate management practices are needed for their development and sustainable use as per their capability. For practical purposes, a systematic scientific and rational approach would be to use watershed as the unit of planning and development, and to achieve this objective a framework for the watershed is a prerequisite.

The terms catchment, sub-catchment, and watershed are often synonymously employed, defined by a single river system and further grouped into macro, meso, and micro level in a hierarchical system for management using a codification system linking different levels. It is thus essential to have a hierarchical system of delineating bigger hydrological units into watersheds, and also a codification system needs to be developed so that each watershed could be identified as an individual entity without losing linkage with the bigger units, i.e., catchments, sub-catchment, etc., to which it belongs. The size of the smallest hydrological unit while delineating a bigger system into watersheds/sub-watersheds/micro-watersheds could be restricted to viable size dictated by the working feasibility. In general, the area under different categories covered is 30–50 km^2 for sub-watershed, 10–30 km^2 for mini-watershed, 5–10 km^2 for micro-watershed, and 500–5000 ha for the implementation unit.

The concept of stream order is often followed in the geomorphic analysis of the natural drainage system. Every stream, tributary, or river has an associated watershed, and small watersheds aggregate together to become a larger watershed. Water travels from headwater to the downward location and meets with similar strength of stream, then it forms one order higher stream as shown in Figure 3.1.

The stream order is a measure of the degree of stream branching within a watershed. Each length of stream is indicated by its order (for example, first-order, second-order, etc.). The start or headwaters of a stream, with no other streams flowing into it, is called the first-order stream. First-order streams flow together to form a second-order stream. Second-order streams flow into a third-order stream and so on. Stream order describes the relative location of the reach in the watershed. Identification of stream order is useful to assess the amount of water availability in reach and its quality; stream orders are also used as criteria to divide a larger watershed into smaller units. Moreover, the criteria for selecting the watershed size also depend on the objectives

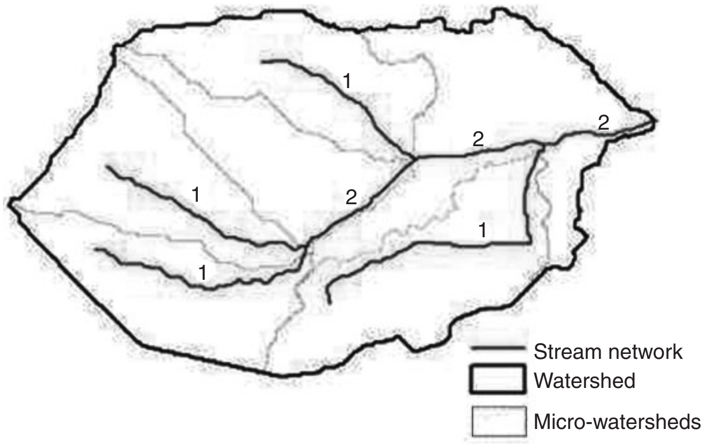

Figure 3.1 A large watershed divided into six micro-watersheds based on stream order (Note: Numbers on the stream network show the stream order of respective stream) (Source: Wani and Garg 2009)

for development and terrain slope. A large watershed can be managed in plain valley areas or where forest or pasture development is the main objective (Singh 2000). In hilly areas or where intensive agriculture development is planned, the size of watershed relatively preferred is small.

Moreover, because of the lateral and downhill movement of soil and water resources unilateral action taken by any single resource user may impose positive or negative consequences (externalities) on any other resource user. The ability to exclude or prevent these externalities is determined by the nature of property rights held by the resource users. When negative externalities are difficult to exclude or prevent at a low cost, some of the production and resource use decisions for certain resources may fall under the control of other agents. When the externalities are negative, the production or resource use levels may be socially supra optimal. The reverse is true for desirable externalities for which the individual resource users are not fully compensated. The ability to internalize these kinds of mutual spillover effects resulting from spatial and temporal interdependence among resource users requires interventions mediated through targeted policies and institutional incentives that encourage cooperation and collective action. Fragmented land ownership and the settlement patterns coupled with unequal access and use rights create conflict and diverging interests. This reduces the incentives for cooperation and increases the transaction costs involved in organizing the resource users for collective action (Shiferaw *et al.*, 2009).

However, a participatory framework of watershed development calls for a different approach, indicative of macro- and micro-level of delineation encompassing different communities and administrative units, avoiding social conflicts. Considering the role of communities and importance of their participation for sustainable development of the watersheds in India, watersheds of 500 ha were used for development in India as community watersheds covering one village or a cluster of inhabitations.

However, through the meta analysis of available data, it was found that small watersheds were not as effective in terms of economic, environmental, and social impacts as were the larger watersheds of >1200 ha (Joshi *et al.*, 2005, 2008; Wani *et al.*, 2008a). The Common Watershed Guidelines released by the Government of India (2008) adopted larger size (1000–5000 ha) of watersheds by developing them in clusters. Each of the big drainage system is divided and sub-divided through stages using different codes to indicate various stages starting with macro-level and going down to micro-level.

In recent years, watershed management has become the focal point of agricultural and rural development in rainfed areas with the objective of livelihood enhancement. Watershed development is fundamentally the creation of new opportunities both in an institutional sense and ecologically feasible manner. The ultimate indicator of success is the ability of communities to take advantage of new opportunities and the extent to which benefits are sustained in the long-term. Today, the concept of integrated watershed management (IWM) is recognized to go beyond traditional technical interventions for soil and water conservation, to include multiple crop-livestock-tree, and market related innovations that support and diversify livelihoods to build the resilience against changes in the future, including those by globalization and climate change (Wani *et al.*, 2008b). The concept ties together the biophysical notion of a watershed as a hydrological unit with that of the community and institutional factors that regulate the demand and determine the viability and sustainability of such interventions. The hydrological approach helps to identify the appropriate technical interventions on the supply side, while the village or community-based planning and implementation is fundamental for creating institutions for community empowerment and sustainability on the demand side (Shiferaw *et al.*, 2009). The landscape level, but community-based IWM interventions create synergies among targeted technologies, policies, and institutions that improve productivity, resource use sustainability, and market access for the resource users.

Integrated watershed management has become an approach integrating sustainable management of natural resources through collective action of the resource users for improving livelihoods of people in harmony with nature rather than a mere unit for managing natural resources and has shown the potential for scaling-out the benefits ensuring community participation, due largely as a result of the tangible economic benefits as well as capacity development through knowledge sharing (Farrington and Lobo 1997; Wani *et al.*, 2000, 2003a).

3.3 IMPORTANCE OF LAND USE PLANNING INWATERSHED DEVELOPMENT

The unevenly distributed, diverse, and interconnected natural resources and interdependence of human beings and animals for their living and sustainability calls for proper planning for the development, management, and use of land resources. Adinarayana (2008) employed Watershed Management Information System (WATMIS) to evaluate the agroecological characteristics using primary data, soil erosion assessment, and aspects of conservation management. Data from various sources such as National Bureau of Soil Survey and Land Use Planning (NBSSLUP), remote sensing, groundwater, agriculture, forestry, rural development departments, and markets can be effectively used with the help of geographical information systems (GIS), simulation models (crop, water, soil loss, runoff), and bioeconometric models for the sustainable development and management of watersheds (Wani *et al.*, 2008a, 2008b, 2009).

3.4 CRITERIA FOR PRIORITIZATION OF WATERSHEDS

One of the conventional approaches for prioritization of the watershed was based on the silt yield index (SYI) method developed by the All India Soil and Land Use Survey (AISLUS), which consumed a lot of time and sizable human and financial resources. Sidhu *et al.* (1998) used these approaches and prioritized the development of detailed work plan for watersheds. To provide efficient framework of watersheds in the country, AISLUS first developed Watershed Atlas of India comprising 17 sheets at a 1:1 million scale. The country was hydrologically demarcated into six major water resource regions, 35 river basins, 112 catchments, 500 sub-catchments, and 3237 watersheds. Subsequently, Digital Watershed Atlas of India was developed by the organization for a GIS-based Web service on watershed, soil, and land information.

Andhra Pradesh Rural Livelihoods Programme (APRLP) adopted integrated watershed development approach to improve rural livelihoods in Andhra Pradesh, India and devised a nine-point selection criteria (Sreedevi and Wani 2009) for watersheds, integrating the natural resource degradation criteria with multiple deprivation criteria (social and material deprivation) to arrive at reliable indicators for both technical and social features (Table 3.1). Micro- and macro-watersheds were identified and prioritized based on the SYI indicators of land degradation due to erosion and the dependability of rainfall and evapotranspiration, which depend on the variability and deviation of rainfall. Multiple deprivation criteria include the indices of poverty, considering the multiple dimensions of poverty as reflected in deprivation of income, accessibility to services, and social status. Since APRLP took a holistic view of people towards their livelihoods and opportunities, it integrated the indices of natural resource degradation and multiple deprivations, and a matrix was drawn up where each parameter was given equal importance while selecting the watersheds. A probation period of up to 18 months was made mandatory for the capacity building plans for the primary and secondary stakeholders and the preparation of strategic (perspective plan for 5 years) and annual action plans. Thus, it is a farmer-friendly Participatory Net Planning (PNP) approach (Sreedevi and Wani 2009).

The IWM program has adopted similar criteria for prioritizing the watersheds in different states in India as well as for prioritizing and allocating the financial resources for the program. Higher priority and weightage is given to the extent of rainfed area in the state, level of poverty, drinking water and groundwater status, low crop yields, poverty index [people in the categories of below poverty line (BPL), scheduled caste (SC)/scheduled tribe (ST), etc.], area owned by small and marginal farmers, SC/ST and BPL people, contiguity to the already treated/ongoing watersheds, the extent of treatable common property resources, and willingness of the villagers to participate, contribute, and support the program.

Table 3.1 Nine-point criteria for the selection of watersheds under APRLP in Andhra Pradesh, India[a]

Parameters	*Range*	*Mark*	*Weightage*
% of small and marginal farmers	<25	5	
	>25 to 50	10	
	>50	15	15
% of SC/ST holdings	<10	3	
	>10 to 25	10	10
% of women organized in self-help groups and participating in the program	<20	3	
	>20 to 50	5	
	>50	10	10
Status of groundwater (m)	<10	2	
	>10 to 15	3	
	>15	5	5
Andhra Pradesh Remote-sensing Application Centre (APSRAC) prioritization	Very low	6	
	Low	12	
	Medium	18	
	High	24	
	Very high	30	30
Livestock population	<1000	2	
	>1000 to <2000	3	
	>2000	5	5
Number of families affected/involved in migration	<50	3	
	>50 to <100	5	
	>100	10	10
Contiguity	Yes	5	
	No	0	5
Availability of fallow/wasteland and common property resources for the poor to utilize usufruct (%)	<10	3	
	>10 to <20	5	
	>20	10	10
Total			100

[a]Source: Sreedevi and Wani (2009).

3.5 COMMON FEATURES OF THE WATERSHED DEVELOPMENT MODEL

Government agencies, development thinkers, donors, researchers and non-government organizations (NGOs) have gradually learnt from each other and evolved the watershed management approach (though some are ahead in the field and others deficient in some aspect or other, principally in people participation or in the science). But in general nowadays, the improved models have some or all of the following features in common (Wani *et al.*, 2008a):

- Participation of the villagers as individuals, as groups or as a whole, improving their confidence level, enabling their empowerment and ability to plan for the future with self-determination;
- Capturing the power of group action in the village, among villages, and from the federations, e.g., capturing economies of scale by collective marketing;

- Construction of basic infrastructure with contributions in cash or as labor from the community;
- Better farming techniques, notably the improved practices for the management of soil, water, diversifying the farming systems, and integrating the joint management of communal areas and forest;
- Involvement of the landless, often in providing services;
- Arrangements for the provision of basic services and infrastructure;
- Establishment of village institutions and their linking with the outside world;
- Improved relationships between men and women;
- Employment and income generation through enterprise development predominantly in but not exclusively agricultural-related activities.

And in some instances:

- The fusion of research and development (R&D) by capturing the extraordinary power of participatory technology development, including varietal selection with direct links to germplasm collections as has happened in the case of the establishment of model watersheds as well as some of the internationally funded watershed programs, for example, the APRLP project supported by Department for International Develoment (DFID), UK, the World Bank-funded Sujala Watershed Development Program in Karnataka, India, and the Integrated Watershed Development Program supported by Asian Development Bank (ADB), Manila, the Philippines in Thailand, Vietnam, China, and India implemented by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT);
- A complete avoidance of corruption so that the trust is built and all the benefits are passed on to the community;
- Reduction in distress migration from the rural areas to towns in search of a livelihood.

Recent additions to the watershed model:

- A pragmatic use of the scientific knowledge as the entry point rather than money, leading to tangible economic benefit from low-cost interventions that generate rapid and substantial returns for large number of people at low level of risk. Among these are novel interventions focusing on seeds of improved cultivars, the assessment of soil fertility status, integrated pest management (IPM), micronutrients, and soil conservation and water table recharge structures (Wani *et al.*, 2003a, 2008b; Dixit *et al.*, 2007).
- A broad-based approach to income generation, involving private sector associated with scientific advances and markets; for instance, in the remediation of micronutrient deficiencies; in marketing of the products from medicinal and aromatic plants; with premium payments paid by industrial processors for aflatoxin-free maize and groundnut; with high sugar sorghum, and selected crops such as *Jatropha* and *Pongamia* sold to industry for ethanol and bio-diesel production; with the production for sale of commercial seed, hybrid varieties, and biopesticides (Wani *et al.*, 2003a; Sreedevi and Wani 2009).

- Employing remote sensing, GIS, and simulation modeling for planning, execution, and monitoring and to provide feedback to farmers; yield gap analysis and rapid assessment of the fertility status of watersheds to improve productivity (Wani *et al.*, 2009).
- Building the capacity of the formal and informal rural institutions through bottom-up approach with emphasis on owning of the program from the beginning for sustainability. The consortium partners have come up with an innovative model of "Advisory Council" (*Salaha Samithi*) in addition to the watershed committee, at the watershed level, for transparency, equity, gender related issues, and conflict resolving.
- Building productive partnership and alliance in a consortium model for conducting research and technical backstopping and for this the members of the consortium work together right from the planning stage (Wani *et al.*, 2003a, 2008b, 2009).
- Focus to build resilience in the watershed and its community against climate change and events of the post-program intervention (Wani *et al.*, 2008a).

Where implemented properly, the model has led to profound changes in the farming systems including improved food self-sufficiency, enhanced employment, commerce and income. Where indifferently executed, the approach has not brought desirable results to the community. Thus, yield gap is observed between research station and farmers' yields. Much of the difference can be captured by the implementing agencies by adopting the best practice. The more recent linking of natural resource science with private sector markets and with peoples' broader livelihoods in consultation with them, has been transforming the dynamic and success rate of the developmental efforts (Wani *et al.*, 2008a).

3.6 EVOLUTION OF WATERSHED DEVELOPMENT APPROACH IN INDIA

In the beginning, watershed development in the rainfed areas was synonymous to soil and water conservation and was achieved by constructing field bunds and structures to harvest runoff water (Singh *et al.*, 1998; Wani *et al.*, 2002). In these activities, the techno-centric, compartmental, and target-oriented approaches were followed by involving one or two departments of the Government without much coordination. It was a top-down target-based approach with hardly any involvement of the stakeholders in the planning, implementation, and maintenance of the structures and bunds. Hence, such efforts did not make headway in impacting livelihoods of the rural poor in the rainfed areas (Farrington and Lobo 1997; Joshi *et al.*, 2000; Dixit *et al.*, 2001; Kerr 2001; Wani *et al.*, 2002; Kerr and Chung 2005; Shah 2007).

Rainfall pattern in the tropical and subtropical rainfed areas is highly variable both in terms of total amount and distribution. This leads to moisture stress during critical stages of crop production and makes agriculture production vulnerable to pre- and post-production risks. Watershed development projects in India have been sponsored and implemented by the Government from early 1970s onwards. The phases in the journey through the evolution of watershed approach are shown in Figure 3.2 (Wani *et al.*, 2005, 2006a). Various watershed development programs like Drought Prone

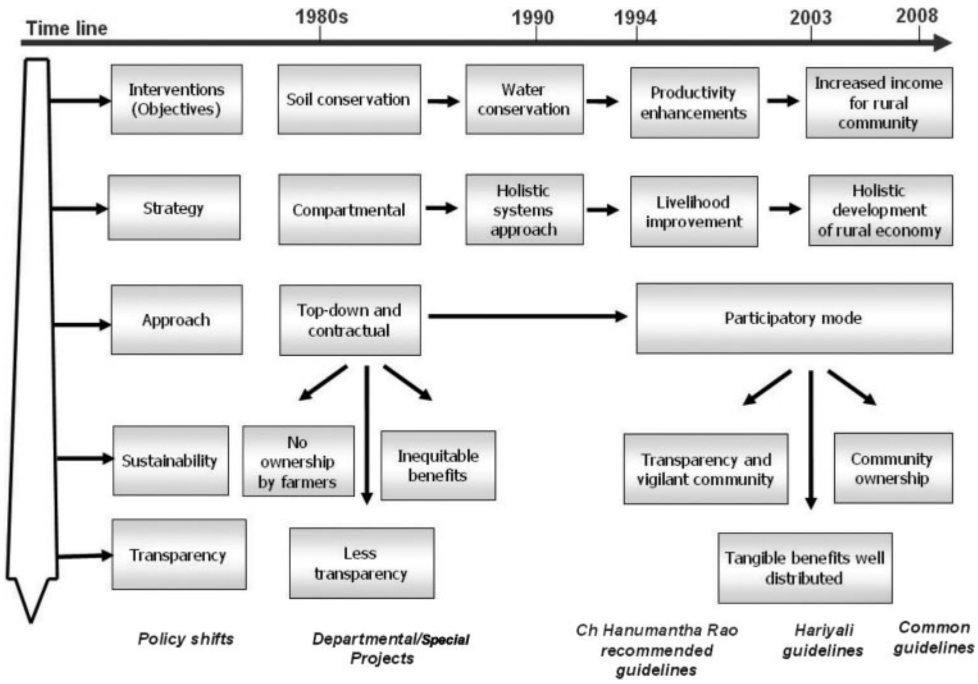

Figure 3.2 Journey through watershed approach in India (Source: Wani *et al.*, 2005, 2006a)

Area Programme (DPAP), Desert Development Programme (DDP), River Valley Project (RVP), National Watershed Development Project for Rainfed Areas (NWDPRA), and Integrated Wasteland Development Programme (IWDP) were launched subsequently in various hydro-ecological regions consistently affected by water stress and drought like situations. The entire watershed development program was primarily focused on structure-driven compartmental approach of soil conservation and rainwater harvesting during 1980s and benefited a few well to do farmers through increased groundwater availability. In spite of putting efforts for maintaining soil conservation practices (contour bunding, pits excavation, grassed waterways, etc.), the farmers used to plow through the structures from their fields. It showed that a straightjacket top-down approach cannot bring desired impact in watersheds and a mix of the individual- and community-based interventions are essential along with the productivity enhancement measures to ensure tangible benefits to small farm holders.

The integrated watershed development program with participatory approach was emphasized during the mid 1980s and in the early 1990s. This approach had focused on raising crop productivity and livelihood improvement in watersheds (Wani *et al.*, 2006b) along with the implementation of soil and water conservation measures. The Government of India appointed a committee in 1994 under the chairmanship of Prof. C.H. Hanumantha Rao, which strongly felt a need to move away from the conventional government department approach based on bureaucratic planning without involving the local communities (Raju *et al.*, 2008). The new guidelines were recommended in 1995, which emphasized collective action and community participation, including participation of the primary stakeholders through community-based organizations (CBOs), NGOs, and Panchayat Raj Institutions (PRIs) (GOI 1994, 2008; Hanumantha Rao *et al.*, 2000; DOLR 2003; Joshi *et al.*, 2008). The watershed development guidelines were again revised in 2001 (called Hariyali guidelines) to further simplify and facilitate the involvement of PRIs more meaningfully in planning, implementation, and evaluation, and in the community empowerment (Raju *et al.*, 2008). The guidelines were issued in 2003 (DOLR 2003). Subsequently, "Neeranchal Committee" (2005) evaluated the entire government-sponsored, NGO and donor-implemented watershed development programs in India and suggested a shift in focus "away from a purely engineering and structural focus to a deeper concern with livelihood issues" (Raju *et al.*, 2008).

Appreciating the fact that to reduce poverty in the rainfed areas holistic watershed development is a must (Wani *et al.*, 2003a, 2009; Rockström *et al.*, 2007, 2010), the new generation of watershed development programs are implemented with a larger aim to address the problems such as food security, equity, poverty, gender, severe land degradation, and water scarcity in the dryland areas. Hence, in the new approach, watershed, a land unit to manage water resources has been adopted as a planning unit to manage total natural resources of the area. Improving livelihoods of local communities is highlighted by realizing the fact that in the absence of them, sustainable natural resource management (NRM) would be elusive. With these considerations, the watershed programs have been looking beyond soil and water conservation into a range of activities from productivity enhancement through interventions in agriculture, horticulture, animal husbandry, livelihoods, community organization, and gender equity (Wani *et al.*, 2002; APRLP 2007; GOI 2008). This holistic approach required optimal contribution from different disciplinary backgrounds, creating a demand for multi-stakeholder agenda in the watershed development programs (Wani *et al.*, 2002, 2003b).

During 1990s, there has been a paradigm shift in the thinking of policy makers based on the learnings from the earlier programs. In India, the watershed programs are silently revolutionizing agriculture in the rainfed areas (Joshi *et al.*, 2005; Wani *et al.*, 2006b); and by 2006 (up to 10th Five Year Plan) about US$7 billion have been invested by Government of India and other donor agencies treating 38 million ha in the country (Wani *et al.*, 2008b). During a detailed evaluation of the on-farm watershed programs implemented in the country, the ICRISAT team observed that once the project team withdrew from the villages the farmers reverted back to the earlier practices and very few components of the improved soil, water, and nutrient management options were adopted and followed. Although, the economic benefits of improved technologies were observed in the on-farm experiments, the adoption rates were quite low. Individual component technologies such as summer plowing, improved crop varieties, and intercropping were continued by the farmers. However, the soil and water conservation technologies were not much favored (Wani *et al.*, 2002).

The importance of the local community participation in the watershed programs to enhance their efficiency and sustainability has been widely acknowledged (Kerr *et al.*, 2000; Samra and Eswaran 2000; Wani *et al.*, 2002; Joshi *et al.*, 2004). As a result, through a series of policies and guidelines the responsibilities of managing the watershed programs have shifted towards the local communities. But achieving participation of the primary stakeholders has not been easy. One of the major learnings over a period of time has been that unless there is some tangible economic benefit to the community, peoples' participation does not come forth (Olson 1971; Wani *et al.*, 2002). To enhance community participation, it is necessary to achieve tangible impact of the watershed development activities. To achieve a tangible impact, it is necessary that different agencies such as research centers, development line departments of the Government, training institutions, CBOs, and NGOs come together and share their expertise in a complementary way through the convergence of approaches, actors, and actions (Wani *et al.*, 2002).

3.7 NEED FOR A HOLISTIC APPROACH FOR WATERSHED MANAGEMENT

The watershed implementing agencies have inbuilt strengths in community organization but majority of these agencies lack technical competencies in the development and management of natural resources. They depend heavily on the technical resource agencies for building capacities of their staff and the community members involved in NRM. Since different resource agencies have their compartmental specializations in specific areas, there is a lack of holistic approach in providing technical support to the NGOs, government line departments, and other implementing agencies, thereby affecting their performance in implementing the watershed programs. On the other hand, the research organizations are usually mandated to work at the individual farm level. Biophysical scientists often have limited experience in the dynamics of forming the collective action groups that is essential for watershed-based activities. However, with the approach of ultra disciplinary specialization (reductionist approach) and the lack of professional reward mechanisms in the research institutions, and disciplinary hierarchy, scientists are more comfortable to work in their own area of specialization rather than working in the multidisciplinary teams (Wani *et al.*, 2009). In projects that have been led by research centers, researchers seem to document results and findings mainly for the scientific sector (Gündel *et al.*, 2001). Focus on social organization is less in these programs, reducing their effectiveness. Government departments have their strengths in specific technical competencies and wider reach, but they lack skills in social organization. Traditionally, the watershed programs implemented by government departments have been supply-driven and target based. The Central and State governments allocated resources for watershed development. Subsequently, the officials used to identify locations and decide various activities for implementation. Such an approach did not match the needs of stakeholders in the watershed (Kerr *et al.*, 2000; Joshi *et al.*, 2004). Since these departments operate mostly in a compartmental way, integrated approach was lacking in such programs and thus desired success could not be achieved. Due to such deficiencies in capacities of the implementing agencies, most of the watershed programs failed to achieve optimal benefits (Farrington and Lobo 1997; Kerr and Chung 2005). This situation has strongly supported the idea of different agencies coming together to support watershed programs. But bringing together organizations with different strengths, weaknesses, and styles of functioning on a common platform to work together for a common cause is challenging. ICRISAT has successfully evolved a scalable model based on the 'Consortium Approach' through

ADB-supported watershed development program at Kothapally in Rangareddy district of Andhra Pradesh (Wani *et al.*, 2003a).

3.8 EVOLUTION OF THE CONSORTIUM APPROACH

ICRISAT was one of the earliest CGIAR (Consultative Group on International Agricultural Research) centers to give formal recognition in its mandate to supplement research on individual crops with research in farming systems. Watershed-based research was an example of interdisciplinary research even before the term assumed significance (Shambu Prasad *et al.*, 2005, 2006). This interdisciplinary research, over the years, has shaped up into an Integrated Genetic Natural Resources Management (IGNRM) approach at ICRISAT (Twomlow *et al.*, 2006). But in the beginning, ICRISAT also faced the problems of hierarchy of disciplines among scientists who were working together. After realizing the importance and potential of combining disciplinary expertise in a complementary way, such issues were sorted out which gave rise to the idea of the Consortium Approach based on the success of multidisciplinary approach at the research station (Wani *et al.*, 2003a).

The Consortium is a convergence of agencies/actors/stakeholders who have a significant role to play in the watershed development project. Facilitated by a leader/leading organization, member-organizations prepare common plans and work towards achieving the agreed common objectives. After witnessing ICRISAT's pioneering and quality work and its results, many agencies approached ICRISAT for sharing of the knowledge/approach/technology in their areas. It was decided to work along with the reputed NGOs in the on-farm watersheds, which much helped in strengthening the idea of the Consortium Approach.

The ADB-supported project enabled ICRISAT to test the integrated watershed model at Kothapally village of Rangareddy district in Andhra Pradesh, to attempt to minimize the gap between research findings and on-farm development. The purpose of the work was also to adopt the learning loop in the planning of strategic research based on the participatory model in the research for development. There was also a request from the Government of Andhra Pradesh to demonstrate the benefits by increasing crop productivity through watershed approach in the rainfed areas under farmers' conditions. The beginning itself of this work was highly encouraging as there was a demand for demonstrating the success of the new approach of watershed development on farmers' fields and space was created for innovations in the ongoing DPAP under the watershed program by the Government of Andhra Pradesh.

For this model, as opposed to single institution based approach, relevant organizations were identified and brought into the network to form a consortium of institutions for technical backstopping of the project. ICRISAT, M Venkatarangiah Foundation (MVF), an NGO, Central Research Institute for Dryland Agriculture (CRIDA), National Remote Sensing Agency (NRSA), and DPAP, now called the District Water Management Agency (DWMA), Rangareddy district administration of the Government of Andhra Pradesh along with farmers of the watershed formed the consortium (Figure 3.3) (Wani *et al.*, 2003a).

The first success of the new approach was evident when more number of farmers came forward to undertake the participatory evaluation of the technologies for which

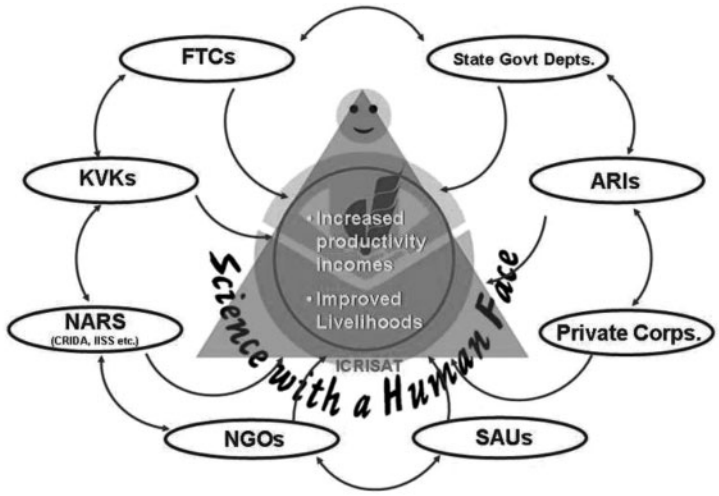

Figure 3.3 A pictorial representation of different partners in the Adarsha Watershed Consortium (See color plate section)

except for the knowledge, farmers had to pay for inputs in cash or kind. Farmers obtained threefold increase in the yields of pigeonpea and other crops in the first rainy season itself (Table 3.2). During the second year, people from four villages surrounding Kothapally came to ICRISAT and asked for technical help, promising that they would show similar or better results than shown by Kothapally farmers, in a shorter period. This indicated to the Consortium team members that the approach was self-replicating as people from the surrounding villages saw tangible benefits from the approach. ICRISAT and DWMA of Rangareddy district decided to provide technical support and necessary inputs on a cost basis to these four villages. True to their words, the villagers demonstrated the benefits in terms of doubling their crop productivity (Table 3.3). The model has become a success story and henceforth the model has been suitably adapted and scaled-up/out in many other locations.

3.9 COMPONENTS OF INTEGRATED WATERSHED MANAGEMENT

3.9.1 Entry Point Activity

Entry Point Activity (EPA) is the first formal project intervention, which is undertaken after the transect walk, selection, and finalization of the watershed. It is highly recommended to use the knowledge-based EPA to build the rapport with the community (Wani *et al.*, 2002, 2008a). Direct cash-based EPA must be avoided as such activities give a wrong signal to the community at the beginning of the implementation of various interventions. A detailed discussion on the knowledge-based EPA to build rapport with the community ensuring tangible economic benefits to the community members is provided by Dixit *et al.* (2008).

Table 3.2 Average crop yields with different practices at Adarsha watershed, Kothapally, 1999–2009[a]

	Yield (kg ha^{-1})													
Cropping system	*Before 1998*	*1999–2000*	*2000–01*	*2001–02*	*2002–03*	*2003–04*	*2004–05*	*2005–06*	*2006–07*	*2007–08*	*2008–09*	*Mean*	*CV (%)*	*SE ±*
Improved system														
Sole maize	–	3250	3760	3300	3480	3920	3420	3920	3630	4680	4810	3820	17.8	80
Maize/Pigeonpea intercrop system	–	5260	6480	5600	5650	6290	4990	6390	6170	6120	6680	5960	16.7	116
Sorghum/ Pigeonpea intercrop system	–	5010	6520	5830	–	5780	4790	5290	5310	–	–	5500	13.4	154
Sole sorghum	–	4360	4590	3570	2960	2740	3020	2860	2500	–	–	3330	23.9	141
Farmers' practice														
Sole maize	1500	1700	1600	1600	1800	2040	1950	2250	2150	–	–	1890	17.2	53
Sorghum/ Pigeonpea intercrop system	1980	2330	2170	2750	3190	3310	3000	3360	3120	–	–	2900	19.2	110
Hybrid cotton	–	2295	7050	6600	6490	6950	–	–	–	–	–	5880	37.0	511
BT cotton	–	–	–	–	–	–	–	6210	5590	7310	9380	7120	26.1	315
Mean		3477	4970	3833	4018	4814	3651	4584	4320	6268	7396			
CV (%)		11.9	31.4	10.7	8.0	14.5	20.3	10.8	12.2	16.7	16.2			
SE ±		415	1559	410	323	698	742	495	525	1049	1201			

[a]Source: Updated from Wani *et al.* (2008b).
In Sorghum/Pigeonpea intercrop system with farmers' practice, the improved pigeonpea variety ICPL 87119 was grown along with local sorghum variety Pacha Jonna from 2001; pigeonpea variety used earlier was discontinued as it was highly susceptible to fusarium wilt.

Table 3.3 Crop response to the improved management practices in 98 farmers' fields in four villages around Kothapally watershed, Andhra Pradesh, India in 2001 rainy season and 2001–02 postrainy season[a]

			Maize yield (kg ha^{-1})	
Cropping system	*Farmers' practice (kg ha^{-1})*	*Improved practice (improved seed + management) (kg ha^{-1})*	*Farmers' practice*	*Improved practice*
Maize/Pigeonpea				
Maize	1900	4365	1900	4365
Pigeonpea	350	1130	1240	3995
Sorghum/Pigeonpea				
Sorghum	1200	2725	1755	3990
Pigeonpea	330	1185	1170	4190
Maize/Chickpea				
Maize	2200	4800	2200	4800
Chickpea	650	1085	2380	3870

[a]Derived from Wani *et al.* (2009).

Table 3.4 Farmers' fields deficient in plant nutrients in various states of India[a]

			Farmers' fields (%) deficient[b]					
State	*No. of districts*	*No. of farmers*	*OC*	*Av P (ppm)*	*Av K (ppm)*	*Av S (ppm)*	*Av B (ppm)*	*Av Zn (ppm)*
Andhra Pradesh	11	3650	76	38	12	79	85	69
Gujarat	1	82	12	60	10	46	100	85
Jharkhand	2	115	42	65	50	77	97	71
Karnataka	10	27500	70	46	21	84	67	55
Kerala	3	28	11	21	7	96	100	18
Madhya Pradesh	12	341	22	74	1	74	79	66
Rajasthan	9	421	38	45	15	71	56	46
Tamil Nadu	5	119	57	51	24	71	89	61
Total	53	32256	69	45	19	83	70	58

[a]OC = Organic carbon; Av P = Available phosphorus, Av K = Available potassium, Av S = Available sulfur, Av B = Available boron, Av Zn = Available zinc.
[b]Below critical limit for a particular nutrient.

During the process of scaling-out of the consortium model for APRLP of the Government of Andhra Pradesh supported by DFID, UK, in the states of Rajasthan, Madhya Pradesh, Gujarat and Karnataka, supported by Sir Dorabji Tata Trust, Mumbai, ADB, Sujala Watershed (program of Government of Karnataka supported by World Bank), the baseline characterization of soils in the watersheds was used as a knowledge-based EPA along with other EPAs. The analysis of a large number of soil samples from farmers' fields in various states of India revealed that soil resource base in the tropics is not only thirsty, but also hungry, especially for micronutrients like zinc (Zn) and boron (B) and secondary nutrients like sulfur (S), along with macronutrients including nitrogen (N) and phosphorus (P) (Table 3.4). About 80–100% farmers' fields

Table 3.5 Increase in crop productivity with micronutrient (MN) amendments in 50 watersheds in three districts of Andhra Pradesh, 2002

	Average grain yield (kg ha^{-1})		
Crop	*Control*	*MN treatment*[a]	*Yield increase (%) over control*
Maize	2800	4560	79
Mung bean	770	1110	51
Castor	470	760	61
Groundnut (pod)	1430	1825	28

[a]Micronutrients applied: boron (0.5 kg ha^{-1}), sulfur (30 kg ha^{-1}), and zinc (10 kg ha^{-1}).

Table 3.6 Increase in crop productivity with micronutrient amendments and recommended dose of macronutrients in 50 nucleus watersheds in Andhra Pradesh, 2003[a]

	Yield (kg ha^{-1})					
Crop	*Control (C)*	*Sulfur (S)*	*Boron (B)*	*Zinc (Zn)*	*C + SBZn*	*C + NP + SBZn*
Maize	2790	3510 (26)	3710 (33)	3710 (33)	4140 (49)	4890 (75)
Groundnut	830	930 (12)	1000 (20)	1060 (27)	1230 (48)	1490 (78)
Mung bean	900	1210 (33)	1130 (24)	1320 (46)	1390 (54)	1540 (70)
Sorghum	900	1190 (32)	1160 (29)	1330 (47)	1460 (62)	1970 (119)

[a]Source: Rego *et al.* (2007).
Figures in parentheses indicate yield increase (%) over control.

in several states of India were found critically deficient in Zn, B, and S (Sahrawat *et al.*, 2007). Subsequent follow-up participatory research and development (PR&D) trials in 50 micro-watersheds in Andhra Pradesh with amendments of Zn, B, and S increased yields by 30–174% for maize, 35–270% for sorghum, 28–179% for groundnut, 72–242% for pearl millet, and 97–204% for pigeonpea (Tables 3.5 and 3.6) (Rego *et al.*, 2007).

3.9.2 Land and water conservation practices

The implementation of soil and water conservation practices is basic in the watershed management program. These practices can be divided into two main categories: (1) In-situ, and (2) Ex-situ. Land and water conservation practices made within an agricultural field like construction of contour bunds, graded bunds, field bunds, terrace scoops, broad-bed and furrow (BBF) system and other soil moisture conservation practices are known as in-situ water management interventions. These practices minimize land degradation, improve soil health, and increase soil moisture availability and groundwater recharge. The construction of check-dams, farm ponds, and gully control structures, and pits excavation across the stream channel are known as ex-situ management interventions (Figure 3.4). Ex-situ watershed management practices reduce the peak discharge in order to reclaim gully formation and harvest substantial amount of runoff, which increases groundwater recharge and irrigation

Figure 3.4 Ex-situ water management in Andhra Pradesh, India. (left) A dugout farm pond at Guntimadugu watershed in Kadapa; (right) Mini percolation tank in Kothapally (See color plate section)

potential in the watersheds. Soil and water conservation measures for sustainable watershed management are dealt in detail in this volume by Pathak *et al.*

3.9.3 Integrated pest and nutrient management

Water alone cannot increase crop productivity to its potential level without other interventions. A balanced nutrient supply along with adequate moisture availability and pest and disease-free environment can increase agricultural production extremely compared to unmanaged land. Integrated nutrient management (INM) involves the integral use of organic manure, biological inputs such as biofertilizers, crop straw, and other plant and tree biomass materials along with the application of chemical fertilizer (both macro- and micronutrients). Integrated pest management involves the use of different crop pest control practices like cultural, biological, and chemical methods in a combined and compatible way to suppress pest infestations. Thus, the main goals of INM and IPM are to maintain soil fertility, manage pests and the environment so as to balance cost, benefit, public health, and environmental quality.

3.9.4 Farmers' participatory research and development trials

The PR&D approach helps in empowering and capacity building of the farmers should be an integral part of any watershed development program. Farmers' participatory selection of improved crop cultivars in 150 micro-watersheds of APRLP in five districts of Andhra Pradesh resulted in identification of improved cultivars of sorghum, pearl millet, maize, castor, green gram (mung bean), groundnut, pigeonpea, and chickpea (Table 3.7). Through this approach farmers are able to identify location specific material considering the traits, which researchers would not have considered while selecting the cultivars. Further, to ensure the availability of the seeds of improved cultivars, self-help groups (SHGs) in the watershed villages are trained to handle village seed banks (Dixit *et al.*, 2005; Ravinder Reddy *et al.*, 2007). Trained farmers undertook seed production using breeders' seeds for sowing, and with the help of consortium

Table 3.7 Farmers' participatory evaluations for productivity enhancement in watersheds under APRLP in Andhra Pradesh, India during 2002–04

District	*Watershed villages*	*Crop*	*No. of trials*	*Cultivars*	*Yield (kg ha^{-1})* *Farmers' practice*	*Best-bet*	*Yield gain (%)*
Kurnool, Nalgonda, Mahabubnagar	17	Castor	41	Kranthi	780	1240	59
Mahabubnagar, Nalgonda	22	Maize	40	Ratna 2232	2770	4510	63
Kurnool	13	Groundnut/ Pigeonpea	53	ICGS 76, ICGV 86590	775	1320	70
Kurnool	19	Sole groundnut	52	ICGS 76, ICGV 86590	1075	1605	49
Kurnool	2	Chickpea	34	ICCV 37	1370	1930	41
Anantapur	19	Sole groundnut	35	ICGS 76, ICGV 86590	770	1100	43

partner farmers maintained their purity. The village seed banks are very effective in overcoming the bottleneck of availability of good quality seed in the villages particularly of improved varieties of cereals such as pearl millet and sorghum, and legumes such as groundnut, chickpea, and pigeonpea, which the private seed companies do not handle.

The Government of Andhra Pradesh has scaled-up this initiative by providing ₹100,000 (US$2200) as a revolving fund to each SHG and organizing breeder or foundation seeds for the SHGs. In all, 200 village seed banks are operating in the state (Shanti Kumari 2007). In all, 255 farmers' participatory evaluation trials with improved cultivars of castor, maize, groundnut, sorghum, and chickpea along with improved nutrient management showed 41–70% increase in crop yields over farmers' management practice (Table 3.7).

In 208 watersheds in Asia, yields of several crops increased by 30 to 242% over the baseline yields varying from 500 to 1500 kg ha^{-1}. Recently under the World Bank aided Sujala-ICRISAT initiative in 22 villages in five districts of Karnataka, the results from 232 on-farm PR&D trials showed 56–198% increase in productivity of groundnut, maize, finger millet, sunflower, and other crops (Table 3.8).

3.9.5 Crop diversification and intensification of crops and systems

Crop diversification refers to bringing about a desirable change in the existing cropping patterns towards a more balanced cropping system to reduce the risk of crop failure; and crop intensification is the enhancement of cropping intensity and production to meet the ever increasing demand for food in a given landscape. Watershed management puts emphasis on crop diversification and sustainable intensification through the use of advanced technologies, especially good variety of seeds, balanced fertilizer application, and supplemental irrigation.

Table 3.8 Farmers' participatory evaluations for productivity enhancement in watersheds under ICRISAT-Sujala project in Karnataka, India during 2005–06

District	Watershed villages	Crop	No. of trials	Cultivars	Yield (kg ha^{-1}) Farmers' practice	Best-bet	Yield gain (%)
Kolar and Tumkur	7	Groundnut	63	JL 24, ICGV 91114, K1375, K6	915	2260	146
Kolar and Tumkur	9	Finger millet	62	MR 1, L 5, GPU 28	1154	1934	67
Chitradurga	2	Sunflower	30	KBSH-41, KBSH-44, GK 2002	760	2265	198
Chitradurga and Haveri	4	Maize	49	PA 4642, GK 3014	3450	5870	70
Haveri	4	Sole groundnut	16	ICGV 91114	1100	1716	56
Dharwad	4	Soybean	12	JS 335, JS 9305	1350	2470	83

Farmers in watersheds in northern Vietnam diversified maize-based systems by including groundnut and vegetable crops, obtained increased productivity as well as income (Table 3.9). The inclusion of groundnut, a legume, reduced inorganic N fertilizer requirement for maize and also increased yield by 18%. Soil and water conservation measures such as staggered contour trenching, planting of *Gliricidia*, or pineapple vegetative border, rainwater harvesting pits and loose boulder gully control structures on the sloping lands, improved water availability in open wells (Figure 3.5) and enabled the farmers to grow high-value watermelon crop with the highest benefit-cost ratio amongst the cropping systems (Table 3.10). In the Tad Fa and Wang Chai watersheds of Thailand, the farm incomes increased by 45% within three years (US$1,195 per cropping season). The Lucheba watershed in Guizhou, China transformed its economy through crop-livestock integration with buckwheat as an alley crop that controlled soil erosion, provided fodder, and increased per capita income from US$200 to US$325 in two years. The implementation of improved soil, water, nutrient, and crop management practices reduced runoff and soil loss in the nucleus micro-watersheds in Vietnam, China, Thailand and India (Table 3.11).

3.9.6 Use of multiple resources

Farmers solely dependent on agriculture hold high uncertainty and risk of failure due to various extreme events, pest and disease attack, and market shocks. Therefore, integration of agricultural (on-farm) and non-agricultural (off-farm) activities is required at various scales for generating consistent source of income and support for farmers' livelihood. For example, agriculture, livestock production, and dairy farming together can make a more resilient and sustainable system compared to adopting agricultural production alone. The products or by-products of one system could be utilized for the other and vice-versa. In this example, biomass production (crop straw) after crop harvesting could be utilized for livestock feeding and dung/excreta obtained from livestock could be used for energy production through biogas plants, and the plant nutrient rich

Table 3.9 Crop yields as influenced by best-bet options in Andhra Pradesh and Karnataka[a]

		Grain yield ($t\,ha^{-1}$)		
District	*Watershed*	*Improved practice*	*Traditional practice*	*Yield advantage (%)*
Andhra Pradesh				
Nalgonda	Kacharam	4.40	1.68	162
	D. Gudem	2.96	2.25	32
	K. Gudem	3.83	2.34	64
	Sadhuvelli	4.02	2.84	42
	Gouraipalli	3.85	1.91	102
Mean		3.81	2.20	73
Mahabubnagar	Sripuram	5.76	4.44	30
	Uyyalawada	3.90	2.02	93
	Aloor	4.37	2.40	82
	Nallavelli	5.81	4.27	36
	Vanapatla	5.92	4.31	37
	Naganool	5.64	4.20	34
	Malleboinpally	3.89	1.62	140
	Sripuram	8.32	3.04	174
	Naganool	8.00	3.12	156
	Vanapatla	8.39	5.52	52
	Gollapally	4.73	3.56	33
Mean		5.88	3.50	68
Grand mean		5.24	3.10	69
Karnataka				
Kolar and Tumkur (Groundnut)		2260	915	247
Kolar and Tumkur (Finger millet)		1934	1154	167
Chitradurga (Sunflower)		2265	760	298
Chitradurga (Maize)		5870	3450	170
Haveri (Sole groundnut)		1720	1100	156
Dharwad (Soybean)		2470	1350	183
Mean		2753	1454	203

[a]Source: Derived from Sreedevi and Wani (2009).

slurry from biogas plants can be applied to agricultural plots to maintain soil fertility. The integrated system includes horticulture plantation, aquaculture, and animal husbandry at an individual farm, household, or the community scale. In all the community watersheds, the equity issues are addressed through productivity enhancement and income-generating activities in addition to the normal soil and water conservation measures.

3.9.7 Capacity building

Watershed development requires multiple interventions that jointly enhance the resource base and livelihoods of the rural people. This requires capacity building of all the stakeholders from the farmer to the policy makers. Capacity building is a process

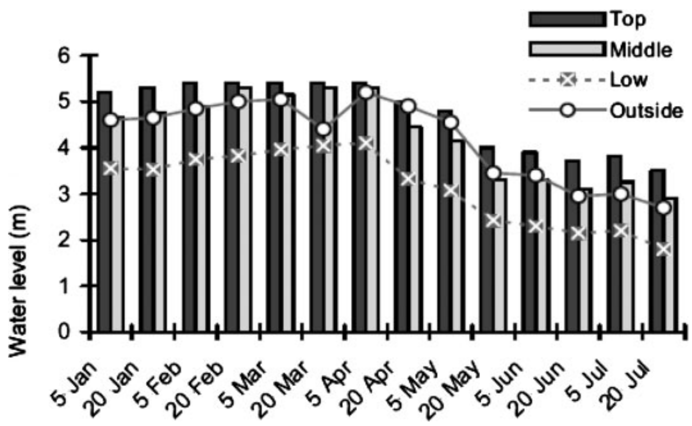

Figure 3.5 Groundwater levels in the open wells in Thanh Ha watershed in Vietnam during 2004

Table 3.10 Economics of crops grown in Thanh Ha Commune, Ho Binh Province, Vietnam

Crop	*Area (%)*	*Yield (t ha^{-1})* *Average*	*Range*	*Income (US$)*	*Benefit-cost ratio*
Maize	83	3.4	0.9–7.0	421	1.41
Watermelon	6	17.8	10.0–36.0	2015	1.73
Sugarcane	8	58.3	20.0–83.0	1270	1.06

Table 3.11 Seasonal rainfall, runoff, and soil loss from different benchmark watersheds in Thailand and India

Watershed	*Seasonal rainfall (mm)*	*Runoff (mm)* *Treated*	*Untreated*	*Soil loss (t ha^{-1})* *Treated*	*Untreated*
Tad Fa, Khon Kaen, NE Thailand	1284	169	364	4.21	31.2
Kothapally, Andhra Pradesh, India	743	44	67	0.82	1.90
Ringnodia, Madhya Pradesh, India	764	21	66	0.75	2.2
Lalatora, Madhya Pradesh, India	1046	70	273	0.63	3.2

to strengthen the abilities of people to make effective and efficient use of resources in order to achieve their own goals on a sustained basis (Wani *et al.*, 2008b). Unawareness or ignorance of the stakeholders about the objectives, approaches, and activities is one of the reasons that affects the performance of the watersheds (Joshi *et al.*, 2008). Capacity building programs focus on the construction of low-cost soil and water conservation methods, production and use of biofertilizers and biopesticides, income-generating activities, livestock-based activities, wasteland development, organizing groups and promoting collective action, participatory monitoring, social auditing, leadership skills, and market linkage for primary stakeholders. Clear understanding of strategic planning, monitoring, and evaluation mechanism and other expertise in the field of science and management is essential for the government officials and policy makers. The stakeholders should be aware about the importance of various activities and their benefits in terms of economics, social, and environmental factors. Therefore, organizing various training programs at different scales is important for watershed development.

3.10 KEY FEATURES OF FACILITATING THE CONSORTIUM APPROACH

The key features of the consortium approach for watershed management are described by Wani *et al.* (2009).

3.10.1 Need for a common goal – team building

Working in partnership is successful only if all the members share a common goal. For the consortium approach, ICRISAT attempted to achieve this by identifying important institutions whose objective is to enhance agricultural productivity and income and reduce rural poverty, and which are working in the area of watersheds. A series of team building workshops addressed the following objectives:

- Develop a common vision of the watershed development program among consortium partners.
- Inculcate a team spirit among the members to achieve the goal of sustainable NRM for improved rural livelihoods.
- Develop an understanding of and appreciation for the efforts and initiatives taken up by various teams.
- Discuss and develop action plans for the desired impacts.
- Develop a combined strategy to up-scale the impact to neighboring watersheds.

3.10.2 Building on the strengths

The consortium's main principle is to harness the strengths of the partners and overcome the weaknesses. This principle must be ingrained amongst all the partners and the strengths of each partner's valuable inputs need to be highlighted to ensure the feeling of importance.

3.10.3 Institutionalization of partnerships

The process of institutionalizing partnership began with the identification of suitable scientists with required expertise and necessary institutions for the project to achieve its goal. This approach was found to be more effective than that based on identifying organizations first and then trying to find people within those organizations who can get represented in the consortium. While being part of the consortium, participating organizations appreciated strengths of each other and rapport was built. This collaborative spirit has been shared in many other projects that followed.

3.10.4 Internal and external institutional arrangements

For facilitating the functioning of the consortium, there is a need to put in place an institutional mechanism, both internal and external, to review the progress of the project from time to time and to take necessary action (Wani *et al.*, 2009).

3.10.5 Dynamic and evolving

The consortium approach is not a static model but should be adapted based on field situation and requirements. It provides the philosophy and framework, while specific components need to be added to make it relevant as per the situation. In addition to the critical stakeholders such as NGOs, national agricultural research systems (NARS), State and Central Government line departments, and farmers' organizations, based on the need, relevant private industries can also be brought into the consortium.

3.10.6 Scaling-up/out the approach

Following the success of the model, the Consortium Approach has been scaled-up to several locations. Starting with different districts in Andhra Pradesh through APRLP, other states in India with financial support from the Sir Dorabji Tata Trust, Sir Ratan Tata Trust, and Government of India have established watershed sites as sites of learning. Also with the support from ADB, Bureau of Agriculture, Government of the Philippines watersheds have been established in India, China, Vietnam, and Thailand. There has been spill over effects of the learnings of this approach in Africa, particularly in Eastern Africa through ICRISAT's association with the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The South-South collaboration between Indian Council of Agricultural Research (ICAR) and ASARECA in the area of integrated watershed management is facilitated by ICRISAT and International Water Management Institute (IWMI).

3.11 ADVANTAGES OF CONSORTIUM APPROACH

The main advantages of the approach include synergy and creativeness in the tackling of NRM challenges for which solutions are rarely found with a single discipline expertise; for example, in the management of livestock-fisheries-agricultural systems along with credit-markets and institutions. In the Consortium Approach where a multidisciplinary team addresses the problem situation, there is a potential for creative thinking and new ideas, which benefit the farmers as well as researchers and developmental workers (Wani *et al.*, 2008b).

3.11.1 Sustainability

The Consortium Approach facilitates members of the network to have ownership of the objectives of the program. This leads to optimal contribution from diverse disciplinary backgrounds providing a holistic systems approach. As a result solutions for problems are effective. Activities are planned and are demand driven, and implementation is in a participatory manner leading to effective solutions with good prospects of their being sustainable initiatives.

3.11.2 Cost-effectiveness

At the time of project implementation, working linkages are established among various actors in the consortium. This ensures quick access to relevant people when primary stakeholders encounter a situation, leading to timely solutions. One of the main issues in NRM work is the involvement of various departments independently and this in many cases results in the duplication of work. In the Consortium Approach, each of the actors knows what other departments are doing. So there is less chance for duplication of the work.

3.11.3 Win-win solution through empowerment of partners

The Consortium Approach allows members to learn from one another. It spreads interdisciplinary knowledge among partners. Strengths of each of the partners are harnessed and help is provided mutually by partners to get over their weaknesses. When there is an effort to build upon strengths of each of the partners, weaknesses get covered with strengths of other partners. In the team, biophysical scientists not only started offering solutions for issues related with other related disciplines but also got sensitized with socioeconomic, gender, and institutional issues. One team became more cohesive overcoming conventional disciplinary hegemony (Wani *et al.*, 2008c).

3.11.4 Rapid scaling-up

Many studies on NRM indicated that it is important to work with different partners to facilitate scaling-up. The Consortium Approach ensures intensity and closeness in which communication and collaboration takes place among partners, which contributes to an effective scaling-up. Impact could be further enhanced through new innovative partnerships. Since different partners are involved, necessary enabling institutions and policies are put in place in a shorter time. For example, when the need to undertake research on *Jatropha* arose in Andhra Pradesh, the watershed consortium partners came together and formed the consortium in a short period and included new members as needed (Wani *et al.*, 2008c) while working in a watershed consortium model to benefit landless people through bio-diesel plantations in common property resources.

3.11.5 Change in organizational behavior

The general tendency of a researcher is to develop technology in the laboratory/research station and transfer it to the field through extension agencies. This tendency got reengineered into working closely with primary stakeholders and developing technology in a participatory way. Governmental and non-governmental extension agencies also find it worthwhile to play a role in developing the technology by listening to farmers carefully and contributing through feedback and sharing indigenous knowledge options with researchers. Different researchers within ICRISAT and other partner institutions also got sensitized in social, gender, equity, and other disciplines and this helped to overcome the disciplinary bias. Good research and management practices got internalized amongst the partners (Wani *et al.*, 2008c).

3.11.6 Public–private partnerships are facilitated (multiplier effect)

Backward and forward linkages are important to enhance income and agricultural production in rural areas. Private entrepreneurs came forward to join the consortium for harnessing the opportunity. For example, during baseline characterization, widespread deficiency of not only B, Zn, and S but also N and P was observed in 80–100% of farmers' fields (Sahrawat *et al.*, 2007). Farmers' participatory trials with amendments of deficient nutrients showed substantial yield increases and enhanced incomes (Rego *et al.*, 2007). However, the availability of B and other micronutrients in remote villages became an issue. Borax Morarji Ltd., producer of B fertilizers in India, came forward to join the consortium to ensure the availability of B fertilizers in the villages through SHGs. Similarly, for handling the marketing of produce and processing, various industries came forward to join the consortium; for example, in the case of bio-diesel initiative, a public–private partnership amongst GTZ-Southern Online Bio-Technology (SBT) and ICRISAT is ongoing under which SBT is operating $40\,kl\,d^{-1}$ bio-diesel plant in Nalgonda district, Andhra Pradesh with German technology provided by Lurgi and ICRISAT is providing technical support to the farmers for cultivating bio-diesel plantations and facilitating buy-back arrangements between the farmers and SBT (Kashyap 2007).

3.12 LEARNINGS FROM THE EXPERIENCE AND TRIGGERS FOR SUCCESS

The most crucial issue that determines the success of a consortium is capable leading or facilitating partners. Partnerships need to be nurtured by the lead partner. As mentioned earlier, the Consortium Approach is dynamic and continually evolves. Following the framework and philosophy, the lead partner should be innovative enough to facilitate adaptation and evolution of the model to suit the local needs. Quite often there would be conflicting ways of working among partners. The consortium leader needs to understand this fact and ensure flexibility and transparency among partners to accommodate opinions of the members without causing damage to the overall objectives.

Each member of the team should know that he/she can influence the team agenda. There should be a feeling of trust and equal influence among team members that facilitates open and honest communication. This allows each member to provide their technical knowledge and skills in helping to solve the problems, complete the project, and develop new programs.

The consortium leader, where possible, should help select or influence the composition of consortium members. Selection of members should be based on their willingness to work in a team and share their resources, both technical skills and financial contributions. The selection of a right set of partners determines the success to a major extent. Learning behavior among the partners is essential for the Consortium Approach. More importantly, there should be predisposition to work collectively for the community development. It is essential to achieve shared understanding of objectives by the members. They should be able to identify themselves with the common objectives. The lead organization should facilitate this process. Once the objectives are evolved, it is again the responsibility of the lead partner to always bring members' attention to the objectives and help in ensuring focused work in the correct direction (Wani *et al.*, 2009).

There is a need to develop, understand, and accept a set of principles by the members, which include norms for operating within the team. Team building measures go a long way in developing stronger partnerships and internalizing the operating guidelines. Sharing of the credit for the impact, publications, and policy guidelines amongst the partners is very critical. The leader has to ensure that in all communications about the consortium activities, all partners are recognized, acknowledged, and rewarded. Such measures go a long way to build a trust amongst the consortium partners. Similarly, open communication and conflict resolving mechanisms must be in place.

Tangible economic benefits to individual primary stakeholders are essential for participation in the consortium. Integration of new science tools such as GIS and remote sensing enhanced the efficiency of recommendations and resulted in higher benefits to the community. Knowledge-based EPA is another reason for enhanced sustainable community participation. Motivation of the farmers was sustained due to the fact that there is continuous learning which is directly relevant to their fields. Capacity building of partners and sensitization of policy makers helped in building partnerships. Transactions costs (time and money) are higher for partnership building but higher benefits call for partnerships (Shambhu Prasad *et al.*, 2006; Wani *et al.*, 2009).

3.13 OPERATIONALIZING COMMUNITY WATERSHED AS A GROWTH ENGINE

For community watershed development program to become the growth engine for sustainable development of rainfed areas, the major challenge is the scaling-up to large areas as the successful watersheds remained a few and unreplicated (Kerr *et al.*, 2002; Joshi *et al.*, 2005). An integrated consortium approach for the sustainable development of community watersheds with technical backstopping and convergence is developed and evaluated in Asia (Wani *et al.*, 2002, 2003a) and adopted by Government of India (GOI 2008). The systems approach looks at various components of the rural economy – traditional food grains, new potential cash crops, livestock, and fodder production as well as the socioeconomic factors such as alternative sources of employment and income. The adoption of this new paradigm in rainfed agriculture has shown that with proper management of the natural resources, the systems productivity can be enhanced and poverty can be reduced without causing further degradation of the natural resource base (Rockström *et al.*, 2007, 2010; Wani *et al.*, 2008a).

3.14 WATERSHED AS AN ENTRY POINT TO IMPROVE LIVELIHOODS

Watershed as an entry point should lead to exploring the multiple livelihood interventions (Wani *et al.*, 2006a, 2006b, 2007, 2008b). The overall objective of the whole approach being poverty elimination through sustainable development, the new community watershed management provides an envelope that fits into the framework as a tool to assist in providing sustainable rural livelihoods. The task is to sustainably intensify complex agricultural production systems, while preventing damage to the natural resources and biodiversity, and to improve the welfare of the farmers through value addition and market linkages.

ICRISAT's consortium model of community watershed management espouses the principles of collective action, convergence, cooperation and capacity building (four Cs) with technical backstopping by a consortium of institutions to address the issues of equity, efficiency, economics, and environment (four Es) (Wani *et al.*, 2006b). The new integrated community watershed model provides technological options for the management of runoff, water harvesting, in-situ conservation of rainwater for groundwater recharging and supplemental irrigation, appropriate nutrient and soil management practices, waterway system, crop production technology, and appropriate farming systems with income-generating micro-enterprises for improving livelihoods, while protecting the environment. The current model of watershed management as adopted by ICRISAT watershed consortium team involves environment-friendly options and the use of new science tools (Wani *et al.*, 2000, 2002, 2008a; Sreedevi *et al.*, 2004).

Adarsha watershed (in Kothapally, Ranga Reddy district in Andhra Pradesh) led by ICRISAT consortium, has clearly demonstrated increased crop productivity from rainfed systems through integrated watershed management approach (Table 3.3). Similar benefits are recorded by several other watersheds in Asia (Wani *et al.*, 2008c; Pathak *et al.*, 2009; Sreedevi and Wani 2009).

3.15 CONVERGENCE IN WATERSHED

Convergence in watersheds evolved with the community watershed management model, which apart from the IGNRM strategy, encompasses several other entities. The holistic community watershed is used as an entry point to converge and to explicitly link watershed development with rural livelihoods and effective poverty eradication and in the process identify policy interventions at the micro-, meso-, and macro-levels. Convergence takes place at different levels; at the village level it requires facilitation of the processes that bring about synergy in all the watershed-related activities. The scope for the issues relate to the processes for the change in micro-practices, macro-policies, convergence, and information and management systems (Wani *et al.*, 2008b, 2009).

Government of India has come up with an innovative approach of converging the various schemes and programs at the watershed platform to avoid duplication and for efficient use of available funds. There are several schemes that are in operation and one of them is Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) that provides employment for the wage seekers. In most of the land-based developmental activities, the landless were left out, but the MGNREGA is helping the poor by providing employment at the doorstep. Under this program, most of the activities are land-based involving earth work. Besides, the landless, marginal and small farmers can take up in-situ and ex-situ soil and water conservation works on their own land and the cost met by the program. Some of the states in India like Gujarat and Madhya Pradesh have already initiated MGNREGA planning on a watershed basis even in the non-IWM program areas; and in Andhra Pradesh, the activities of MGNREGA have been converged with the IWM program.

The activities in IWM approach which involves convergence include: rainwater conservation and harvesting, productivity enhancement through improved crop and management options, soil test based integrated nutrient management options including the application of micro- and secondary nutrients that are deficient in the production systems, soil conservation, crop diversification using high-value crops, establishing the village seed banks through SHGs, processing for value addition (seed material, poultry feed, animal feed, grading and marketability, quality compost preparation), rehabilitation of degraded common lands with suitable soil, water, and nutrient management options using grass and plantation including bio-diesel plant systems, livestock-based livelihood activities through improvement of breed, health, and feed quality, poultry rearing for egg and meat production and local hatching to provide chicks, and vermicomposting with cow dung, fodder waste, and weeds to provide quality compost locally.

3.16 MULTIPLE BENEFITS FROM INTEGRATED WATERSHED DEVELOPMENT

The adoption of IWM effected remarkable multiple impacts on resource-poor farm households in the semi-arid tropics (SAT).

Reducing rural poverty in the watershed communities was evident in the transformation of farmers' economies. The improved productivity with the adoption of cost-efficient water harvesting structures as an entry point improved livelihoods through crop intensification and diversification with high-value crops (Wani *et al.*, 2008b, 2009; Sreedevi and Wani 2009). It also benefited the women, landless, and vulnerable members through income-generating activities.

Building on social capital made a huge difference in addressing rural poverty in watershed communities. Crop–livestock integration is another facet harnessed for poverty reduction. The Lucheba watershed, Guizhou province of southern China has transformed its economy through modest injection of capital-allied contributions of labor and finance to create basic infrastructure like access to roads and drinking water supply. In the Tad Fa and Wang Chai watersheds in Thailand, there was 45% increase in farm income within three years. Farmers earned an average net income of US$1195 per cropping season.

Increasing crop productivity is a common objective in all the watershed programs. Enhanced crop productivity is achieved after implementation of soil and water conservation practices along with appropriate crop and nutrient management. Overall, in the 65 community watersheds in Andhra Pradesh and 30 watersheds in Karnataka (Tables 3.5 to 3.9) (each measuring approximately 500 ha), implementation of best-bet practices resulted in significant yield advantages in sorghum (35–270%), maize (30–174%), pearl millet (72–242%), groundnut (28–179%), sole pigeonpea (97–204%), and intercropped pigeonpea (40–110%). In Thanh Ha watershed of Vietnam, yields of soybean, groundnut, and mung bean increased three- to fourfold (2.8–3.5 t ha^{-1}) as compared with baseline yields (0.5–1.0 t ha^{-1}), reducing the yield gap between potential farmers' yields. A reduction in N fertilizer (90–120 kg urea t ha^{-1}) by 38% increased maize yield by 18% in Thanh Ha watershed in Vietnam. In Tad Fa watershed in northeastern Thailand, maize yield increased by 27–34% with improved crop management (Wani *et al.*, 2008b; Sreedevi and Wani 2009).

Improving water availability in the watersheds was attributed to the efficient management of rainwater and in-situ conservation, establishment of water harvesting structures, and improved groundwater levels. Even after the rainy season, the water level in wells close to the water harvesting structures sustained good groundwater yield and benefited the village women through drinking water availability as well as men with increased irrigation (Wani *et al.*, 2006a, Pathak *et al.*, 2009; Sreedevi and Wani 2009). Supplemental irrigation played a very important role in reducing the risk of crop failures and in optimizing the productivity in the SAT region.

Sustaining development and protecting the environment are the two-pronged achievements of the watersheds for reducing soil loss and runoff loss. Introduction of IPM in cotton and pigeonpea substantially reduced the number of chemical insecticidal sprays in Kothapally, Andhra Pradesh during the season and thus reduced the pollution of water bodies with harmful chemicals. The introduction of IPM and improved cropping systems decreased the use of pesticides worth US$44 to 66 ha^{-1} (Ranga Rao *et al.*, 2007). Increased carbon sequestration of 7.4 t ha^{-1} in 24 years was observed with improved management options in a long-term watershed experiment conducted at ICRISAT, Patancheru, India. By adopting fuel-switch for carbon, the women SHGs in Powerguda (a remote village of Andhra Pradesh) have pioneered the sale of carbon units (147 t CO_2 C) to the World Bank from their 4,500 *Pongamia* trees, seeds of which are collected for producing saplings for distribution/promotion of bio-diesel plantation (Wani *et al.*, 2009). Normalized difference vegetation index (NDVI) estimation from satellite images showed that within four years, the vegetation cover could increase by 35% in Kothapally (Wani *et al.*, 2005).

Conserving biodiversity in the watersheds was engendered through participatory NRM. Pronounced agrobiodiversity impacts were observed in Kothapally watershed where farmers now grow 22 crops in a season with a remarkable shift in cropping pattern from cotton (200 ha in 1998 to 100 ha in 2002) to maize/pigeonpea intercrop system (40 ha in 1998 to 180 ha in 2002), thereby changing the crop agrobiodiversity factor (CAF) from 0.41 in 1998 to 0.73 in 2002. In Thanh Ha, Vietnam the CAF changed from 0.25 in 1998 to 0.6 in 2002 with the introduction of legumes (Wani *et al.*, 2005). Building resilience is an important facet of IWM approach. The resilience framework for watersheds using case studies is described in detail by Barron and Keys in this volume.

3.17 CONCLUSION

The growing biotic pressure and over-exploitation along with inappropriate management of natural resources are causing their degradation and reducing agricultural productivity. Rainfed areas in the tropics are fragile ecosystems that are prone to severe land degradation and are the hot-spots of poverty and water scarcity.

Management of a small catchment or watershed through participatory approach is recommended for sustainable use of natural resources to increase agricultural productivity and reduce rural poverty. Integrated watershed management is an approach integrating sustainable management of natural resources through collective action of resource users for improving livelihoods of people in harmony with nature rather than a mere hydrological unit. Interdependence of human beings and animals for their living through sustainable use of scientific land use planning on interconnected natural resources need codification up to national level and scientific criteria to prioritize development of watersheds in the country. Improved models of watershed development include some or all of the features such as community participation, collective action, consortium of soil and rainwater conservation structures, better farming practices, involvement of women and landless people through income-generating activities, fusion of research and development, transparency, science-based productivity enhancement, monitoring and evaluation measures, building capacity of the formal and informal rural institutions, building productive partnerships and alliances in a consortium model, and building resilience of the communities and the natural resources. The current IWM program in India has evolved over the past thirty years from top-down target oriented approach to conserve soil and water to community participatory integrated holistic livelihood approach to improve rural livelihoods through sustainable management of natural resources. The holistic, participatory, and consortium approach integrates biophysical interventions with socioeconomic and institutional innovations to sustainably develop and manage natural and human resources for reducing poverty and provisioning ecosystem services. When implemented the IWM programs produced multiple benefits in terms of conserving soil, water, and biodiversity, increased productivity and family incomes, building social capital and resilience to cope with impacts of changes in future including those due to climate change and globalization. Integrated watershed management approach could become the growth engine for sustainable development of dryland areas in the tropics.

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