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Impact analysis of participatory integrated watershed management programme in semi-arid region of Tamil Nadu, India

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ABSTRACT

Watershed management aimed to containing the deterioration of natural resources for maintaining the ecological balance and sustainable economic development. This paper presents the impacts of the participatory watershed development. The runoff varied from 27 mm to 43.2 mm, which was 4.5 to 7.2% of the total rainfall. A total of 266 ha-cm additional surface water storage capacity was created through water resource development and increased wells recuperation rate by 10 to 15%. Influence zone of percolation ponds showed increased irrigated area from 13.7 ha to 25.1 ha (84%) with crop diversification. The average survival percent of fruit plants varied between 51 and 98.66%. The yield of dry land crops was increase by 11 to 14%. Cultivated Land Utilization Index (CLUI) increased by 0.13 (47 days) in dry land and by 0.04 (15 days) in irrigated condition. Overall Crop Productivity Index (CPI) increased from 0.547 to 0.613 with an increase of 12% in productivity level of crops. Overall Crop Fertilization Index (CFI) increased from 0.69 to 0.75, registering an increase of 8% in rate of nutrients application. The overall Watershed Productivity (WP) increased by 17.2% of horse gram. The overall People's Participation Index (PPI) was 62% indicating that the stake holders' overall participation was high. A total of 10105 mandays employment was generated due to various interventions. Average milk production has increased by 59 liters per family per year and consumption increased from 0.91 to 1.03 liters family^{-1}day^{-1}.

1. INTRODUCTION

Effective use of land and water is fundamental to growth and sustainable development. The increasing human as well as livestock population coupled with widespread incidence of poverty, and current phase of economic growth are exerting heavy pressure on India's limited land resources to meet various demands. Over 120 M ha area has been declared degraded or problem soils (Maji, 2007; NRAA, 2011) in India. Water and soil resources are finite, non-renewable over the human life time frame, and prone to degradation through misuse and management (Lal, 2000). Scarcity of water for agricultural and domestic purpose remains a major problem and has led to low crop productivity and environmental degradation. Decline in per capita agricultural production has seriously affected food security and livelihoods of people. There is a considerable potential to bridge the yield gap between the actual and potential yield through adoption of improved resource management technologies (Singh *et al.,* 2001). Several studies have highlighted that appropriate rainwater management and utilization results in enhanced agricultural productivity (Samra, 1997; Wani *et al.,* 2003; Joshi *et al.*, 2005).

The concept of watershed management has evolved to ensure effective use of both natural and social capitals. Therefore, the watershed development programmes include land, water, vegetation, livestock and human resources as essential components. The watershed programme is primarily a land based programme, which is increasingly being focused on water, with its main objective being to enhance agricultural productivity through increased in-situ moisture conservation and protective irrigation for socio-economic development of rural people (Joshi *et al.*, 2004; 2005).

Rainfed agriculture is now emerging as a major opportunity in raising overall agricultural growth. Even after achieving the full irrigation potential, nearly 50% of the net cultivated area will remain dependent on rainfall. Rain-fed agriculture supports nearly 40% of India's estimated population of 1210 M in 2011. India ranks first among the rainfed countries in the world in terms of rainfed area, but ranks among the lowest in rainfed yields (<1 t ha^{-1}) due to significant production loss caused by water erosion. Estimated that in India on an average loss in 16% productivity of rainfed cereals, oilseeds and pulses due to water erosion alone (Sharda et al., 2010).Watershed Development Programmes (WDPs) have been accorded high priority in Indias' development plans. These programmes have been initiated in India to improve and sustain productivity and the production potential of the dry and semi-arid regions of the country through adoption of appropriate production and conservation techniques. Future growth in agricultural production and food security is likely to depend on improving the productivity in the semi-arid rainfed areas (Fan and Hazell, 2000).

In recognition of the socioeconomic and bio-physical benefits, India has one of the largest micro-watershed development (WSD) programmes in the world. The Government of India (GoI) adopted watershed management as a strategy to address the sustainable agricultural productivity in the rain-fed areas since the last three decades. Further, GoI has adopted watershed management as a national policy since 2003 (*Joshi et al.,* 2004). Most watershed projects are implemented with the twin objectives of soil and water conservation and enhancing livelihoods of rural poor. The importance of these programmes is particularly high in regions where agriculture is dominantly rainfed.

Evaluation of watershed management programmes in ten agro-ecological regions of India indicated that due to various soil and water conservation interventions, soil loss has decreased by 10-80% and runoff by 2-42%, while arable land productivity increased by 4.2 to 15.4 q ha^{-1} (Ram Babu *et al.,* 1997). Integrated development of watersheds helps in moderating floods in the downstream, mitigating the effects of droughts and improving soil moisture regimes for biomass production, apart from augmenting ground water recharge (Samra,1997). Quantification of bio-physical and socio-economic impact parameters is considered to be the component of any livelihood development programme. This paper presents the bio-physical and socio-economic impacts of the watershed interventions, particularly in the semi-arid region of Tamil Nadu, India.

2. MATERIALS AND METHODS

Location of Watershed

Saliyur watershed is located in Annur block of Coimbatore district in Tamil Nadu. The geographical location is 77^{0}02'46" to 77^{0}03'55" E longitude and 11^{0}12'43" to 11^{0}14'02" N latitude with an elevation range of 370 to 472 m above msl. The total area of the watershed is about 513 ha with undulating to moderately sloping (3-15%) topography. The order of the watershed is 3rd with a drainage density of 2.72 km km^{-2}. Integrated wasteland development programme (IWDP) funded by the Ministry of Rural Development, Govt. of India, New Delhi was implemented and monitored from 1997 to 2003.

Rainfall and Water Balance

Climate of the region is semi-arid sub-tropical monsoon type. Average annual rainfall is 602 mm with standard deviation of 244 mm and co-efficient of variation of 40%. The north-east monsoon accounts for about 33% (259 mm) of the total rainfall followed by 32% (191 mm) during the south-east monsoon and 23% (142 mm) and 2%(10 mm) during summer and winter, respectively. Evaporation is high with an average of about 8 mm day^{-1} from March to May and about 3 to 4 mm day^{-1} between October and December. Almost throughout a year, water deficit or moisture stress is expected for a little surplus during the month of October (Fig. 1).

Socio-economic Status

Agriculture and labour accounts for 56 and 38% of the stakeholders' occupation, respectively indicating high dependency of the community on natural resources for their livelihood. Average landholding was 1.78 ha, indicating that majority of the farmers fall in small and marginal categories with an average family income of ₹ 1653 per month (Table 1).

Resources and their Status

The soils are red, moderately deep to shallow in depth and medium textured with gravels. Majority of the lands belongs to land capability class (LCC) III followed by class IV and VII. The nutrient index values for N, P and K indicates low to medium status for overall soil fertility status of the watershed. Major area in the watershed is under agriculture (79.2%) out of which 66.4% is under dry lands and 12.8% is under irrigated. Wastelands constitute about 18.4% of the total watershed area (Table 1). Fodder sorghum (*Sorghum* spp.), cowpea (*Vigna unguiculata*),

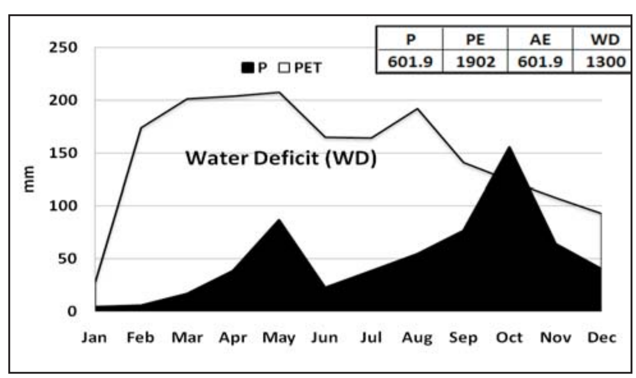

Fig. 1. Water balance diagram for Salaiyur watershed

Table: 1
Physiographic, socio-economic and land use details of Saliyur watershed in Coimbatore district of Tamilnadu

S.No.	Physiographic		Socio-economics		Land use	
1	Agro-ecological region	19	No. of families	314	Dryland (ha)	340.5
2	Area (ha)	513	Total population	1314	Irrigated (ha)	65.6
3	Elevation range (m amsl)	370-472	Major occupation (%)		Wasteland (ha)	94.3
4	Slope range (%)	3-15	Agriculture	56	Habitation (ha)	12.6
5	Order of the watershed	Third	Landless labourers	45	Density of trees (ha^{-1})	
6	Drainage density ($km\ km^{-1}$)	2.72	Av. Land holding (ha)	1.78	Irrigated	117
7			Av.monthly income (₹)	1653	Rainfed	68
8			Av.family size (No)	4.18	No.of open wells	114
9					No. of tube wells	68

groundnut (*Arachis hypogaea*), castor (*Ricinus communis*), redgram (*Cajanus cajan*), cotton (*Gossypium hirsutum*), greengram (*Vigna radiate*), horsegram (*Macrotyloma uniflorum*), and field bean (*Vicia faba*) are the commonly grown dryland crops and sugarcane (*Sacharum Officinarum*), banana (*Musa paradisiacal*) and vegetables are the major crops under irrigated condition. Natural or man-made vegetation cover is very poor with the tree density of 117 and 68 trees ha^{-1} in irrigated and drylands, respectively. Hydrologic characteristics of a semi-arid watershed typically contain ephemeral streams having monsoon flow with limited subsurface flow. Poor vegetation cover, light textured gravel soil, low rainfall and high evaporation causes reduced sub-surface flow and ground water recharge. There were 114 open wells and 68 deep tube wells fitted with jet pumps together with 7.5 HP air compressors. The overall irrigation efficiency is less than 25% (Table 1).

Community Organization and Capacity Building

Community organization is considered to be an important component of any rural development project. Multi-disciplinary team of scientists including women and social scientists, and technical officers constituted watershed development team (WDT) who conducted several rounds of meeting with the watershed community. Participatory rural appraisal (PRA) exercise was conducted to generate awareness about the project and its mode of operation and execution. Further, exposure visits to successfully executed watersheds were conducted to build confidence of the watershed communities and several entry point activities (EPA) were taken by the WDT in the watershed with the community contributions. Watershed level local people's institutions represented by various sub-communities of the watersheds were constituted for implementation and execution of various watershed development activities (Table 2).

Interventions for Watershed Development

Various interventions were undertaken in the watershed based on the problems, needs, priorities of the watershed community and their technical suitability and economic viability. The watershed development activities taken in the watershed were soil and water conservation measures in arable lands, water resource development, productivity enhancement activities, entry point and income generation activities and community organization, including capacity building (Table 3).

Monitoring and Impact Assessment

Periodic monitoring and measurement of hydrological, soils, growth parameters and yield of crops, and horticultural and forest plants, land use, social and economic parameters were conducted in the watershed. Three gauging stations were installed for runoff monitoring. For monitoring ground water levels, piezometers and observation wells (dug wells) were used from where observations were taken at fortnightly interval. Water level in the pondage area of percolation ponds was continuously monitored with a staff gauge and /or water level recorder to measure change in storage level. This change in storage level was then converted to volume based on stage capacity relationship. Siltation behind check dams and ponds were also measured annually at selected places. Soil samples from different depths (0-15 and 15-30 cm) were taken from selected plots/pits before imposing interventions and then after three years. Crop growth parameters and crop yields were recorded for selected plots in farmers' fields. Survival rate and growth parameters of fruit and forest trees were recorded periodically. Besides biophysical data, socio economic data in terms of contribution, change in income, income from SHGs, participation of community in different activities *etc*., were collected through pre-tested questionnaires and interviews. Impact of various interventions on biophysical, participatory, and socio-economic aspects in the watershed was assessed through different impact indicators (Table 4). Pre and post project approach was adopted for impact assessment.

Table: 2
Details of local level institutions at the watershed level

S. No	People's Institute	No. Group	Total Members	Activity/Role
1	SHGs	28	124	Tailoring, coir rope making, coconut frond weaving,vegetables/ coconut/cattle feed selling, sheep/goat rearing, power sprayer, petty shop, thrift society, plastic bag knitting, over lock machine, agave fiber extraction unit
2	UGs	03	29	Agroforestry systems, construction of check dams and percolation ponds, desilting and deepening of ponds etc.
3	Watershed Committee	01	13	Overall coordination and liaison, execution of watershed development activities and other activities as per the guidelines.
4	Watershed Association	01	-	Apex body of the watershed

Table: 3
Activities taken in Salaiyur watershed

S.No	Activity	Unit	Quantity
I.	Conservation Measures		
	1 Vegetative barriers	rm	3213
	2 Field bunding	rm	5000 (30 ha)
II.	Water resource development		
	1 Check dams	No	5
	2 Percolation ponds	No	7
	3 Rejuvenation of ponds	No	8
	4 Lining of shallow water storage ponds	No	5
	5 Micro-irrigation units	No	17
III.	Productivity enhancement		
	1 Agri-horticulture system	ha	94
	2 Afforestation	ha	8.5
	3 Agri-silviculture	No	3900
	4 Sericulture units	No	4
	5 Fodder production units	No	12
IV	Income generating activities	Group	28
V	Entry point activities	No	6
VI	Capacity building	No	7

3. RESULTS AND DISCUSSION

Bio-physical Impacts

Surface runoff and soil loss

The extent of runoff varied from 27 mm to 43.2 mm, which was 4.5 to 7.2% of the rainfall. During the project period (1997-2003), a peak discharge of 1.2 cum at the outlet was recorded with the total runoff of 8.9 mm, which was 1.3% of the rainfall. This suggested that most of the rain water was conserved and runoff was stored within the watershed to augment groundwater recharge. Based on silt deposited behind selected check dams/ponds, soil loss estimated to vary in the range of 0.5 to1.6 t $ha^{-1}yr^{-1}$, which was very well within the permissible limits. Wani *et al.* (2001) has shown significant impact of watershed management on crop production, increase in ground water level, reduction in runoff water, increase in income, *etc.*

Surface water storage

A total of 266 ha-cm additional surface water storage capacity was created through construction of new ponds, check dams and rejuvenation of existing percolation ponds/tanks in the watershed. In addition to this fixed capacity, storage capacity was repeatedly available for different fillings once the already stored water percolated. Altogether, it helped in improving ground water recharge, water availability for livestocks, and other uses in the watershed.

Ground water availability

On the basis of data collected from observation wells, it was observed that water table rose in the range of 0.5 to 1.0 m in the influence zone of percolation ponds. A total of 53 wells (46%) were observed to be partly or fully influenced. Increased water availability duration in wells was also observed (Fig. 2). The duration of water availability in wells

Table: 4
List of impact indicators used for evaluation of impacts of watershed development activities

S.No.	Impact Indicators	Methodology
1	Land Improvement Index	Ratio of recommended land slope to the existing land slope (Sikka *et al.*2004; Sharda *et al.*2005).
2	Crop Diversification Index	Sikka *et al*.(2004); Sharda *et al* (2005)
3	Cultivated Land Utilization Index	Chuang (1973); Sikka *et al.*(2004); Sharda *et al.*(2005)
4	Crop Productivity Index	Sikka *et al.*(2004); Sharda *et al.*(2005)
5	Crop Fertility Index	Sikka *et al.*(2004); Sharda *et al.*(2005)
6	Induced Watershed Eco-Index	Sikka *et al.*(2004); Sharda *et al.*(2005)
7	People's Participation Index (PPI)	Katar Singh (1992)
8	BCR & IRR	Gittinger (1972); Gittinger (2004)
9	Storage Capacity of Ponds	Capacity survey
10	Ground Water Table	Piezometric wells and open wells
11	Duration of Water Availability in Wells	Survey and monitoring of selected wells
12	Well yield /Recuperation Rate	Pumping test
13	Soil Fertility Status	Jackson (1973)
14	Density of Trees	Survey technique (Total trees in the watershed to the watershed area)
15	Watershed Productivity	Sikka *et al.*(2004); Sharda *et al.*(2005)

went up from 3-6 months before watershed interventions to 9-12 months (38 to 45%) after watershed interventions (Fig. 2). This was attributed to in-situ soil moisture conservation measures and water resources development in the watershed areas.

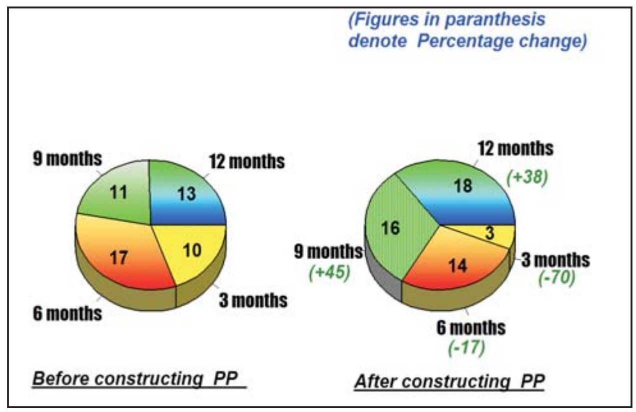

Fig. 2.Increased duration of water availability in wells

Increased well yield / recuperation rate

Water yield/recuperation rate before and after watershed interventions for different wells indicated that recharge rate increased by 10 to 15%. Before watershed programme, the wells used to go dry after water pumping for 0.5 to 1.5 hrs, and got recuperated in 38-48 hrs. After the various soil and water conservation interventions, pumping could be done for 1.0 to 2.5 hrs before well went dry and it took 24-36 hrs to recuperate. This may be attributed to enhanced groundwater augmentation as a result of watershed management.

Increased irrigated area, productivity of crops and crop diversification

Sample survey of selected farmers in the influence zone of percolation ponds indicated increased irrigated area from 13.7 ha to 25.1 ha (84%) and crop diversification(Fig. 3a). The average yield of different crops was collected for pre and post project period from the watershed area and presented in figure 3b. The yield of all dry land crops increased considerably in the range of 11 to 14%. Season wise Crop Diversification Index (CDI) was worked out based on the area under each crop in different seasons for the period before and after the project. CDI values near to 1 indicate complete diversification. CDI worked out separately for the rainfed and irrigated conditions are presented in figure 4a. Under rainfed condition CDI increased by 50.7% (0.469 to 0.707) and under irrigated condition, it increased by 29.2% (0.59 to 0.762).

Cultivated Land Utilization Index (CLUI)

Cultivated Land Utilization Index was worked out for dry land and irrigated conditions separately for the period before and after the project (Fig. 4b). CLUI is calculated by summing the products of land planted to each crop, multiplied by actual duration in days of that crop, divided by the total cultivated land area times 365 days. CLUI increased by 0.13 (47 days) in dry land and by 0.04 (15 days) in irrigated condition as a result of large scale introduction of horticultural plantation in dry land and increased area under irrigation. This indicated that irrigated area was put under intensive cultivation with high value commercial crops. This also clearly indicated the impact of watershed interventions reflected in the increase in cultivable land area and duration of crop cultivation.

Land Improvement Index (LII)

Land improvement index is the ratio of recommended land slope to the existing land slope. The LII improved to a unit from 0.02-0.13 due to land leveling and bunding in the agricultural lands. The additional grain yield of 70 to 120 kg

ha^{-1} which yielded additional net returns of `1400-2400 ha^{-1} was obtained due to better *in-situ* moisture conservation. The farmers' were of the opinion that field bunding is essential not only to conserve soil and water within the field, but also to improve the ground water recharge status in the watershed areas.

Dry land horticulture

Prominent dry land fruit crops like mango (*Mangifera indica*), tamarind (*Tamarindus indica*), guava (*Psidium guajava*), sapota (*Manilkara zapota*) and amla (*Phyllanthus emblica*) crops were introduced in the watershed area. The average overall survival percent of different fruit plants at the end of five years varied from 51 to 99%. The average survival per cent of tamarind and mango was 100 and 94% in mechanical pitting by JCB and manual pitting, respectively. Mechanical pitting by JCB gave better growth performance in terms of increased plant height, basal diameter and crown area cover as compared to manual pitting. In mechanical pitting by JCB, greater pit size, loosened sidewalls of the pits coupled with improved micro site condition, greater soil moisture holding capacity and cracks/fractures for easy/better penetration of roots resulted in 100% survival and better growth performance. Economic analysis was done for mango and tamarind under dry land condition by projecting cost and benefits upto 15 years to know the economic viability of these two fruit crops. Benefit Cost analysis was carried out at 10, 15 and 20% discount rates.

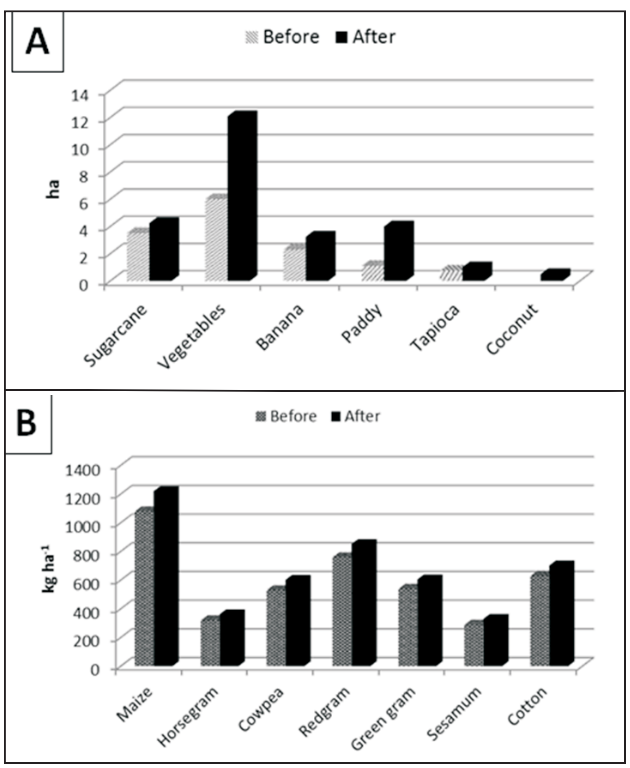

Fig. 3. Change in irrigated area of crops (A) and average yield of crops (B) during pre and post project periods in dry land

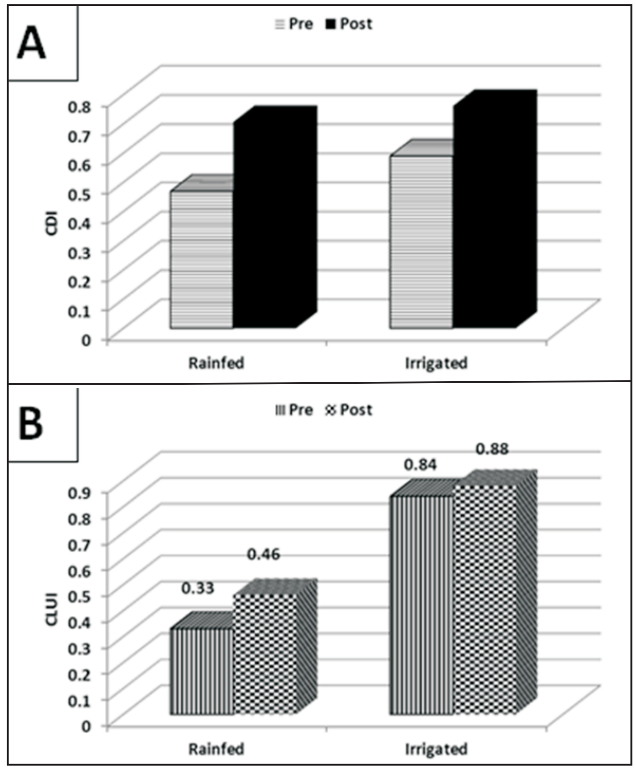

Fig. 4. Crop Diversification Index (A) and Cultivated Land Utilization Index (B) under rainfed and irrigated conditions

The BCR worked out to be 2.97 and 2.41 at 10 and 15% discount rates, respectively for mango with the Internal Rate of Return (IRR) of 19.28%. For tamarind, the BCR worked out to be 24.23 at 10% discount rate and this higher BCR can be attributed to low cost of cultivation with least maintenance requirement. Due to agroforestry interventions, the density of trees, particularly in dry land, increased to 97.36 trees ha^{-1} from 68 trees ha^{-1}.

Crop Productivity Index (CPI)

Crop Productivity Index indicates the extent of crop productivity level in comparison to the normal yield of crops as per the package of practices. It was calculated by using farmers' yield data and normal yield of crops as per the package of practices to evaluate change in productivity level of crops which are grown in the watershed. Over all CPI was increased from 0.547 the pre project period to 0.613 after the project, registering an increase of 12% in productivity level of crops and it was partly due to distribution of inputs *viz.,* seeds and fertilizers.

Crop Fertilization Index (CFI)

Crop Fertilization Index indicates extent of crop nutrients (NPK) applied to the crop in comparison to the recommended level of nutrients to that crop. Overall CFI increased from 0.69 during the pre project period to 0.75 after the project, registering increase of 8% in rate of nutrients application. This was partly due to distribution of inputs during the project period.

Watershed Productivity (WP)

Watershed Productivity indicates the overall productivity level in the watershed. This was calculated by taking yield of crops, cropped area and output price of different crops grown in the watershed and expressed in equivalent yield of dominated crop in the area. WP was worked out for dry land and irrigated lands separately. Dry land productivity was expressed in equivalent yield of horse gram and of irrigated land was expressed in equivalent yield of sugarcane. Overall watershed productivity was expressed in equivalent yield of horse gram. Dry land productivity increased from 959.8 kg ha^{-1} of horse gram for the pre-project period to 1095 kg ha^{-1} after the project period. Where in productivity of irrigated land increased from 50.76 t ha^{-1} of sugarcane during the pre project period to 57.98 t ha^{-1} after the project period. In both the cases, the productivity level increased by 14% which was partly due to the interventions during the project period. The overall WP increased from 2178 kg ha^{-1} of horse gram during pre project period to 3898 kg ha^{-1} after the project period. This was mainly due to increased area under irrigation, slightly increased productivity of crops and diversification of dry land towards horticultural fruit crops. Deshpande and Reddy (1991), Shah (2001), Joshi (2004) and others have reviewed different dimensions of watershed management and these studies have focused on the positive impact of watershed management on cropping, agricultural productivity, employment generation and increase in income, amongst others.

Induced Watershed Eco-Index (IWEI)

Induced Watershed Eco Index is used to represent the fraction of green area in the watershed. This represents an additional area made green through watershed treatment as proportion of whole watershed area. The value of IWEI observed found to be 0.14, suggesting that an additional 14% of watershed area was rehabilitated through green biomass cover.

Socio-Economic Impacts

People's participation

People's participation in watershed management project is an important index for its sustainability and it measured through People's Participation Index (PPI). PPI was worked out for planning, implementation and maintenance stages of the project (Fig. 5). The overall PPI was observed to be 62% indicating that the stake holders' overall participation was high. Among the three stages of the project, the level of people's participation was highest (74.6%) at planning followed by 62.8% at implementation stage and 54.3% at maintenance stage indicating very high to high level of participation. This high level of people's participation could be attributed to the sincere, committed and devoted efforts of the WDT and watershed functionaries. Further, this could be attributed to the expertise of PIA in watershed management areas. Active people's participation is, therefore, highly critical in the success of the watershed programme (Kerr *et al*. 2000; Joshi *et al.*, 2005). People's participation in planning, developing and executing the watershed activities is indispensable (Wani *et al*., 2003; and Joshi *et al*., 2005). Active and voluntary participation of all stakeholders guarantees the successful implementation of watershed programme.

Income and employment generation

To study the change in income, respondents were classified based on occupation *viz*., landless, marginal, small, medium and large and the source of income was tabulated. The study revealed about 44% increase in income after the project for the sample as a whole. The maximum increment in income was observed from agriculture, in the case of large farmers followed by small and medium farmers. A considerable increase in income from labour was observed in the case of landless. It could be attributed to more employment opportunities in the watershed. A total of 10,105 mandays employment was generated, whereas it was in maximum in water harvesting structures and plantation works. During the initial three years, employment generation was maximum due to more activities/works.

Community contribution

Contribution of community towards watershed activities/works is considered as a measure of participation. Moreover, contribution in terms of cash and kind enhances the responsibility and commitment to maintain the works and activities created under the project. People came forward enthusiastically to contribute for private as well as

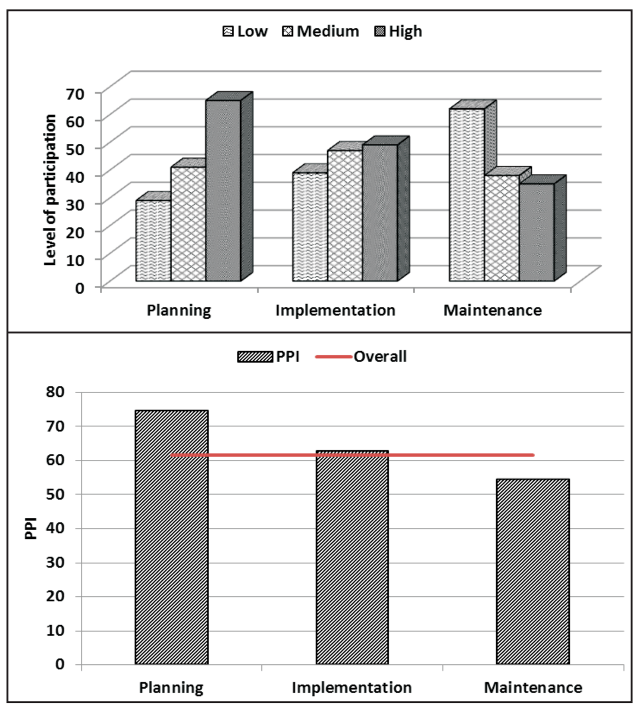

Fig. 5. Peoples Participation and PPI at different stages of watershed development

Table: 5
Community capacity building through IWDP in Salaiyur watershed

Name of training	No of participants			Follow up (%)
	Male	Female	Total	
Awareness camp for women on health, hygiene and income generation activities	0	41	41	10
Nursery raising training	7	0	7	12
Farmers training for plantation techniques	53	0	53	70
Training for watershed committee members to maintain accounts and receipts etc.	4	2	6	95
Training for Users Groups to supervise watershed works	33	0	33	75
Training for SHGs on concept of thrift society, realization of loans from society & bank and to carry out income generating activities etc.	8	49	57	85
Awareness camp/ training for livestock development	62	25	87	45
Total	167	117	284	

panchayat land in terms of cash and kind giving indication of sustainability of works carried out under the project. Contribution received from farmers towards various works varied between 10 to 40% depending upon the nature of work. It is important to note that most of the contribution came in cash rather than kind. This suggests positive impact of the project in terms of community participation. The highest contribution was received through distribution of seedlings (₹15,200) followed by water harvesting structures (₹13,913) and for drip irrigation (₹ 11,834).

Livestock composition and milk production

To know about the status of livestock possession of different categories of respondents, only those respondents were contacted who owned livestock. It was occured that a considerable increase in the number of milch animals (cow 109 to 127 and buffaloes 77 to 79) took place after the project. Similar trend was observed in the case of sheep and poultry, but in case of bullocks and goat this trend was reverse. The annual milk production, consumption and marketed surplus for post project period was worked out on the basis of 135 respondents representing landless, marginal, small, medium and large farmers and then extrapolated for 342 families. It was observed that milk production increased about 59 liters per family per year. The consumption also increased from 0.91 to 1.03 liters per family per day due to increase in income level of the watershed people.

Community capacity building programme

The realization of the project objectives very much depends on the knowledge, skill and attitude of the human resources present in the project and capacity building of the community. Recognizing the critical role of human resources and the need to constantly update the capacity and skills of the people, the project organized a series of training programmes, awareness camps and exposure visits. The training programmes/ exposure visits organized over a period of time are presented in Table 5. Perusal of the table revealed that about 42% female and 58% male, out of the total 277 participated in different types of trainings. The follow up action indicated that utilization of training skills was maximum in the case of watershed committee members (95%) followed by members of SHGs (85%) and user groups (75%) and farmers trained in agroforestry plantation techniques (70%) . This is a good indicator of making use of skill/ techniques given to the stake holders to sustain the watershed development programme.

Economic viability of the project

Economic analysis of the project was carried out for the entire watershed (arable and non-arable) by considering the cost and direct benefits from different activities. The productive life of the watershed project was assumed up to 20 years. The BCR at 10 % discount rate was observed to be 1.13:1 and IRR of 18% for arable lands. On the other hand, BCR for non-arable lands at 10, 15 & 20% discount rate was 9.8, 7.3 and 5.4, respectively with IRR was 62.9. The BCR and IRR for arable and non-arable lands indicate economic viability of the project.

4. CONCLUSIONS

Development and management of watersheds through Integrated Watershed Management with active participation of local community yielded positive results. Community contributions towards various works is considered a major significance of the programme. The watershed interventions helped in increasing ground water table, permeability of water in the wells and recuperation yield that resulted in increased area under irrigation and crop diversification. The works related to water harvesting and ground water recharge, plantation with mango and tamarind, water use measures *etc*., received greater social acceptability. SHGs involving lesser investments with a smaller group proved worthy in generating alternative source of income for landless people and this has tied up their interest in watershed programmes. Our experience indicating that, bottom up approach with a blend of top down approach is fruitful in integrated watershed management. This helped in capacity building of local level people's institutions to ensure smooth take over and future maintenance and sustenance of the programme by themselves after withdrawal of the project.

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