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Impacts of Watershed Development Programmes: Experiences and Evidences from Tamil Nadu

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Abstract

The overall performance of watershed development programmes has been examined in the state of Tamil Nadu. The impacts of major watershed development programmes have been outlined in terms of bio-physical impacts, environmental impacts, socio-economic impacts and overall economic impacts. It is pointed out that the watershed development activities have made significant positive impacts on various biophysical aspects such as soil and water conservation, soil fertility, soil and water erosion in cropped area, changes in cropping pattern, cropping intensity, production and productivity of crops. Watershed development activities have shown significant positive impacts on water table, perenniality of water in wells, water availability for cattle and other domestic uses, etc. The overall economic impacts have been evaluated in terms of NPV, IRR and BCR. The peoples' participation in watershed development activities has been found satisfactory but the optimal level is yet to be achieved. Training of farmers has been found effective in disseminating technical knowledge. According to the study, the future strategy should be the movement towards a balanced approach of matching the *supply-driven menu with a set of demand-driven activities*. Peoples' participation, involvement of Panchayati Raj Institutions, local user groups and NGOs along side institutional support from different levels, viz. the Union Government, the state, the district and block levels should be ensured to make the programme more participatory, interactive and cost-effective. Convergence of various rural development programmes around the watershed could be ensured to promote holistic development of watersheds. For its continued success, the programme, should be economically efficient, financially viable, technically feasible and socially acceptable while ensuring equity. For, sustainable development, regular and routine monitoring of environmental parameters is important as environmental enhancement increases the credibility and acceptability of the programme.

Introduction

In India, most watershed projects are implemented with the twin objectives of soil and water conservation and enhancing the livelihoods of the rural poor (Sharma and Scott, 2005). Different types of treatment activities carried out in a watershed include soil and moisture conservation measures in agricultural lands (contour/field bunding and summer ploughing), drainage line treatment measures (loose boulder check dam, minor check dam, major check dam, and retaining walls), water resource development/management (percolation

pond, farm pond, and drip and sprinkler irrigation), crop demonstration, horticulture plantation and afforestation (Palanisami and Suresh Kumar, 2003). The aim has been to ensure the availability of drinking water, fuel wood and fodder and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity (Rao, 2000). Today watershed development has become the main intervention for natural resource management. A total of 45.58 million hectares of land has been treated through various watershed development programmes in India with an investment of Rs 17,037 crore. The average expenditure per annum during the Tenth Plan is around Rs 2300 crore (Department of Land

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Resources, 2006). With programmes so large and varied, it is important to understand how well they function overall and which aspects should be promoted and which be dropped. Keeping these issues in view, the present paper has examined the overall performance of watershed development programmes in the Tamil Nadu state.

Watershed Development Programmes in Tamil Nadu

To increase the overall agricultural production and to improve the living conditions of the farmers depending on the rainfed lands, watershed development programmes are being widely implemented in the state. There are 19331 micro watersheds identified in the state, of which, approximately 4000 watersheds have already been treated. The important programmes such as Drought Prone Areas Programme (DPAP), National Watershed Development Project for Rainfed Areas (NWDPR) and Integrated Wasteland Development Programme (IWDP) are implemented through watershed approach, apart from the Comprehensive Watershed Development Projects implemented with the assistance from DANIDA.

The aim of Drought Prone Area Programme is to promote the overall economic development of the watershed community through optimum utilization of natural resources, employment generation and restoring ecological balance. The programme is implemented in 80 blocks of 16 districts, viz. Dharmapuri, Thoothukudi, Sivagangai, Ramanathapuram, Virudhunagar, Pudukottai, Tirunelveli, Salem, Namakkal, Coimbatore, Tiruvannamalai, Dindigul, Vellore, Tiruchirappalli, Perambalur and Karur. From 1999-2000 to 2006-07, the Government of India had sanctioned 1222 watersheds in seven batches at a total cost of Rs 33,670 lakhs, for treating a total area of 6.1 lakh ha (Government of Tamil Nadu, 2009).

The Integrated Wasteland Development Programme (IWDP) has been under implementation in Tamil Nadu since 1993-94 to develop non-forest wastelands on the principles of watershed development. This programme is being implemented in 96 blocks of 24 districts, viz. Coimbatore, Dharmapuri, Dindigul, Karur, Krishnagiri, Namakkal, Perambalur, Pudukkottai, Ramanathapuram, Salem, Sivagangai, Tiruvannamalai, Thoothukudi, Tiruchirappalli, Tirunelveli, Vellore, Erode, Theni, Madurai, Kancheepuram, Villupuram, Tiruvallur,

Cuddalore and Virudhunagar. From 1999-2000 to 2006-07, the Government of India has sanctioned 910 watersheds at a total cost of Rs 26,220 lakhs for treating a total area of 4.57 lakh ha (Government of Tamil Nadu, 2009).

Another important watershed development programme is the National Watershed Development Project for Rainfed Areas (NWDPR). It is being implemented in the state from 1990-91. During the period from 2002-03 to 2007-08, a total of 755 watersheds (2.90 lakh ha) with a total outlay of Rs 13065 lakhs have been treated.

In addition to these major watershed development programmes, the National Bank for Agriculture and Rural Development (NABARD)-assisted watershed programmes are being implemented in the state. These cover a total number of 100 watersheds at a cost of Rs 60 crore in 23 districts of the state.

Impacts

The watershed development programmes involving the entire community and natural resources influence (i) productivity and production of crops, changes in land use and cropping pattern, adoption of modern technologies, increase in milk production, etc., (ii) attitude of the community towards project activities and their participation at different stages of the project, (iii) socio-economic conditions of the people such as income, employment, assets, health, education and energy use, (iv) impact on environment, (v) use of land, water, human and livestock resources, (vi) development of institutions for implementation of watershed development activities, and (vii) ensuring sustainability of improvements. It is thus clear that watershed development is a key to sustainable production of food, fodder, fuel wood and meaningfully addresses the social, economical and cultural status of the rural community.

Recognising the importance of watershed development programme in the state, a large number of studies have assessed the impact of watershed development over a period of time. These studies vary in purpose, regions and domain of impacts. The impact studies vary from impact of specific water harvesting intervention such as percolation ponds to overall impacts of watershed development programme. The impact assessment studies focus mainly on the impact

of different interventions such as water resources development, soil and moisture conservation measures, drainage line treatments, and afforestation and assess the impacts on different aspects like increase in surface and groundwater resources, cropping pattern changes, yield, environmental conditions, socio-economic conditions, including the social capital and institution building as a result of watershed interventions.

Bio-physical Impacts

The watershed development activities have significant positive impacts on various bio-physical aspects such as investment on soil and water conservation measures, soil fertility status, soil and water erosion, expansion in cropped area, changes in cropping pattern, cropping intensity, production and productivity of crops.

The watershed treatment activities improve conservation of soil and moisture; improve and maintain the fertility status of soil (Sikka *et al.*, 2000; Ramasamy and Palanisami, 2002; Palanisami and Suresh Kumar, 2002); and reduce soil and water erosion. The organic carbon has increased by 37 per cent due to watershed intervention (Sikka *et al.*, 2000) and most studies have revealed that there is a significant reduction in soil and water erosion.

The impact and evaluation study of soil conservation scheme under DPAP has indicated that only marginal impacts are realised in terms of land-use pattern, crop pattern, yield rate, etc. (Evaluation and Applied Research Department, 1981). Evidences show that soil conservation has a positive impact on the retention of moisture, reduced soil erosion, change in land-use pattern and yield. Soil loss reduced from 18758 kg/ha in 1988 to 6764 kg/ha in 1989. Between 1985-86 and 1989-90, the yield rate of all the crops had increased with an annual CGR of 3.94 to 16.40 per cent (Evaluation and Applied Research Department, 1991).

The cropping pattern changes have taken place both in additional area brought under well irrigation from the fallow lands and in area under rainfed cultivation. The area under high water-consuming crops increased by 25.3 per cent in first crop and 29.4 per cent in second crop period (Evaluation and Applied Research Department, 1991). Similarly, the evidence shows that the cropping intensity has increased from 120 per cent to 146.88 per cent in Kattampatti watershed and 102.14

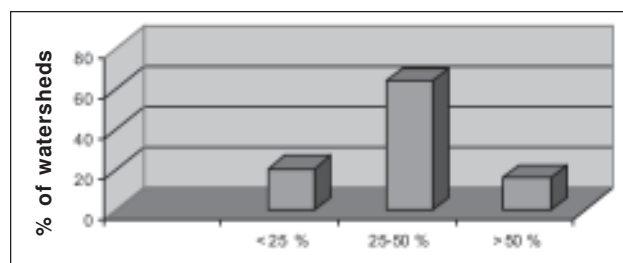


Figure 1. Percentage of watersheds by increase in yield

per cent to 112.08 per cent in Kodangipalayam watershed (Palanisami and Suresh Kumar, 2005). Increase in Crop Productivity Index, Fertilizer Application Index, and Crop Diversification Index was also observed (Sikka *et al.*, 2000; 2001).

Environmental Impacts

The watershed development activities generate significant positive externalities which have a bearing on improving the agricultural production, productivity, socio-economic status of the people who directly or indirectly depend on the watershed for their livelihood. The environmental indicators include water level in the wells, changes in irrigated area, duration of water availability, water table of wells, surface water storage capacity, differences in the number of wells, number of wells recharged /defunct, differences in Irrigation intensity and Watershed Eco Index (WEI).

The impact assessment studies conducted across regions have revealed that watershed development activities generate significant positive impacts in the environment and the treatment activities help in conservation and enhancement of water resources. Most of the studies have reported that water level in the wells increased leading to expansion in irrigated area in the watershed. The increase in water level of the wells has been reported from 0.1 metre to 3.5 metres and this varied across seasons. Similarly, the expansion in irrigated area due to watershed development activities has been found from 5.6 per cent to 68.0 per cent across regions and seasons.

The rainwater harvesting structures constructed in the watershed help in enhancing the surface water storage capacity. The structures like minor and major check dams, percolation ponds, farm ponds, and renovation of irrigation tanks help enhance the surface water storage capacity. Evidences show that, on an average, about 92 ha-cm additional capacity was

created and it varied from 63 ha-cm to 136 ha-cm. In addition to the fixed capacity, repeated storage is also available for different fillings once the stored water is percolated. Maximum additional storage capacity of 359 ha-cm was created in Tiruppur block of Coimbatore district of Tamil Nadu. The additional surface water storage created helped in improving groundwater recharge and water availability for cattles and other non-domestic uses in the watershed villages. The perennality of water in the wells inspected during the sample survey was found to have improved as a result of watershed projects. The analysis of recuperation rate before and after watersheds indicated that recharge rate had increased in the range of 16 to 39 per cent. It was also observed that recharge to wells decreased with distance of wells away from the percolation pond and influence could be generally observed upto a distance of about 500-600 m (Palanisami and Suresh Kumar, 2004; Sikka *et al.*, 2000).

Impact of percolation ponds has revealed increase in water columns of wells from 1.2 m to 1.8 m. The gross irrigated area (GIA) increased by 13.6 per cent by the pond intervention. Increase in GIA per well was 0.27 ha. The new wells in the zone of influence ranged from 1 to 4 wells (Evaluation and Applied Research Department, 1990). Palanisami and Suresh Kumar (2004) in their study in Coimbatore district of Tamil Nadu, followed combination of with and without approach and before and after approach to assess the impact of watershed development activities. The additional surface water storage capacity created was worked out to be 9299 M³ in Kattampatti watershed, comprising 4245 M³ from renovation of tanks, 4924 M³ (percolation ponds), and 130 M³ from construction of major and minor check dams. In Kodangipalayam watershed, the additional water storage capacity

created was worked out to be 12943 M³. This additional storage capacity further helped in improving the groundwater recharge and water availability for livestock and other non-domestic uses in the village. The water level in the open-dug wells has risen in the range of 2.5 m to 3.5 m in Kattampatti and 2.0 m to 3.0 m in Kodangipalayam watersheds. The groundwater recuperation in the nearby wells had increased. The irrigated area increased and the irrigation intensity increased from 115.74 per cent to 122.73 per cent in Kattampatti watershed and from 101.45 per cent to 102.01 per cent in the Kodangipalayam watershed.

Watershed development activities produced significant positive impact on water table, perennality of water in the wells and pumping hours that resulted in an increased irrigated area and crop diversification (Sikka *et al.*, 2000; 2001). Madhu *et al.* (2004) have found that the conservation and water harvesting measures in the watershed helped in improving the groundwater recharge, water availability for cattle and other domestic uses, increased perennality of water in the streams, rise in water table in the wells, sediment trapping behind the conservation measures/structures and stabilization of gully bed. The productivity of crops increased from 6.65 per cent to 16.59 per cent in the watershed village.

Planting of trees in the private farm lands and common lands is also being undertaken as a part of the watershed development. This has created additional green cover, improving the environment. The Watershed Eco-Index which reflects the addition green cover created varied from 1.8 per cent to 43 per cent (Sikka *et al.*, 2000; 2001; Palanisami and Suresh Kumar, 2002; 2005; Ramaswamy and Palanisami, 2002).

Thus, it is evident from the analysis that watershed development activities generate sufficient positive externalities and have significant impacts on the environment.

Socio-economic Impacts

The watershed development programmes influence bio-physical and environmental aspects and thereby bring changes in the socio-economic conditions of the people (Deshpande and Rajasekaran, 1997). The socio-economic indicators like changes in household income, per capita income, consumption expenditure, employment, migration, peoples' participation,

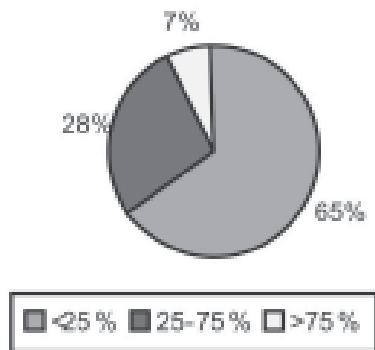


Figure 2. Distribution of watersheds — Impact on irrigated area

household assets and wage rates at the village level were considered for the impact assessment.

The watershed intervention was found to help the rural farm and non-farm households in enhancing their income level. The rural labour households in the treated villages were found to derive Rs 28732 as compared to Rs 22320 in control village, which was 28.73 per cent higher in Kattampatti watershed. Similarly, the per capita income was also higher among households of treated watershed villages. The percentage difference among households across villages worked out to be 13.17 per cent in Kattampatti and 70.44 per cent in Kodangipalayam watershed (Palanisami and Suresh Kumar, 2005). In addition, increase in employment generation, social empowerment, reduction in out-migration were also seen in many watersheds.

Overall Economic Impacts

Experiences show that watershed development activities have overall positive impacts on the village economy. The impact of these watershed development activities can be assessed by using key indicators such as net present value (NPV), benefit cost ratio (BCR) and internal rate of return (IRR). However, only a few studies (Palanisami and Suresh Kumar, 2005; Palanisami, *et al.*, 2002; Ramaswamy and Palanisami 2002; Palanisami *et al.*, 2006; Palanisami and Suresh Kumar, 2006) have assessed the overall impact of watershed development activities through BCR and NPV. The benefit cost ratio was found to range from 1.27 to 2.3. The size of BCR also depended on the magnitude of benefits accrued due to the watershed development activities which in turn critically depended on the rainfall. The analysis also revealed that the BCR was more than 2 in around nine per cent of watersheds. About 91 per cent of watersheds had BCR of less than 2 (Figure 3). Similarly, about 45.45 per cent of watersheds exhibited IRR of less than 15 per cent, 52.27 per cent of watersheds had IRR between 15 and 30 per cent and only 2.27 per cent of watersheds

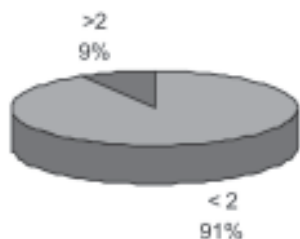


Figure 3. Percentage of watersheds by benefit cost ratio

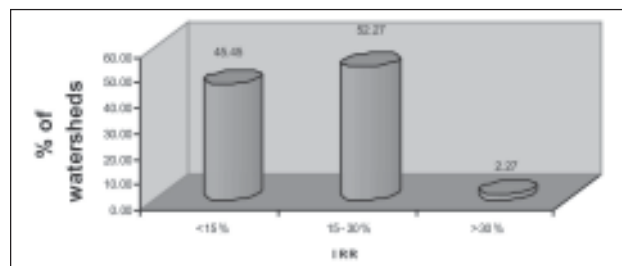


Figure 4. Percentage of watersheds by IRR category

had IRR more than 30 per cent (Figure 4).

It was also evidenced that the BCR varied across regions and depended on the agro-climatic conditions. The financial analysis of impact of watershed development indicated that the returns to public investment such as watershed development activities were feasible.

Peoples Participation in Watershed Management

Like all other development programmes, watershed development also banks heavily on the participatory approach. Though, watershed development programme envisages an integrated and comprehensive plan of action for the rural areas, peoples' participation at all levels of its implementation is very important. It is so because the watershed management approach requires that every piece of land located in watershed be treated with appropriate soil and water conservation measures and used according to its physical capability. For this to happen, it is necessary that every farmer having land in the watershed accepts and implements the recommended watershed development plan. As the issue of sustainable natural resource management becomes more and more crucial, it has also become clear that sustainability closely linked to the participation of the communities who are living in close association with these natural resources. This requires sustained effort in two important areas: (i) to inform and educate the rural community, demonstrate to them the benefits of watershed development and that the project can be planned and implemented by the rural community with expert help from government and non-government sources, and (ii) to critically analyse the various institutional and policy aspects of watershed development programmes in relation to participatory watershed management.

Experience from evaluation study of 15 Drought Prone Area Programme (DPAP) watersheds

conducted in the Coimbatore district of Tamil Nadu, has shown that the overall community participation was 42 per cent. The participation was found to be 55 per cent, 44 per cent and 27 per cent, respectively at planning, implementation and maintenance stages. This suggests that the community participation in watershed development programme is yet to reach the optimum level. Similarly, overall contribution for works on private land was found to be 14.71 per cent. It varied from a low of 7 per cent for fodder plots to a maximum of 22 per cent for horticulture and farm pond. However, contribution in terms of cash/or kind towards development of structures at common lands such as percolation ponds, check dams, etc. was found to be absent. Level of adoption of various soil and moisture conservation measures and their maintenance indicated that there was a wide variation in level of adoption, with a low of 2.4 per cent in farm pond, 30.40 per cent in summer ploughing, 36.80 per cent in land leveling, and 44 per cent in contour bunding. Follow up by farmers was also found to be poor in most of the technologies and it accounted for 5.23 per cent in farm ponds, 21.58 per cent for contour bunding, etc. (Sikka *et al.*, 2000).

Experience from DPAP and IWDP Watersheds in Coimbatore District

Active participation of watershed community at every stage of watershed development programme is a must for effective development and sustenance of the watershed activities. This also helps improve their capacity building, sense of responsibility, etc.

People's participation index for planning (pre-implementation), implementation and maintenance (post-implementation) stages of watershed development programme in DPAP watersheds revealed that overall community participation was low with overall PPI as 42 per cent (Table 1). The PPI was found to be 55 per cent, 44 per cent and 27 per cent, respectively at planning, implementation and maintenance stages, suggesting medium, low and very low level of community participation at planning, implementation and maintenance stages of watershed development programme. This could be attributed to the fact that those who were not benefited from the project directly might not have participated in the implementation and maintenance.

Community Participation in Watershed Development Activities

Community participation can be judged in terms of giving time to the project and contribution in cash/or kind towards works, both on development and management of private and common property resources. It was found that the community members of watersheds had contributed in cash and kind towards the works on private lands. Overall their contribution for works on private land was found to be 14.71 per cent (Table 2). It varied from a low of 7 per cent for fodder plots to a maximum of 22 per cent for horticulture and farmpond. Overall, it could be considered as satisfactory. However, contribution in terms of cash and/or kind towards development of common property resources such as percolation pond, check dams, etc., was found absent.

Table 1. Peoples' participation in DPAP watersheds of Coimbatore district of Tamil Nadu

Level of participation	Peoples' participation (Number)		
	Planning	Implementation	Maintenance
Low	45 (36)	79 (63)	98 (78)
Medium	52 (42)	32 (26)	22 (18)
High	28 (22)	14 (11)	5 (4)
Total	125 (100)	125 (100)	125 (100)
Overall PPI (%)	55	44	27
Level of participation	Medium	Low	Very Low

Note: Figures within parentheses indicate percentages to total

Table 2. Community participation for watershed development activities in DPAP watersheds of Coimbatore district of Tamil Nadu

Activity	Contribution (per cent)		
	Cash	Kind	Total
Contour bunding	10	3	13
Land levelling	10	3	13
Summer ploughing	10	4	14
Vetiver plantation	10	2	12
Farm pond	15	7	22
Horticulture plantation	12	10	22
Fodder plots	5	2	7
Total	12.57	4.44	14.71

Adoption of Soil and Moisture Conservation Measures

Level of adoption of various soil and moisture conservation measures and their follow-up by the farmers can also be considered as a combined effect of awareness, involvement in the program and contribution. The result indicated a wide variation in the level of adoption, with a low of 2.4 per cent in farm pond, 44 per cent in bunding, to a high of 92 per cent for horticulture plantation (Table 3). Follow up by farmers was also found to be maximum (98 per cent) in horticulture plantation, followed by summer ploughing (66 per cent) and minimum in farm pond.

Peoples' Participation in Training and Exposure Visits

Experience from IWDP watershed implemented in the Coimbatore district revealed that 60-93 per cent participants attended the training programme. In a

Table 3. Level of adoption of soil and moisture conservation measures in DPAP watersheds of Coimbatore district of Tamil Nadu

Activity	Rate of adoption		Maintenance (%)
	Frequency (N=125)	Percentage	
Land levelling	46	36.80	52.12
Bunding	55	44.00	21.58
Summer ploughing	38	30.40	65.76
Crop demonstration	25	20.00	25.36
Farm pond	3	2.40	5.23

Table 4. Participation in training and exposure visits in IWDP watersheds of Coimbatore district

Particulars	Attended	Not attended	Total
User group training	142 (78.9)	38 (21.1)	180 (100.0)
Exposure visits	83 (30.74)	187 (69.26)	270 (100.00)

Note: Figures within the parentheses indicate percentages to total

majority of the watersheds, the total number of participants who attended the training exceeded 80 per cent, indicating the interest of the beneficiaries in attending training and gaining technical knowledge (Table 4).

Of the total respondents, nearly 31 per cent attended the exposure visits and gained knowledge (Table 4). Among the members attending the exposure visits, nearly 94 per cent found the visits very useful. Therefore, it was suggested that more exposure visits covering different successful watershed models, community nurseries and research institutes involved in watershed development research may be organized. This will help gain knowledge regarding recent technical know-how and benefits of various watershed treatment activities among the members.

Factors Influencing Peoples' Participation

A recent study has indicated that the households contribution towards watershed development and maintenance is influenced by various household level and supra household level factors (Suresh Kumar and Palanisami, 2009). The factors such as number of workers in the farm family, number of wells owned by the farm households, distance between the farm and the rainwater harvesting structure have been found to significantly influencing the household contribution. Similarly, the supra household level factors such as the extent of social homogeneity as represented by caste at group level and the type of watershed technology positively and significantly influenced household contribution.

Drivers of Success

Watershed development is basically a strategy for protecting livelihoods of the people inhabiting the fragile

eco-systems experiencing soil erosion and moisture stress. The aim has been to ensure availability of drinking water, fuel wood and fodder and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity (Rao, 2000).

Various impact assessment studies conducted in the state have revealed a significant impact on soil and water erosion, soil moisture conservation, water resources development, cropping pattern, and increase in yield. The watershed development has also produced desired results in terms of improvement in socio-economic conditions, and the environment.

The reasons for the successful implementation of watershed development activities in the country include physical and agro-climatic conditions of the watershed villages like rainfall, soil type and hydro-geological features. In addition, some of the administrative and institutional issues such as guidelines for effective watershed development, role of different organizations like the state and central governments, line departments, and type of Project Implementing Agencies (PIAs), play crucial roles in implementing watershed development activities.

Future Directions

- Watershed development programmes not only protect and conserve the environment, but also contribute to livelihood security. All the stakeholders should be involved at various stages of project activities, planning and implementation with the ultimate objective of sustainability. In addition, strengthening of community organizations within the watershed, implementation of the planned watershed management activities, encouraging linkages with other institutions and initiating groups towards formation of apex bodies will help motivate the people and make it a peoples' movement.
- Given the increasing demand for watershed program by the community, it is difficult to provide adequate funding for all locations. Hence, development and adoption of a Decision Support System (DSS) to promote the watershed investment is highly warranted.
- As impact assessment of watershed development has been felt crucial, a general framework has to

be developed and trained personnel should be involved in watershed development impact assessment. Developing a framework, selection of right approach and methods of impact assessment, identification and use of indicators will enable a proper impact assessment. Establishing proper institutional mechanism in a multidisciplinary approach will be a viable step in impact assessment. Panel database should be created for the watersheds in different agro-ecological regions for proper evaluation.

Redefining the quantification of benefits due to watershed development is warranted at present.

Upstream and Downstream Conflicts: Being a common property resource, treatments in watersheds generate various positive externalities. Conflicts arise between downstream and upstream farmers in sharing benefits and making investments. Thus, care should be taken while taking into account the quantum of benefits and cost of investments across watersheds regions when quantifying the cost and benefits for impact assessment in watersheds.

Zone of Influence: As the rainwater harvesting structures are the main structures which generate various positive externalities, quantifying the benefits from these structures like percolation ponds, check dams and farm ponds assumes important in impact assessment. When quantifying the benefits, determining the zone of influence is very crucial and challenge to the evaluators. For instance, the zone of influence of percolation pond varies from 300 m to 400 m downstream and 200m to 250 m upstream. Similarly, the zone of influence of tanks as groundwater recharge structure varies from 4 km to 5 km downstream based on the size of the tank. Thus, one must be careful in determining the zone of influence when quantifying the benefits from the rainwater harvesting structures.

Natural and Artificial Recharge: The rainwater harvesting structures like percolation ponds, check dams, tanks and farm ponds are expected to increase the groundwater recharge in the wells located in zone of influence. Enough care should be taken to segregate the natural and artificial recharge. Experiences show that the total groundwater recharge in wells due to various structures is around 30 per cent. However, the natural recharge without any rainwater harvesting structures is reported to be about 10 per cent. Thus, the net recharge due to rainwater harvesting structures

is only 20 per cent. Thus, while evaluating the impact of recharge structures, care should be taken to account for the natural and artificial recharges (Palanisami *et al.*, 2006).

Addressing all these issues will help achieve sustainability in watershed management in the state and elsewhere.

Conclusions and Policy Implications

Today watershed development has become the main intervention for natural resource management and rural development. Watershed development programmes not only protect and conserve the environment, but also contribute to livelihood security. The importance of watershed development as a conservation programme is being recognized, not only for rainfed areas, but also for high rainfall areas, coastal regions, and catchment areas of dams. With large investment of financial resources in the watershed programme, it is important that the programme becomes successful. Experiences show that the watershed development programmes have produced desired results and there are differences in their impacts. Hence, the watershed impact assessment should be accorded due importance in the future planning and development programmes.

Watershed development activities have significant impact on groundwater recharge, access to groundwater and hence the expansion in irrigated area. Therefore, our policy focus must be on the development of these water-harvesting structures, particularly percolation ponds, wherever feasible. In addition to these public investments, private investments through construction of farm ponds may be encouraged as these structures help in a big way to harvest the available rainwater and hence groundwater recharge.

Watershed development activities have been found to alter crop pattern, increase crop yields and crop diversification and thereby provide enhanced employment and farm income. Therefore, alternative-farming system combining agricultural crops, trees and livestock components with comparable profit should be evolved and demonstrated to the farmers. Once the groundwater is available, high water-intensive crops may be introduced. Hence, appropriate water saving technologies like drip be introduced without affecting farmers' choice of crops. The creation and implementation of regulations in relation to depth of wells and spacing between wells will reduce the well

failure, which could be possible through formation of Watershed Association. The existing NABARD norms such as 150 m spacing between two wells be strictly followed.

The future strategy should be the movement towards a balanced approach of matching the *supply-driven menu with a set of demand-driven activities*. Peoples' participation, involvement of Panchayati Raj Institutions, local user groups and NGOs along side institutional support from different levels, viz. the Union Government, the state, the district and block levels should be ensured to make the programme more participatory, interactive and cost-effective. Convergence of various rural development programmes in around the watershed could be ensured to promote holistic development of watersheds. For its continued success, the programme, should be economically efficient, financially viable, technically feasible and socially acceptable while ensuring equity. For, sustainable development, regular and routine monitoring of environmental parameters is important as environmental enhancement increases the credibility and acceptability of the programme.

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