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Unlocking the Potential of Rainfed Agriculture Through Integrated Watershed Management

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Integrated watershed management allows in-situ conservation of water and soil nutrients, which gradually offers the opportunity to harvest several crops in a given year through supplementary irrigation.

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INTRODUCTION

Rainfed systems[a] globally account for 58 per cent of the world food production (Rosegrant *et al.*, 2002) and accounts for about two-thirds of total cropped area and generate nearly half of the total value of agricultural output In India (Kerr, 1996). Because of rainfall variability, accelerating land degradation, lack of appropriate technologies, and limited economic investments, the productivity of rainfed systems has been quite low. Hence, the relative share and severity of poverty is often higher in rainfed regions (Ryan and Spencer, 2001). Addressing the problems of natural resource degradation, poverty and food insecurity at national level necessitates improvements of the productivity of rainfed systems through efficient use of water and development of new technological and policy options for sustainable intensification and diversification of production systems.

MAJOR ISSUES

With increasing population pressure and the intensification of irrigated crop production, the costs of new water development have increased and environmental problems like the depletion of groundwater reserves, salinization, waterlogging and land degradation have become major sustainability issues. In addition, increased competition for scarce water for industrial and household use is expected to reduce future water supply for low-value irrigated crops. Low economic efficiency of water use in irrigated regions has also contributed to overuse and shortage of water for non-agricultural uses. As the sources of growth in irrigated areas decline, rainfed production must increase to fill the gap. Over 67 per cent of the country's cultivated land is dependent on the truant monsoon. Even if the full irrigation potential is met, nearly 50 per cent of the cultivated land will continue to be rain dependent and droughts are going to be a common feature over a large part of the country. The second green revolution has to occur in water scarcity prone tropical environments, among resource poor smallholder farmers, to a large extent relying on a vulnerable resource base subject to human induced land degradation.

The rainfed tracts suffer also from greater incidence of land degradation. The torrential character of the seasonal rainfall creates high risk for the cultivated lands. Of the estimated 173 million tonne of sediment discharged into the oceans annually the rainfed areas contributes nearly half of the load even though the actual area is just one-third. This is an eloquent testimony to the intensity of the process and the consequential damage to the producing ability of land. Besides soil erosion, runoff also leads to reduced water supplies in the catchment and increased downstream flooding.

WATER SCARCITY PROBLEM

The water scarcity problem is likely to be one major limiting factor in further intensifying agriculture in rainfed areas and alleviating poverty. The International Water Management Institute (IWMI) and International Crops Research Institute for the Semi-Arid

[a] The rainfed systems are farming systems primarily dependent on rainfall. Rainfall is the main water source and supplemental irrigations are used for increasing productivity but the systems remain predominantly rainfed.

Tropics (ICRISAT) envisage that one billion of the world's poorest people living in arid and semi-arid lands are likely to be affected by severe water shortages by 2025 (Ryan and Spencer 2001). Sustainable intensification of agriculture in rainfed areas for poverty alleviation requires combating and reversing the problem of degradation of the natural resource base, through judicious management and use of scarce water and soil resources. Integrated watershed management allows *In-situ* conservation of water and soil nutrients, which gradually offers the opportunity to harvest several crops in a given year through supplementary irrigation. Efficient water harvesting and integrated crop, soil and nutrient management allows diversification of incomes and better management of risk in drought prone environments. *In-situ* conservation of soil and water also helps in regenerating the vegetation cover and protection of biodiversity, which brings additional environmental benefits to the community and the society.

Strategies to Improve Livelihoods and Minimize Land Degradation

The approach of integrated watershed management is quite critical improving livelihoods and for minimizing land degradation through sustaining increase land productivity and incomes of the people through holistic natural resource management. This covers wide ranging aspects like land quality, farming systems, agroforestry, infrastructure development, soil and water conservation, community participation and employment generation. Watershed management is defined as an integration of technologies within the natural boundaries of a drainage area for optimum development of land, water and plant resources to meet the basic needs of the people in a sustainable manner. Watershed management solutions must address the problem of rural poverty, increasing productivity, protect the natural resources and rehabilitate degraded areas. The way forward is to conserve rainwater, reduce land degradation and replenish the impoverished soil through renewable resources such as biological nitrogen fixation, improved crop combinations and management, which will result in sustained productivities and improved livelihoods of the poor farmers of semi-arid tropics.

Watershed programme is reckoned as the engine of agricultural growth and development in fragile and marginal rainfed areas. Since,. the seventh five year plan, the Government of India accorded high priority to the rainfed areas after realizing that the Green Revolution in the irrigated areas bypassed large number of poor people residing in rainfed areas. The programme was reckoned to bring the second generation of Green Revolution in the rainfed areas. More than Rs.11,213 crores (Rs.7,147 crores at 1980-81 prices) have been allocated until 2003-2004 for watershed development programmes. The Union Ministry of Finance, Government of India declared, 'National Movement for Watershed Development' in 1999-2000 and the plan allocation for watershed programmes was stepped upto 677 crores.

Innovative Integrated Participatory Watershed Management Model

The watershed research was initiated by ICRISAT in partnership with National Agricultural Research Systems (NARSs) with the objectives to increase the productivity and sustainability of the SAT systems through environment friendly resource management practices that will conserve soil and water resource. Participatory watershed management is a process, which aims to create a self-supporting system essential for sustainability and development. The process begins with the management of soil and water, which eventually leads to the development of other resources. People's participation is critical for sustainable development and management of watersheds. Lack of involvement of people in the past in the management of watersheds has been a major hindrance in sustaining whatever conservation measures have been adopted. Based on the lessons learnt over the years, ICRISAT in partnership with NARSs have developed an innovative farmer participatory consortium model for management of watersheds (Wani *et al.*, 2002a).

At ICRISAT, Patancheru, operational watersheds were maintained over last 26 years and have compared the Integrated Natural Resource Management (INRM) options and farmers' traditional options for managing Vertisols. (Wani *et al.*- 2003a) have successfully assessed the sustainability of the INRM options adopted in these watersheds using the yield production time series data during 1977 to 2002 along with soil quality parameters. Grain yields were higher in the improved system than in the traditional system. Sorghum and pigeon pea together recorded an average grain yield of 4.7 t ha^{-1} yr^{-1} compared with the 0.9 t ha^{-1} yr^{-1} average yield of sole sorghum in the traditional system.

The Improved INRM options not only increased mean grain yield productivity over the traditional farmers'

management practice but the annual productivity gain was 77 kg ha^{-1} along with increased C sequestration of 0.335 t c ha^{-1} y^{-1} in soil, in case of improved INRM system as that of 26 kg ha^{-1} gain in the farmers' management.

The trend analyses indicated that both the systems were sustainable as both the systems are recording the annual gain in productivity and have not reached new state of equilibrium yet. However, the sustainability of both the systems varies tremendously when put in the context of the carrying capacity of the lands. For a country like India, the improved INRM treated watershed is of relevance as it supports 18 persons per ha of land as against 4 persons per ha in case of traditional system as the country needs to fulfill the current need of feeding it's a billion and above population.

***Adarsha* Watershed : Kothapally – A Success Story**

The on-farm *Adarsha* watershed, Kothapally, Ranga Reddy district in Andhra Pradesh refined and evaluated the consortium model. The farmers evaluated improved crop management practices (INM, IPM and soil and water management) along with researchers. Farmers obtained high maize yield increase ranging from 2.2 to 2.5 times with improved technologies as compared to the yields of sole maize (1.5 t ha^{-1}) in 1998 (Table 1). In case of intercropped maize with pigeon pea improved practices resulted in four fold increased maize yield (2.7 t ha^{-1}) compared with farmers' practices where the yields were 0.7 t ha^{-1}. In case of sorghum the improved practices adopted increased yields by three fold within one year. Yield of intercropped pigeon pea with improved management practices increased by five times in 2000 (Wani *et al.* 2002b).

TABLE 1. **Average Yields with Improved Technologies in Adarsha Watershed, 1999–2002.**

		Yield (kg ha^{-1})			
Crop	**1998 Baseline Data**	**1999**	**2000**	**2001**	**2002**
Sole Maize	1500	3250	3750	3300	3480
Intercrop Maize	-	2700	2790	2800	3083
(farmers' practice)		700	1600	1600	1800
Intercrop Pigeon pea	190	640	940	800	720
(farmers' practice)	-	200	180	-	-
Sole Sorghum	1070	3050	3170	2600	2425
Intercrop Sorghum	-	1770	1940	2200	-

Out of all cropping system studied maize/pigeon pea and maize/chick pea proved to be more beneficial (Benefit-Cost Ratio 2.67) than the traditional maize or cotton systems. Sole Sorghum, sole chick pea and sorghum/pigeon pea intercrop also proved to be beneficial where as sorghum, maize, green gram traditional systems were significantly less beneficial to the farmers.

The impact of integrated watershed management interventions on poverty and livelihoods of the rural communities was assessed. Results clearly showed that average net returns per hectare for dryland cereals and pulses are significantly higher within the watershed. For cereals, the returns to family labour and land (net income) is 45 per cent higher even with irrigation, while the net returns on rainfed cereal crops have more than doubled. Similarly for pulse crops, per hectare net returns within the watershed are more than double with irrigation and almost double without irrigation. This is mainly because the watershed development approach based on Integrated Genetic and Natural Resource Management (IGNRM) includes improved cultivars of sorghum (cereals), chick pea and pigeon pea (pulses) developed by ICRISAT along with improved management of water and soil fertility. Adoption of the improved varieties has, not only increased crop yields, but also enhanced the economic profitability of other soil and water conservation investments, which may otherwise be economically not attractive to farmers. In addition to the impacts on the net productivity of land, we also compared household incomes among the households within and outside the watershed. The results are quite striking. Average household income from crop production activities within and outside the watershed is 15,400 and 12,700 respectively. Based on the baseline data from a random sample of 54 households, we also computed the average net incomes (accounting for the cost at family labour) within the watershed in 1998, before the project started in the village. The average net crop income (in 2001 prices) in 1998 was Rs.6,200, this despite the high rainfall recorded in the village during that year (1084 mm vs 676 mm in 2001). The average household net income from crop production (2001 prices) in 2001 year was Rs.12,700, which shows that the average net crop income has doubled

since 1998 (Sreedevi *et al* 2004). The respective per capita income is 3,400 and 1,900. This shows a significant impact of watershed intervention activities (initiated in 1999) towards poverty reduction in Kothapally watershed through increased incomes for the poor from crop production activities. The average income from agricultural wages and non-farm activities is 17,700 and 14,300 within and outside the watershed, respectively. The increased availability of water (and hence supplementary irrigation) and better employment opportunities in watershed development related activities have contributed to diversification of income opportunities and reduced vulnerability to drought and other shocks. (Wani *et al* 2003 c)

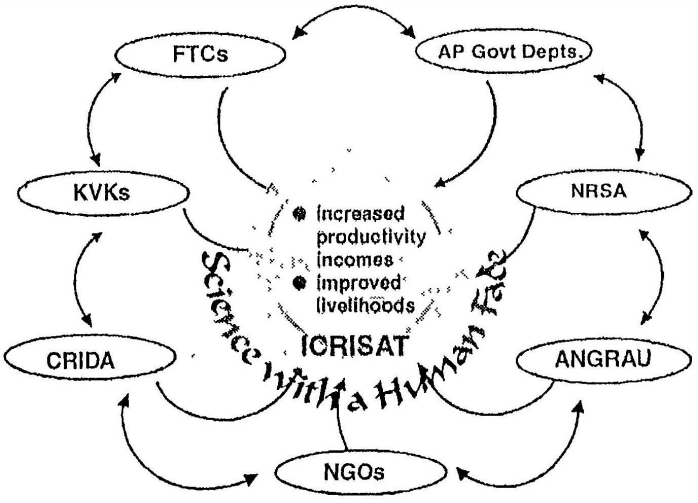
Innovative Integrated Participatory Watershed Management - ICRISAT's Pioneering Consortium Model

Based on the success of the participatory consortium watershed management model at Kothapally, the Andhra Pradesh Rural Livelihoods Programme (APRLP), Sir Dorabji Tata Trust and the Asian Development Bank (ADB) has selected this model for scaling up the benefits in Andhra Pradesh, Madhya Pradesh and Rajasthan in India and NE-Thailand, Northern Vietnam and South China. As most of NRM technologies are agroecoregion and site specific, the representative benchmark watersheds will allow transferring the findings from benchmark nucleus watersheds to the similar areas in the target ecoregion. In the target ecosystems project implementing agencies (PIAs) were selected based on their strengths and current knowledge available base. Nucleus watersheds were selected for development and critical monitoring as the sites for undertaking action research and also to study the processes to select different partners in the consortium. An innovative model with a consortium of institutions, as opposed to single institution approach, for technical backstopping was initiated (Fig. 1) for project implementation (Wani *et al.* 2003b). All the partners have worked in partnership with another institution to manage the watershed sustianably.

A successful partnership based on strong commitment with State and local agencies, community leaders and people is desirable. To promote community participation in the watershed for site selection, implementation and assessment of activities, various committees/groups were formed. It was recognized that to shift the community participation from contractual to consultative and collegiate mode, tangible private economic benefits to individuals are must. Such tangible benefits to individuals could come from *in-situ* rainwater conservation and translating through increased farm productivity by adopting IGNRM approach. Most importantly from the beginning stage of watershed selection to technology selection, crops, systems, and varieties selection and evaluation, monitoring of activities was done in participatory mode. Adopting the principle that "users pay" provided no subsidies for investments on individual's farms for technologies, inputs and conservation measures. Once the individuals could realize the benefits of soil and water conservation they came forward to participate in community activities in the watershed through various organise groups.

In consortium approach emphasis is on increasing agricultural productivity and incomes of rural people through efficient and sustainable use of natural resources in the watershed. However, for holistic development of watersheds and to cover all stakeholders living in, the watersheds should be used as an entry point leading to exploring multiple livelihood interventions. To achieve the

FIG. 1 : **Consortium Approach**



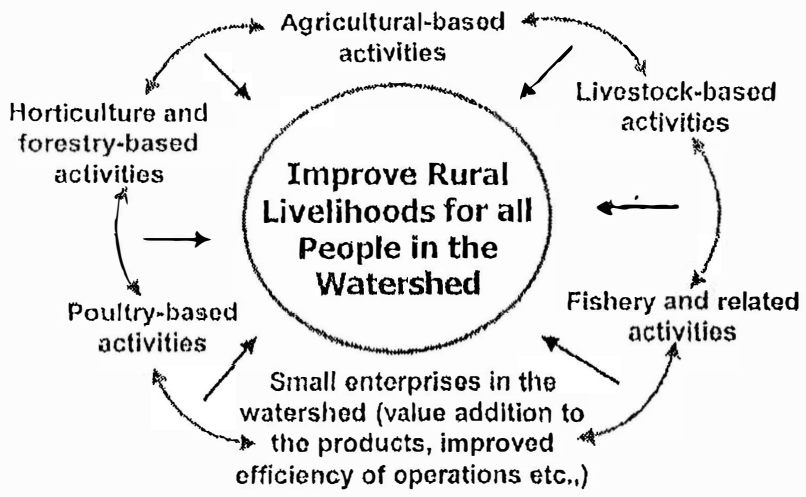
goal of improving rural livelihoods and sustainable utilisation of existing resources, the roadmap chosen is through convergence of activities in the watersheds (Fig. 2). Following the consortium model and convergence approach during first two years farmers in benchmark watersheds in selected districts of Andhra Pradesh, Madhya Pradesh., and Rajasthan harvested 30 to 120 per cent more crop yields along with substantial increase in their incomes also.

For maximizing the efforts so as to meet strategic and practical livelihood concerns of the poor, small and marginal farmers and women, convergence of livelihood options forms the strategy. The overall objective of the whole approach being poverty reduction, the new integrated watershed management model fits into the framework as a tool to assist in sustainable rural livelihoods. For the development of rainfed agriculture based livelihoods, the integrated watershed model conceptually provides an envelope through which many of the options for sustaining agriculture and agriculture related activities could be implemented. The task is to sustainably intensify complex agricultural production systems while preventing damage to natural resources and biodiversity and to improve the welfare of the farmers and landless rural poor.

Impact of Watershed Programme and People's Participation in India

A recent study using the meta-analysis approach the performance of watershed programmes in India is assessed (Joshi *et al.* 2004). Based on an exhaustive review of 311 case studies on watershed programme in India it was noted that the mean benefit cost ratio of watershed programme in the country was quite modest at 2.14. the internal rate at return (IRR) was 22 per cent, which is comparable with any rural development programmes. The watershed programmes generated enormous employment opportunities, augmented irrigated area, and cropping intensity and conserved soil and water resources.

FIG. 2 :



CONCLUSIONS

Degradation of the natural resource base, coupled with high rates of population growth and poverty, is the major problem in the rainfed areas of India. Sustainable intensification of agricultural production (without degrading the resource base) in the less favoured and marginal environments is the key for reducing poverty and the associated problems of malnutrition and high maternal mortality. High intensity of land use without sufficient productivity sustaining investments, has often led to excessive degradation of the resource base (degradation of soils, depletion of water tables, and loss of biodiversity), which in turn exacerbates poverty. Integrated watershed management programme would be able to unlock the enormous potential of rainfed systems and would be a vehicle of development to alleviate poverty by raising farm productivity and generating employment opportunities in marginal and fragile environments. Integrated watershed management allows *in-situ* conservation of water and soil nutrients, which gradually offers the opportunity to harvest several crops in a given year through supplementary irrigation. Efficient water harvesting and integrated soil nutrient management allows diversification of incomes and better management of risk in drought prone environments. *In-situ* conservation of soil and water also helps in regenerating the vegetation cover and protection of biodiversity, which brings additional environmental benefits to the community and the society.

The new approach of convergence and technical backstopping through a consortium opens new vistas for development of

rainfed areas. The mean benefit cost ratio of 2.14 estimated through meta analysis at country level and the IRR of 22 per cent is comparable with any rural development programme. More targeted investments in rainfed areas using integrated watershed management approach along with technical backstopping would address the problems of equity, gender and improve the livelihoods. This calls for increased investments in rainfed areas to unlock the potential of rainfed areas and fuel the development of country by improving livelihoods of millions of poor people.

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