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Watershed Management Approach for Conserving Water Resource in Rainfed Areas

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Abstract – **Soil and water resources are of utmost importance for fulfilling the requirement of food, fodder, fibre, fuel and furniture of fast growing population of the country. Food production from crops and livestock must increase in order to meet future demand. Since the productivity of irrigated areas has started to stagnate or even decline, the attention now must be focused on rainfed areas that have the potential to sustain food production in the country. However, productivity improvement and expansion in rainfed agriculture in developing countries have remained rather slow compared to irrigated agriculture (Rosegrant et al., 2002).**

Watershed development program has been recognized as a potential engine for agriculture growth and development in fragile and marginal rainfed areas (Joshi et al. 2005; Ahluwalia and Wani et al. 2006) as it can address several of the issues associated with these ecosystems. Management of natural resources at watershed scale produces multiple benefits in terms of increasing food production, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity concerns (Sharma, 2002; Wani et al. 2003 a, b; Joshi et al. 2005; and Rockstorm et al., 2007).

Keywords – **Watershed Management, Rainfed Agricultural, Soil and Water Resource.**

WHAT IS A WATERSHED?

A watershed, also called a drainage basin or catchment area, is defined as an area in which all water flowing into it goes to a common outlet. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa. From the hydrological point of view, the different phases of hydrological cycle in a watershed are dependent on the various natural features and human activities. Watershed is not simply the hydrological unit but also socio-political-ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people (Wani et al. 2008). The components of watershed management program are shown in Table 1.

Table 1: Components of new definition of watershed management

Factor group	Component	Emphasis and objective
System factor	Planning	To accomplish maximum return with minimum effort
Modus operandi	Organizing, actuating and controlling, performance	Of the people, by the people and for the people
Economics	Monitoring and evaluation for effective planning and modus operandi	Act as check on direction and performance towards fulfilment of set goals.

Source: Yadav and Bhushan (2001)

WATERSHED CHARACTERIZATION

It involves inventorying and assessment of natural resources, which are essential pre-requisites of any watershed management activity. For example, watershed managers need timely and reliable information on soils, crops, ground water potential and land use. Similarly, an assessment of the properties of the soils and their response to management is required in agricultural and forestry, for decision making in planning and for many other engineering works. Remotely sensed data can be effectively used to prepare maps on various themes such as land use/land cover, soil distribution, geomorphology etc., which in turn form the basic tools for designing a proper management strategy. High resolution remotely sensed data when used in conjunction with conventional data can provide valuable inputs such as watershed area, size and shape, topography, drainage pattern and landforms for watershed characterization and analysis (Obi Reddy et al. 2001).

WATERSHED DEVELOPMENT IN INDIA

The term watershed came in prominence in the domain of soil and water conservation in the second five year plan. Since then emphasis has been laid on land and water conservation on watershed basis. The fragmented field treatment approach got re-modified to watershed scale approach, seeing the logistics and scientific implications, beneficial gains and economic justifications. Indian Council of Agricultural Research started a countrywide scheme on operational research project on Watershed Management,1983. Working research institutions and state agricultural universities (SAUs) available in the area

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provided the scientific back up. Planning of watershed was carried out by the scientific organizations and the state department of agriculture carried out executions. The central Ministry of Agriculture, who funded the project, changed *modus operandi* and renamed it 'National Watershed Development Project for Rain-fed Areas'.

Realizing the potential of resource conservation on watershed basis and of programs of watershed development by different ministries viz. Agriculture, Forest and Environment and Employment and Social Justice, Hanumantha Rao Committee (GOI, 1997) made guideline for participatory watershed management. The participatory watershed management programs are being implemented with many different levels of success and failures (Anonymous, 1998). The objective of this analysis of watershed management and implications is resource conservation and derive a sound management basis for watershed management for sustainable productivity.

Currently $ 1000 million is invested yearly in watershed development programs (WSD) that are implemented by a range of departments at the centre and state level. The Department of Agriculture and Cooperation (GOI) implements the National Watershed Development Projects for Rainfed Areas (NWDPRA). The Ministry of Rural Development (MoRD) implements the Integrated Wasteland Development Programme (IWDP), the Drought Prone Area Program (DPAP) and the Desert Development Program (DDP). The watershed approach has been adopted in other schemes for the development of catchment areas, flood prone areas and control of shifting cultivation in north-eastern regions. In addition to the centrally sponsored schemes several state governments are also implementing schemes for soil and water conservation on watershed lines. There are also a number of donor-funded and research oriented watershed development projects. The goal of most watershed projects is to increase agricultural productivity through soil and water conservation and rainwater harvesting at the micro-watershed scale. There are effectively three routes through which the rehabilitation and development of water scarce watersheds is expected to contribute to rural development: increased agricultural productivity, improved natural resource conservation, and more equitable and sustainable management of common property resources. There is a difference in watershed management approach and objectives between developing and developed countries (Table 2).

Table 2: Different Aspects of Watershed Management in Developing and Developed Countries

Activities	Developing countries	Developed countries
Output	Farm production	Water yield
Focus	Livelihoods of the communities	Water quality
Program	Community based socio-economic activities	More on natural resource management
Approach	Applied science and participatory approach	Science based
Action	People oriented	Natural resource oriented

Source: Brooks et al. (1991) and Sheng (2001)

WATERSHED MANAGEMENT APPROACHES

This approach suggest the 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 people and animals in a sustainable manner. This approach aims to improve the standard of living of common people by increasing his earning capacity by offering all facilities required for optimum production (Singh, 2000). In order to achieve its objective, integrated watershed management suggests to adopt land and water conservation practices, water harvesting in ponds and recharging of groundwater for increasing water resources potential and stress on crop diversification, use of improved variety of seeds, integrated nutrient management and integrated pest management practices, etc. With experience, the watershed management approach keeps on changing. Table 3 compares conventional and new approaches to watershed development.

Table 3: Comparison of conventional and new approaches to watershed development

Conventional approach	New approach
Executive agency-driven	Participatory, people-driven
Target-based	Participatory, process-based (demand-driven)
Aimed only at soil, water and vegetation conservation	Aimed at poverty alleviation and overall human development
Transfer of Technology, Extension method	'People First' approach, dovetailed to TOT approach
Based on Important Technology and Ideas	Based on indigenous technology, traditions and culture and cosmic vision of local people
Top down planning, monitoring and evaluation	Bottom-up (participatory) planning monitoring and evaluation
Land use based on land capability	Land use based on land suitability and people needs and preferences
Empowered the agent of technology transfer i.e. officials	Aimed at people's empowerment

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Attend to select, generally better off farmers	Aimed to marginal, small and poor farmers with special emphasis on equity
Tended to be taken over by single department	Multi-departmental and multi-disciplinary
Villagers were not empowerment	Villagers empowerment
Based on large watersheds	Small watershed based on people's institution

Source: Dube (1999)

PRESENT STATUS OF WATERSHED MANAGEMENT IN INDIA

It appears that in India the art and science of watershed development and management has gone through major change. Initially, in certain water-scarce regions, the anarchy model of watershed development-indiscriminate management of scarce water and land resources-has come to the fore. Institutional and physical (spatial) scale linkages, which are critical to ensure equity and minimize conflicts, have largely been ignored. It has long been acknowledged that technological innovation alone is insufficient to address environmental sustainability concerns. Best watershed practices must be integrated with sound management and governance in order to be viable over the medium to long term. The goals and objectives vary considerably by project and region as well. However, it has been difficult to assess the real outcomes of watershed development of the past decade's massive efforts (Kerr, 2002).

There are some questions that require thinking for effective execution of watershed management programs. What are the key elements of success or failure of these decentralized approaches envisaged to natural resource management? What are the management principles on which future development should take place? Finally, what is the appropriate mix of initiative and investment on the part of government, non-governmental organizations, community groups, and individual users?

WATERSHED MANAGEMENT - ISSUES/BOTTLENECKS

Watershed Management is an effective in soil conservation, community mobilization, and empowering local people for resource management. But, there are some critical issues which are discussed below:

Management issues

Participatory process is a long and costly process. In many developing countries, extension services still suffer from a strong Top-down approach (Michaelsen, 1991; Styczen and Dreyer, 1999). Furthermore, it may be difficult for facilitators and stakeholders in watershed management projects to include representatives of all stakeholder groups in management and decision-making processes.

Policy issues

Participation in conservation programs generally takes place if there exist direct economic benefits (Stocking, 1998). Subsidy policy is not a sustainable option for watershed management programs (Huszar, 1998). Yet in poor mountain communities, where farmers depend for sustenance on crop production in marginal lands, subsidies may be unavoidable to encourage conservation and restoration of degraded lands (Hudson, 1991). In some instances subsidies are misused by local communities by over estimating costs and duplicating the work in the name of participatory approach (Sthapit and Bendtsen, 1999).

Poverty issues

Poverty has a tendency to exacerbate the participatory process. Watershed development projects are essentially land based development activities that aid in raising the productivity of the farmers. However, being incidental to the treatment program, this chiefly helps the large farm size farmers who are centrally positioned and are able to manipulate project management in order to obtain maximum benefits (Farrington and Baumann, 2003).

Upland-lowland issues

Sound natural resource management in the uplands also often provides environmental services for low lands and beyond (Swallow et al., 2001). The protection of forests in upland areas, for instance, reduces soil erosion, sedimentation, and flooding downstream (Pandey, 2003). However, as hardships persist in upland areas due to lack of land tenure and access to markets and negative impacts of national development processes, communities are often unable to tap the full benefits of sustainable natural resource management (Swallow et al., 2001).

Institutional issues

Most of the watershed related activities have been designed with an assumption that willing participation of the local community will be channeled to meet the goals and objectives of watershed rehabilitation. However, there is a big gap between expectations of the people and the institutional arrangements to meet these expectations. Sheng (1999) points out the problems of coordination in many watershed programs in developing countries. Each agency has its own separate plans and responsibilities (Paudel, 2002). Moreover, watershed boundaries and political boundaries do not coincide which tends to aggravate participatory management. Some other conflicting issues regarding equity, poverty, co-ordination, revenue sharing, community forestry taxation and highland-lowland and indigenous user rights exist in participatory natural resource management program. These issues should be addressed to plan and implement the watershed management programs for sustainable development.

ISSUE OF MANAGING COMMON POOL RESOURCES (CPRS)

CPRs of land, water, forest, fisheries, wildlife and agriculture constitute an important component of community assets in India and several other developing

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countries and significantly contribute towards the people's livelihoods despite the decline in their area and physical productivity. The poor households and small farmers secure a substantive portion of their fuel, fodder, income generation, and risk minimization through CPRs (Jodha, 2002). However, despite this CPRs are generally neglected and declining in different areas due to several socio-economic and political reasons (Marothia, 1993; Jodha, 1996). The decline is visible in their shrinking area, biophysical degradation, and loss of management systems. Local land and water management and rainwater harvesting in a watershed context provide the key to the transformation of the ecological and economic base of villages economically dependent on CPRs (Agarwal and Narain, 2002). In order to develop a good village-level natural resource management programme, it is essential to develop a conceptual framework that addresses both the private and common property resources of the village, its diverse biomass needs, and the interests and needs of different socio-economic groups within the village community.

SOME CASE STUDIES AT FARMERS' FIELDS

I. Ravinous Watershed, Jalaun

With a view to optimize the productions, generate more employment to farm families and improve the socio-economic condition of masses through watershed management technology, a 748 ha ravinous area was treated with different soil and water conservation measures in the catchment of river Yamuna by CSAUA&T, Kanpur. The output was:

- Rise in water table by 3.7 m; increased groundwater recharge is being exploited for irrigation and drinking purpose. About 18 hectometre water is being harvested every year for irrigation on 180 ha land during severe moisture stress period. The number of shallow tube wells rose from nil to 51, and dug wells from 10 to 31. The enhanced availability of irrigation water led to increase in are under cultivation form 56 to 690 ha.
- Increase in total food production in the watershed from 11,261 to 1,21,275 q, with increase in average productivity from 6.5 to 28.0 q/ha. Fuel wood production increased from 1174 to 8539 q. The fruit productivity increased from nil to 30.5 q/ha.
- Rise in production of milk, meat and wool from 352700 to 2292000 litres, 55 to 11955 kg and nil to 823 kg, respectively. Likewise, there was increase in the number of tractors and tractor cultivators (3-45 each), threshers (0 to 15), land levellers (0 to 3) and diesel pump sets (0 to 51).

On the basis of above results the following applied research has been passed to the farm families directly for increasing and sustaining the productivity, conserving the soil, harvesting of rain water, checking of runoff, trapping of silt and plant nutrients in situ and increasing the cropping intensity in dry land area of Bundelkhand. The generated technology on watershed basis has been followed 95% by families of watershed area and more than 85% by the other area of watershed in Bundelkhand.

II. Hill and Valley Watershed of Bundelkhand

The southern part of Bundelkhand situated in between hill and valleys of Jhansi district faced low productivity, deep water table, stony coarse rakar soil, high rate of erosion, deficit in food, fuel, fodder and water availability. Some farm households of area are so poor that they could not even afford two square meals. With the objective to develop the eco-system of degraded hillocks and valleys, the holistic watershed approach was launched under World Bank funded program. The land treatments with peripheral/marginal bund, submergence bunding, check dam/nala bunding, water storage structures and masonry structures for moisture conservation and runoff control were executed. They paid dividends in terms of improved ground water table by about 3.22 m. The water storage and number of open stone lined dug-out wells increased from 894 to 2365 million liters and from 14 to 611, respectively, within a period of 6 years (1997-98 to 2003-04). The recharged ground water is available for protective irrigations up to mid March. About 100% cultivated land has been saturated under protective irrigation facilities from recharged and harvested rainwater. The productivity of groundnut, maize, wheat, gram, lentil, mustard, radish, tomato, carrot, onion and potato were raised from 7.0 to 27.5 q/ha, 9.0 to 27.0 q/ha, 7.0 to 40.5 q/ha, 0 to 18.7 q/ha, 6.5 to 11.0 q/ha, 0 to 21.5 q/ha, 0 to 187.0 q/ha, 90 to 295.5 q/ha, 0 to 155.5 q/ha, 0 to 307.0 q/ha, and 0 to 300 q/ha, respectively. Thus the average productivity of watershed enhanced appreciably from 8.46 to 35.21 q/ha. The transport facilities improved from bullock cart to tractors and motorcycles. Number of tractors increased from 17 to 103 in the pilot area. Likewise, diesel operated pump sets increased from 11 to 709 in the operational area of watershed. The demography of cows increased from 2110 to 5379, buffaloes 2205 to 4328 and goats from 1848 to 3567 in the watershed area during this period, with the development of natural pasture land of *Digitaria biformis*, D*igitaria triformis* and *Pasplam*.

As a result of this excellent performance in Rain Water Management project, the CSAUA&T, Kanpur bagged "Best National Productivity Award" for the year 2000-01 and 2001-02.

III. Ravenous Watershed of Bundelkhand

The study was conducted on rainwater management with three tier system during 2008 and 2009 under ravenous Watershed in Jalanu district of Bundelkhand. Uttar Pradesh. The main objective was to increase the productivity, profitability & water use efficiency in ravines affected area through double cropping system. In double cropping system of sesamum-wheat, sesamum and wheat gave significantly higher seed yield of 448 and 4560 kg/ha, respectively, under three tier system of rainwater management over the yield recorded in other systems of moisture management. In blackgram-wheat cropping system, three tier rainwater management systems yielded significantly higher blackgram and wheat of 700 and 4618 kg/ha, respectively, compared with yield recorded under

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mono and two tier, and conventional systems of soil moisture management. The significantly higher wheat equivalent yield of 7248 kg/ha was found in sesamum-wheat cropping system compared with wheat equivalent yield of 7068 kg/ha recorded in blackgram-wheat cropping system under three tier system of rainwater management. The highest net returns of Rs 41510/ha were obtained from sesamum-wheat cropping system, which was significantly superior to the net returns received from blackgram-wheat cropping system (Rs 41045/ha) under three tier system of rain water management.

CONCLUSION

India's rainfed agricultural sector provides livelihoods for millions of people and it is the source of nearly half of the value of the country's agricultural production. As unexploited irrigation potential is increasingly scarce, planners looks towards rainfed agriculture to contribute for food production and economic development in the decades ahead. This is well known fact that irrigated agriculture has always been more productive than rainfed agriculture, but rainfed agriculture have been highly productive, particularly in the last decade, thus providing hope that the rainfed sector can in fact make major contribution in coming years. Most of people below poverty line live in rural areas, where livelihood options outside of agriculture are limited. Many rural poor rely mainly on rainfed farming for food, but variable rainfall, dry spells and drought make rainfed farming a risky business. Better management of rainwater, soil moisture and supplemental irrigation is the key to helping the greatest number of poor people. The strong performance in recent years of rainfed rice in Eastern India and rainfed sorghum in Central India provide the basis for optimism that rainfed agriculture can in fact be an important source of agricultural production in the coming decades. It also suggests that developing new technology in participation with farmers, buildings on their existing farming systems to improve soil and water management, may yield new technologies that are both effective and widely adopted for sustainable production for rainfed areas on watershed basis.

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