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Participatory watershed management - a new paradigm for integrated water resource management

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Abstract
The perspective analysis of land and water availability vis-à-vis their demand suggests the need of harvesting, conserving and managing water in its various forms for sustainable development. The role and importance of community participation in ensuring the sustainable development is now widely accepted. Participatory integrated watershed management is now becoming the new paradigm for natural resource conservation and management to tackle these problems ecologically, socially and economically on sustained basis. The paper presents an overview of the watershed management in relation to water resource conservation and management in general and with special reference to Western Ghats Region of India and demonstrates perspectives of watershed management in improving water resource availability locally through surface and ground water interventions. The results of various participatory Watershed Management (WSM) programmes strongly suggest their importance in water resource management and promoting natural resource conservation through people's participation. Watershed management ensures integrated management of rain water, in-situ soil moisture, surface water and ground water together with land and vegetation management. It is suggested that basinwise planning and management of water resources should integrate participatory WSM programmes for sustainable development.

INTRODUCTION

The management of land and water resources that provide life supporting system is crucial to environment, economic and social sustainability. Soil erosion and depleting/degrading land and water resources are posing serious threat to social, economic and political stability, particularly in the developing countries. The per capita land and fresh water availability in India in early nineties has been 0.2 ha and 2200 m^3 against the world average of 0.27 ha and 7400 m^3 respectively. Due to highly uneven distribution of water resources, per capita water availability in some of the east flowing rivers of Tamil Nadu is as low as 380 m^3 (Anon., 1998). Per capita water availability has now decreased to 1953 m^3 and it is projected to be 1704 m^3, 1465 m^3 and 1235 m^3 by the year 2010, 2025 and 2050 respectively (Navalawala, 2000). It is estimated that even after development of full irrigation potential of 113.5 M ha through large, medium and minor irrigation projects as against the possible cropped area of 200 M ha by the year 2010 AD, still about 85 M ha area will be left as rainfed (dryland). These rainfed areas have no possibility of providing irrigation through conventional methods and large amount of runoff not only goes waste from such lands, but also creates problems of soil erosion, land degradation and flooding.

The perspective analysis of land and water availability vis-à-vis their demands strongly suggests the need of harvesting, conserving and managing rain water in its various forms (rain water, in-situ soil moisture, surface water and ground water) at local scales through small and micro water harvesting systems following watershed management approach. This is especially more so in low rainfall areas, rainfed (dryland) agriculture, drought-prone areas and ghat (hilly) areas. It is also becoming clear that sustainable development is closely linked to the participation of local community who live in close proximity and association with these natural resources - land, water and vegetation. Integrated watershed management has now become a new paradigm for integrated land and water resource conservation and management to tackle these problems ecologically, socially and economically on sustained basis through larger people's participation. Soil and water conservation including micro-scale water resource development is the foundation of any watershed development programme supported by number of other protection, production and livelihood support interventions. In the Ninth Five Year Plan, it has been emphasised to make watershed programme as a National Movement. The role and importance of community participation in ensuring the success and sustainability of watershed management is now widely accepted. The World Water Council also recently emphasised that without full public participation, it was impossible to envisage or implement sustainable solutions for water resource development and management.

The paper presents an overview of the watershed management in relation to water resource conservation and management in general and with special reference to Western Ghats Region, growth and models of watershed programmes in India, approach to people's involvement at different stages of watershed management programme and demonstrates perspectives of watershed management in improving water resource availability locally through surface and ground water interventions with community participation.

WESTERN GHATS : AN OVERVIEW

The Western Ghats are the range of mountains along the west coast about 1600km long, 80 to 100 km wide, running continuously from the mouth of river Tapti in Dhule district of Maharashtra to Kanyakumari interrupted at Palghat. They are a steep and rugged mass of hills, with elevation varying from 100 m to 2700 m towards the south and culminating in the Nilgiris with Dodabetta at a height of 2636 m where the Eastern Ghats meet the Western Ghats after making a sweep from the other side of the peninsular. Western Ghats are spread over the States of Maharashtra, Karnataka, Tamil Nadu, Kerala and Goa. Out of the total area of 16 M ha covered under the Western Ghats Development Programme (WGDP) of Union Planning Commission, Maharashtra, Karnataka, Kerala, Tamil Nadu and Goa constitute 36.35, 27.55, 17.6, 17.4 and 1.1 percent of the total area respectively. The climate of the region is tropical upto 900 m, sub-tropical from 900-1800 m and montane temperate above 1800 m. Average annual rainfall varies widely from a low of about 500 mm to >6000 mm. Western Ghats give rise to important rivers of peninsular India including Godavari, Krishna, Kaveri, Kali Nadi and Periyar. The region is endowed with one of the rich flora and fauna and has a unique biodiversity.

Central Soil & Water Conservation Research & Training Institute, Research Centre, Udhagamandalam has recently classified Western Ghats into five hydro-ecological regions

(Sikka and Singh, 1999). Lower Altitude High and Very High Rainfall Region (i.e., coastal lower ghats) followed by Lower Altitude Low and Medium Rainfall Region (i.e., rain shadow area) form major part of Western Ghats.

Erosion hazards and land degradation problems are severe owing to high rainfall, high erosivity, higher soil erodibility, steep slopes, faulty land use management and heavy water surplus during the monsoon period. Hydrologically, the Western Ghats region assumes greater importance as it is the origin of a number of river systems in South India. Hydrologic characteristics of the Ghat areas and uplands are typical of an upland rainfed mountainous watershed with distinct surface and sub-surface flows contributing to stream flows. Both the surface and sub-surface flow paths are important with sub-surface component being predominant which is typical of such hilly watersheds. The areas under thick forest and 'shola' forest with high infiltration rate contribute more towards sub-surface flow while the degraded lands in the hills and foot hill areas may be responsible for generating relatively more surface runoff. There is increased dependence on ground water especially in drought affected and rain shadow areas in particular. Level of ground water development in Western Ghats region is about 23% (Anon., 1998). In Tamil Nadu exploitation of ground water is about 60% while in the Western Ghats area of Karnataka about 24% of net irrigated area is covered by well irrigation. The ground water exploitation is mostly through dug wells, bore wells and shallow tube wells.

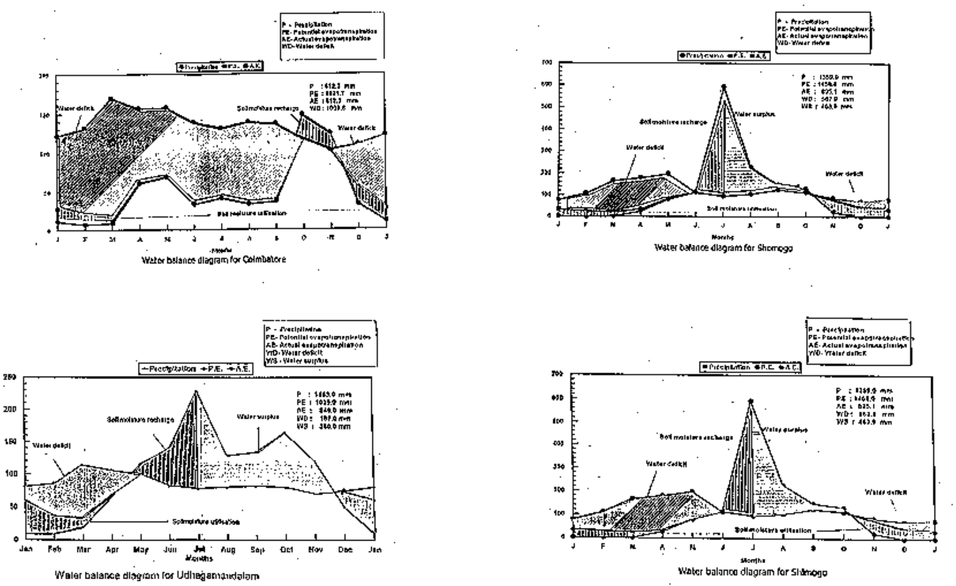

Figure 1. Water Balance diagram of selected stations in western Ghat region.

Water balance diagrams of some selected stations of Western Ghat (Figure 1) indicate that water surplus lasts from June/July to October/November. Water deficit can be noticed during the months from December through April/May. This indicates a good scope of harvesting rainwater surplus as surface or sub-surface storage to overcome the moisture stress conditions. This strongly suggests development of local or micro level water resources through water harvesting, ground water recharge and water conservation in rainfed/dry and hilly areas of Western Ghats following integrated watershed management approach.

WATERSHED PROGRAMMES: GROWTH AND MODELS

Watershed management, though less focussed earlier, has a history of about 50 years in India. Multiple agencies have been involved in the growth and development of watershed programmes. Biophysical aspects of watershed management were first started in the Damodar-Barakar basin under Damodar Valley Corporation, Hazaribagh by establishing a Soil Conservation Department during 1949-50. The focus on watershed research was further sharpened with the establishment of a network of Soil Conservation Research Demonstration and Training Centres at Dehra Dun, Chandigarh, Agra, Kota, Vasad, Hyderabad, Bellary and Ootacamund (now Udhagamandalam) by the Union Ministry of Agriculture in 1954 to provide necessary research back up and trained manpower and these centres became part of the Indian Council of Agricultural Research (ICAR) in 1969.

These Research Centres established 42 small research watersheds for monitoring surface water hydrology, natural vegetation successions, impact of biotic interferences, etc., during 1956. The Centrally sponsored scheme of "Soil Conservation in the catchments of River Valley Projects" was launched by the Soil and Water Conservation Division of the Union Agriculture Ministry in 1961-62 for watershed protection in 27 catchments. Watershed technologies were first demonstrated in actual field settings through integrated watershed management approach in mid seventies through the eye opening model Operational Research Projects (ORPs) on watersheds at Sukhomajri (Haryana) and Nada (Haryana) representing Shiwalik foot hills, Fakot (U.P. hills) representing middle Himalayas and G.R. Halli (Karnataka) representing red soils of low rainfall region. The people's participation was the key to the success of these projects. During this period between 1980-81, watershed programmes were initiated under Flood Prone Rivers Project by the Soil and Water Conservation Division of Union Agriculture Ministry.

As a result of the achievements and benefits of model ORPs, forty seven model watersheds were established in different agro-ecological regions of the country in 1983 for joint development by the Central Soil and Water Conservation Research and Training Institute (CSWCRTI) and Central Research Institute for Dryland Agriculture (CRIDA) of the Indian Council of Agricultural Research, State Governments and State Agricultural Universities (Dhryvanarayana et al., 1987). Based on the successful results of model watersheds in drought alleviation during the drought of 1987, number of nationally and internationally funded watershed development projects/programmes started (Table 1). Major nationwide watershed programmes included Drought Prone Area Programme (DPAP) and Desert Development Programme (DDP) that adopted watershed approach from 1987, National Watershed Development Programme for Rainfed Agriculture (NWDPRA) in 1991 and Integrated Wastelands Development Project (IWDP) on watershed basis since 1994. Western Ghats Development Programme of Union Planning Commission spread over an area of 16 M ha in the States of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala also started integrated watershed based approach since 1987-88 for eco-restoration including Hill Area Development Programme (HADP). World Bank

DANIDA, EEC, Indo-German, Indo-Swiss, Japaneese aided Watershed Projects are some of the externally funded watershed programmes. Apart from these national/international level programmes, a number of State Government sponsored and NGOs supported watershed programmes subsequently started during eighties and nineties. In a policy statement of the early nineties, the Government put forward its intention to involve NGOs as collaborating partners in such developmental programmes.

Table 1. Growth of nationally and internationally funded organized watershed management programmes in India.

Schemes/Projects	Year of launch	Watershed Nos./area	Sponsoring Agencies
Research watersheds	1956	42 Nos.	Min. of Agri., GOI/ CSWCRTI, ICAR
Soil Conservation in RVP Catchments	1961-62	29 catchments in 9 States	Min. of Agri., GOI
Operational Research Watersheds	1974	4 Nos.	CSWCRTI, ICAR
Watershed Management in Catchments of Flood Prone Rivers	1980-81	10 catchments in 8 States	Min. of Agri., GOI
Model Watersheds	1983	47 Nos.	CSWCRTI & CRIDA, ICAR
Watershed Development in Rainfed Areas	1984	28 Nos. (3.47 lakh ha)	World Bank (A.P., Karnataka, M.P. & M.S.)
Watershed Development in Ravines Area	1987	0.62 lakh ha	EEC
Drought Prone Area Programme (DPAP)	1987*	91 districts 615 blocks	MRAE, GOI
Desert Development Programme (DDP)	1987*	21 districts 131 blocks	MRAE, GOI
Western Ghats Development Programme (WGDP)	1987*	158 blocks 5 States	Union Planning Commission
Schemes/Projects	**Year of launch**	**Watershed Nos./area**	**Sponsoring Agencies**
Indo-German Watershed Project	1990-91	Maharashtra	Germany
Indo-German Bilateral Project	1990-91	Monitoring	Germany
NWDPRA	1991	2497 Nos.	Min. of Agri., GOI
IWDP (Hills & Plains)	1991	1.12 lakh ha	World Bank
Comprehensive Watershed Development Project	1991	1.13 lakh ha	DANIDA (Karnataka, Tamil Nadu and Orissa)
Rel Majra Watershed Project	1991	1 No.	CSWCRTI, ICAR/ Min. of Env., GOI
Doon Valley Project, UP	1993	1.72 lakh	EEC
Integrated Wasteland Development Project (IWDP)	1994	25 States	MRAE, GOI
Indo-Swiss Participatory Watershed Development	1995	0..35 lakh	Swiss Government
Attapadi Wasteland Comprehensive Environment Conservation Project, Agali, Kerala	1996	507 Km^2	OECF, Japan

MRAE - Ministry of Rural Areas & Employment *Since Programmes adopted watershed approach
Source: Modified from Samra (1997)

WATERSHED APPROACH

Concept

Watershed is recognized an ideal unit for planning and development of land, water and vegetation resources. Watershed concept has been used extensively because of importance of waer balances in the study of ecosystems. Watershed also allows accurate measurements and monitoring of components of water balance on hydrologic cycle, sediment, energy, heat, carbon and nutrients balances in a watershed ecosystem. This can provide a network of monitoring stations on sites within a basin in a nested form. The monitoring at the level of watersheds or sub-watersheds in a basin will help in analysing impacts of current and future activities and accordingly plan area specific management options or alternatives based on the priorities as per the intended project objectives. Watershed management covering the area from the highest point (ridge line) to the outlet 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 minimum needs of the people in a sustainable manner.

Planning

Some of the watershed ranged from about 1000 ha or less for NWDPRA to 5000 to 10000 ha for RVP and FPR catchments, with further micro and mini-watersheds being adopted for plan implementation. Generally a workable size of 500 to 1000 ha watershed is preferred. Base line/bench mark surveys for physiography, climate, soils, landuse, vegetation, hydrology and socio-economic data are conducted and analysed for preparing watershed plan. Apart from surveys, this information is also supplemented from Participatory Rural Appraisal (PRA) exercise. Multi-data approach involving extraction of data from various conventional sources and new techniques/sources such as remote sensing together with limited ground truth and field survey could be ideally employed in watershed development programmes. The spatial and non-spatial data can be effectively utilized through GIS for watershed planning.

Community Organization and People Institutions

Participatory approach is more pertinent in the planning and development of watershed management (WSM) programmes, because it is basically the people's programme and the government agency should participate in that as a facilitator. The concept of participatory process is easy to advocate but difficult in practice. This needs active involvement and dedication. This also demands some psycological and functional adjustments by the government functionaries. Involvement of social organizations, NGOs and VOs is a must to organize and mobilize community support and make this as people's programme and national movement.

This whole process may involve following steps.

Meetings with the Watershed Community: Conduct regular meetings with the farmers in villages to clearly explain the purpose of the programmes, get their feed backs, develop contacts, gather Indigenous Technological Knowledge (ITK), win their confidence and involvement.

Problems Appraisal and Plan Formulation: Conduct Participatory Rural Appraisal (PRA) or Rapid Rural Appraisal (RRA) exercises in the village to gather information, diagnose their problems, needs and priorities to arrive at a common outline of watershed development plan. During the PRA exercise, activities/works to be taken up under Entry Point Activities for rapport and confidence building may be identified. These items may include work/activity of common interest to the community such as repair of temple, water supply, roads, community hall, school building, etc.

External Organisation - as a Facilitator: External implementing agency, governmental or NGO, to provide technical support, act as a facilitator to help them in programme implementation and community organization.

Formation of local People Institution: Local level people institutions such as Watershed Association/Water Users Society, Self Help Groups (SHGs), User Groups (UGs) are formed, by laws framed and society is registered for day to day running, management and distribution of benefits and create working capital through revenue generation, people contribution, etc., for repair and maintenance of the works. This will create a self sustaining local institution to take over the activities after withdrawal of Project.

WATER - A MAJOR WORK COMPONENT OF WSM

Concept of WSM basically revolves around the conservation, development and management of water resources. Since water plays a catalytic role in healthy development of plants, animals and human resources, concept of watershed has assumed needed importance. It involves integrated use and management of rain water, in-situ soil moisture, surface and ground water together with development and management of land, vegetation and crop in a watershed to meet its various needs. Apart from various production and vegetative measures, major components of WSM programmes include a) in-situ soil moisture conservation measures such as bunding, levelling, terracing, vegetative barriers and conservation farming practices; b) surface water development structures such as ponds, tanks, small water harvesting dams, gully control structures, drainage line treatment, diversions, etc.; c) sub-surface/ground water development measures such as percolation ponds/tanks, sub-surface dams/barriers, diaphragm dams, water spreading, sub-surface collection wells, etc.; d) other measures such as roof top collection/rain water cistern, inter-plot water harvesting, etc.; and e) improved water management practices including promotion of micro-irrigation and other demand management practices. In general, the above measures of soil-moisture conservation, drainage line treatment and water resource development and management account for about 75 to 80 percent of the total work component in a typical watershed programme. These measures when taken up in a watershed in an integrated manner together with efficient land and production management practices not only augment the water resource availability but also improve water use efficiency and productivity in the watershed and provide protection against soil erosion and sedimentation.

This technology and approach of developing and managing water resources together with land and vegetation in participatory process locally at micro-scale is need based and eco-friendly while for major and medium projects environmental stipulations are becoming very stringent. These measures help in creating additional surface storage capacity. Surface storage capacity created varies widely depending upon the topography, catchment conditions and the climate of the region. Storage capacity created in some of the watersheds (500 to 1000 ha) in the country is given in table 2.

Table 2. Storage capacity created in some of the watersheds (500 to 1000 ha) in the country.

Watershed Surface storage capacity created	(ha-m)
Bunga (Haryana)	60.0
Siha (Haryana)	42.2
Chhajawa (Rajasthan)	20.0
Relmajra (Punjab)	13.7
Chinnatekur (A.P.)	5.6
G.R. Halli (Karnataka)	6.8
Joladarasi (Karnataka)	4.0
Kuppepalayam (Coimbatore, T.N.)	3.2
Salaiyur (Coimbatore, T.N.)	3.5
Wagarwadi (Parbhani, MS)	6.6

It can be seen that storage capacity created through watershed projects varies widely in the country. In the Southern Peninsular and Western Ghats region it can be assumed to vary between 4 to 7 ha-m per watershed. However, in case of percolation tanks/ponds actual water impoundment will be more as these are usually designed for two fillings during the monsoon season and storage capacity is assumed to be repeatedly available as a result of water percolation between the two fillings.

IMPACT ON WATER RESOURCES

The results of studies conducted by different agencies, Universities, NGOs and the ICAR's Operational Research Projects on watershed management have shown convincing results about the enhanced surface and ground water availability after implementation of the projects (Dhruvanarayana et al, 1987; WOTR, Bulletin; Samra, 1997; Gaur, 1998; Sikka, 2000; Sikka et al., 2000). Increased surface and groundwater availability due to execution of various watershed measures was evident from increased number of wells, increased irrigated area, rise in water table, increased perenniality of water in wells and streams and increased availability of water for cattle and other needs in watersheds. These impacts are quite visible and some of them well documented and publicised, though its exact quantification might have been less attempted. Based on the information/data and results of some available studies conducted in and around Western Ghats region, impacts on water resources have been discussed.

In a study to determine the recharge from percolation tanks in basaltic formations of Central Maharashtra, it was found that i) the area of influence of tanks on the average was 1.7 Sq.km, ii) the rise of groundwater level was about 2.5 m and iii) the recharge to ground water was about 60% of the tank capacity (Rao, 1979). The rise of water level was generally found to be more in wells nearer to the tank and the same gradually reducing away from the tanks. The results of studies conducted in the percolation ponds of Coimbatore district showed that the zone of influence extends to 1 - 1.3 Sq.km with water table rise in the range of 1.0 to 2.5 m. Rise in water table as a result of watershed treatment works and percolation ponds/tanks at different places in the peninsular region is presented in Table 3.

Though there is a wide variation in water table rise from 0.5 to 3.0 m depending upon the size/type of works and the site conditions, on an average it shows an increase of the order of 1.5 to 2.0 m in the zone of influence.

Table 3. Groundwater recharge through percolation tanks, water harvesting structures and soil conservation measures.

Region Type of measures Rise in Water Table	(m)
Basaltic formations of Central Maharashtra Percolation Tank	2.5
Coimbatore district of Tamil Nadu Percolation Pond	1.0 to 2.5
Chinnatekur, Kurnool, A.P. Check Dams, bunds and weirs	0.5 to 1.0
Anantapur, A.P. Water Harvesting Structures	2.0 to 3.0
G.R. Halli, Karnataka -do-	1.5
Parbhani, M.S. Nala bund, gully plugs	0.3 to 2.5

In Wagarwadi watershed (564 ha) of Parbhani district, an increase of 40 to 50 percent in accumulated ground water potential was observed in treated watershed in period of four years, thus clearly showing the impact of WSM on augmentation of groundwater (Pendke, 1998). In the same watershed, Gore et al (2000), following a groundwater flow modeling approach, estimated that contribution to artificial groundwater recharge from nala bunds and gully plugs was in the range of 36.7 to 64.7 percent of corresponding surface water impoundments under nala bunds and gully plugs. Based on the above studies in Maharashtra, it can be considered that around 50 to 60 percent of water impoundment is contributed to groundwater recharge.

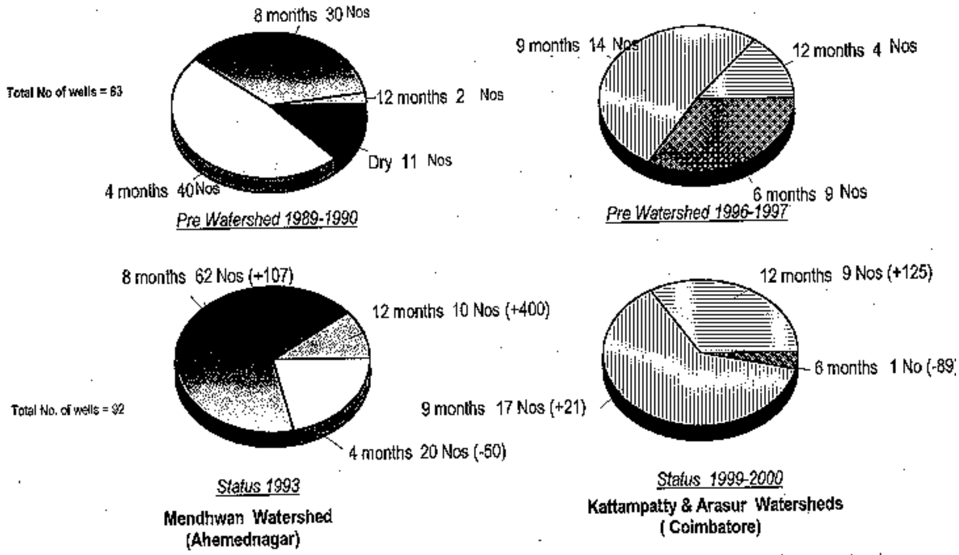

Figure 2. Increased duration of water availability in the wells in selected watersheds after treatment.

Perenniality of water in the wells (i.e., duration of water availability in dug wells) is also found to have improved as a result of watershed management programmes. Data available from Kattampatti and Arasur-I watersheds in Coimbatore and Mendhwan and Kasave watersheds in Ahmednagar district (Sikka, et al., 2000; WTOR Bulletins), as depicted in Figure 2, reveals that period of water availability in wells under the influence zone have significantly gone up from 4-6 months before treatment to 9-12 months after watershed treatment measures in most of the wells.

The number of dug wells after inception of watershed programmes have also increased in some of the watersheds by over 50 to 155 percent. All these have ultimately resulted in increased irrigated area, increased crop yields and crop diversification. Increase in irrigated area of the order of 20 to over 170 percent has been reported in different watersheds. In number of watersheds, where only rainfed crops were taken earlier, significant amount of area has been brought under supplemental irrigation through ponds and water harvesting tanks. Supplemental irrigations reported to have increased yield from 119 to 485% in different watersheds throughout the country depending upon the crop and situation (Samra, 1997).

Apart from these, other impacts include reduction in runoff, soil erosion and sedimentation, on-site and off-site environmental protection, flood moderation, employment generation, etc., as a result of WSM programmes. Benefit cost analysis of various watershed projects in the region varies between 1.45 to 2.10 (Samra, 1997).

Watershed management projects involving micro-level water resource development provide multiple benefits to the local community thus minimising social conflicts. Micro-level water harvesting, storage and recycling systems are beneficial in providing protection and improving biological productivity of catchment as well as cropped area in the command. Community involvement and formation of Watershed Associations/ Committees, Water User Associations, etc, help in proper planning, implementation, management and maintenance of these assets for sustainable development.

CONCLUSIONS AND RECOMMENDATIONS

The encouraging results and the experience of various integrated watershed management programmes in the Western Ghats region and elsewhere in the country strongly suggest their importance and technical, economical, social and environmental viability in water resource development, conservation and management at local or micro-level through people's participation, following a "bottom up" approach with a blend of "top down" input.

The ridge to valley concept of WSM provides an holistic approach not only to conserve and manage water in the form of rainwater, in-situ soil moisture, surface and groundwater, but other related natural resources such as soils, land and vegetation together within the watershed which helps in effective management and efficient utilization of scarce water resources locally. This integrated approach thus not only enhances water resource availability but also protects catchments against erosion and increase productivity of catchments as well command areas.

Participatory WSM helps in local innovations and Indigenous Technological Knowledge (ITK) become part of WSM plans through participatory planning and implementation.

WSM needs a low level of technology than major and medium irrigation projects, but a large amount of planning, survey and community participation at different levels to make the programme need based, socially acceptable, eco-friendly and sustainable.

Water resource management rather than development is the major challenge. It therefore calls for a greater attention towards both supply and demand management of water resources through renovation and rejuvenation of existing/abandoned structures/systems, conservation education and training, institutional financing for improved water management methods/practices including micro-irrigation, promotion of viable, cost effective local rainwater harvesting, rainwater conservation and other groundwater augmentation measures.

The key features of Integrated Watershed Planning for water resource management should involve -

Equal attention to demand as well as supply management

Active and extensive involvement of all stakeholders (local community, NGOs and government) in the planning and decision making process and implementation

Integration of a broad array of biophysical and social objectives and the factors affecting them.

Creation of local level People's Institution (Watershed Association/Water Users' Association, Users' Group) and their capacity building to undertake implementation, management and maintenance of common property resources and assets created for sustainable water resource management.

There is a strong need to have more scientific studies on monitoring and assessment of watershed impact on water resources, especially sub-surface and ground water.

It is suggested that basinwise planning and management of water resources should integrate participatory watershed management programmes for sustainable development, and small and micro water harvesting systems made integral part of the water resource planning, development and management at the national/regional levels.

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