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*Review Paper*

# Watershed development programmes: an evaluation and its impact in India

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## Abstract

*The study is concerned with the watershed development programme evaluation and their impact in India. The study examines the evaluation and the affect of WDPs on various field activities across different states in India. In the present study the total method has been used for watershed programme evaluation. It has been seen that in most of the regions the land use pattern was increased and there was a net raise in the irrigation sources due to increase in the deep drainage or deep drainage through water disambiguation. In comparision with the methods for assessment of impact of watershed programmes, the economic surplus method showed a positive effect and this method seems to have more advantage compared to other methods. It has been concluded that the more wasteland was converted for efficient use by the farmers and the better utilization of land has helped the farmers to increase the intensification of agriculture and thus improve the agricultural production. For the success of the programme the community participation should be effective and it results in better employment opportunities to the people.*

**Keywords**: Watershed development, Intensification of agriculture, Community participation.

## Introduction

Watershed is a natural area that moves to a catchment area and makes it as an attractive unit for technical efforts to conserve soil and maximize utilization of surface and subsurface water for crop production[1]. It is a hydrologic unit that has been used both as a bio-physical unit and as a socio-economic and socio-political unit for planning and implementing resource management activities. It has got importance in India where 60 per cent of the cropped area is rainfed and has low productivity, water scarcity, degraded natural resources and widespread poverty. The Watershed Development Programmes (WDPs) was launched by Government of India (GOI) in 1983-84 to conserve and utilize natural resources for enhanced yield and higher socio-economic status. Different ministries of Government of India like Ministry of Agriculture and Farmers Welfare (MoAFW), Ministry of Rural Development (MoRD) and Ministry of Environment and Forest (MoEF) are involved in the implementation of watershed in the country.

**Watershed Development Programme:** Watershed Development Programme is a simple soil and water conservation programme to the Integrated Rural Development Programme (IRDP) with more and effective people participation. This programme have been implemented by both central ad state and international donors across the country. It is a land based technology and helps to conserve and improve soil inside moisture, check soil erosion and improve water resources, especially deep percolation in the rain fed regions. It helps to have higher land productivity through improved moisture and water availability for agriculture. It helps in improving the management of a watershed or a catchment area by building contour bunds, check-dams and raised edges etc.

**Area Development Programmes:** It includes the following programmes as follows.

**DPAP**: Drought Prone Areas Programme (1973-74): This programme was initiated in 1973-74 in response to the effects of widespread drought in the country in the 1960s and early 1970s. It focuses particularly on areas subject to chronic drought. It covers 972 blocks in 182 districts of 16 states in the country.

**DDP:** Desert Development Programme (1977-78): Following the report of the National Commission on Agriculture in 1976, the DDP was set up a year later in the states of Gujarat, Haryana and Rajasthan and in the cold deserts of Jammu and Kashmir and Himachal Pradesh. In 1995/96, it was extended to parts of Andhra Pradesh and Karnataka. The DDP now covers 235 blocks in 40 districts of seven states in the country.

**IWDP:** Integrated Watershed Development Programme (1989-90): It was launched in 1989/90, this programme is extended to areas not covered under either the DPAP or the DDP. A total of 374 districts of the country have so far been included under this programme.

**IWMP:** Integrated Watershed Management Programme (2008): The above three programmes namely DPAP, DDP and IWDP were combined together and they were included under IWMP.

**Objectives of Watershed Development Programme:** i. To promote the overall development of economy and helps to improve the socioeconomic condition of the resource poor and the disadvantaged sections inhabiting the programme areas. ii. To provide employment, to remove poverty, empower community and to develop human and other economic resources of village. iii. To restore ecological balance by harnessing, conserving and developing natural resources i.e. land, water and vegetative cover. iv. To mitigate the adverse effects of extreme climate conditions such as drought and diversification on crops, human and livestock population for their overall improvement. v. Developing wastelands, drought-prone and desert areas on watershed basis.

**Advantages of Watershed Development Programme:** i. To ensure the availability of drinking water. ii. Fuel wood and fodder. iii. To increase income and provide work or employment for farmers and landless labourers through improvement in agricultural production and yield[2]. iv. Watershed development acts as the main intervention for natural resource management.

**Components of Watershed Development Programme:** It includes the following components: i. Management of soil and land ii. Management of water iii. Management of crop iv. A forestation v. Fodder development vi. Management of livestock vii. Rural energy management viii. Other farm and non-farm activities and ix. Development of community skills and resources.

*__All these components are interdependent and interactive.__

**Impact Assessment:** The problem of impact assessment of WDP includes the following aspects: i. To develop a frame work to identify what impact to asses, where to assess for these impacts and to select appropriate indicators to assess the impacts and ii. To develop a frame work to incorporate the indicators together and assess the overall impact of the project.

**Major Challenges Include:** i. Choice of methodologies ii. Selection of indicators iii. Choice of discount, iv. Quantifying benefits in upstream and downstream and v. Extent of natural and artificial recharge[3].

This programme benefit not only the participating farm households, but also to the nonparticipating and other rural household in the watershed village. In the present study the economic surplus method has been used to study the impact of watershed programmes using data from sample watersheds applying the following three approaches: i. Before and After, ii. With and Without, iii. Combination of Both.

**Before and After:** In this they compare the project parameters to the 'pre-project' situation in which it provides the incremental benefits due to the projects. But these increments in the parameters intrinsically include the changes due to state of-art of technology. This approach is said to be viable when the bench mark information is available. But in reality, most of the WDPs are implemented without collecting full set of benchmark information. Thus sometimes, the benefits may be exaggerated.

**With and Without:** It is used to compare between the project parameters with non-project control region. This method automatically incorporates the correction for the impact of technology in the absence of the project.

**Limitations:** Though the watershed-treated and control regions fall within the same agro-climatic conditions, their differences in hydro-geological profile vary within a village/across plots in the farm. Thus, this approach can be only used when we compare the villages having homogeneous agro-climatic conditions.

**Combination of Both:** When the time span is too long, economists adopt this approach. They compare before and after project periods and with the control village as well so as to get a holistic picture on impact of watershed development activities.

**Table-1:** Minimum indicators and methodologies for evaluation of watershed development Programme

| Component | Minimum Indicators | Source of data |
|---|---|---|
| Bio-Physical | (1) Deep percolation level proxied by (a) Well water level (b) No. of months of water availability (c) Pumping hours (d) Increase in irrigated area | Comparision with baseline and using "With and without approach". |
| | (2) Land use change including conversion of wastelands to productive use | Remote sensing data for watershed and its comparision with baseline |
| | (3) Crop yield change | PRA technique |
| Socio-Economic | Cropped area<br>Crop diversification | Sample survey- Stratified based on water availability status |
| | Income, Distress migration, Productivity, Livestock Population, Credit/ indebtedness | Baseline and PRA |
| | Equity | Baseline, PRA and sample survey |
| Institutional | Status of CBO | Focused group discussion and baseline |
| | Inclusiveness | CBO documents |
| Environmental | Tree cover | Remote sensing |
| | Land use/ Cover | Remote sensing, Survey and baseline including PRA |

The Table-1 indicates that the group focussed on the importance of four major components *viz.* biophysical, socio-economic, institutional and environmental and these are to be assessed with a mix of options including remote sensing.

**Methodologies:** i. Conventional Benefit Cost Analysis, ii. Econometric Models (Economic Surplus Model), iii. Bio-econometric Modelling, iv. Meta Analysis

**Conventional Benefit Cost Analysis:** This primarily includes: i. Net Present Worth (NPW), ii. Benefit-Cost Ratio (BCR), iii. Internal Rate of Return (IRR)

**NPW**:-It is the present value of cash flow stream.

$$NPW = \sum_{t=1}^{n} B_t - Ct/(1+i)^n$$

**BCR:-** It is the total benefits derived from the cash flow stream.

$$BCR = \frac{\sum_{t=1}^{n} B_t}{\sum_{t=1}^{n} C_t}$$

**IRR**: It is the rate at which NPV is equal to zero.

**IRR =** Lower Discount Rate + (Difference between two discount rates) x (NPV at Lower Discount Rate) / (NPV at Lower Discount Rate - NPV at Higher Discount Rate)

## Econometric Approach

**Economic Surplus Approach:** Economic surplus method is widely followed for evaluating the impact of technology on the economic welfare of households[4]. This method is utilized together with the research costs to calculate NPV, IRR and BCR[5]. It measures the aggregated social benefits of a research project. It is possible to estimate the return to investments by product buyers and producer surplus through a change in technology originated by research. This is most commonly used method for assessing the impact of agricultural research investment, particularly those related to crop improvements.

## Theoretical framework

The model is based on the Marshallian theory of economic surplus that results from shifts over time of supply and demand curves. In Figure-1, the rightward shift ($S_1$) of the original supply curve ($S_0$) generates economic surplus for producers and consumers. Such a shift results from changes in production technology, given that the demand and supply function remains constant, the original market equilibrium a ($P_0$, $Q_0$) is transferred by the effect of technological change to b ($P_1$, $Q_1$). Consumers gain because they are able to consume a greater amount ($Q_1$) at a lower price ($P_1$). The area $P_0$ ab $P_1$ represents the consumer surplus. The consumer surplus is the amount that consumers benefit by being able to purchase a product for a price that is less than they would be willing to pay. The producer surplus is the difference between the producers willingness to accept and what they actually get paid for their good or a service. In case of watershed programmes, producers are mainly the farm households who produce the goods using the benefits of the watershed interventions such as soil and moisture conservation, water table increase and livestock improvement activities. Consumers are mainly the other stakeholders in the region, *viz.* non-farm households representing the labourers, business people and people employed in other than agricultural activities.

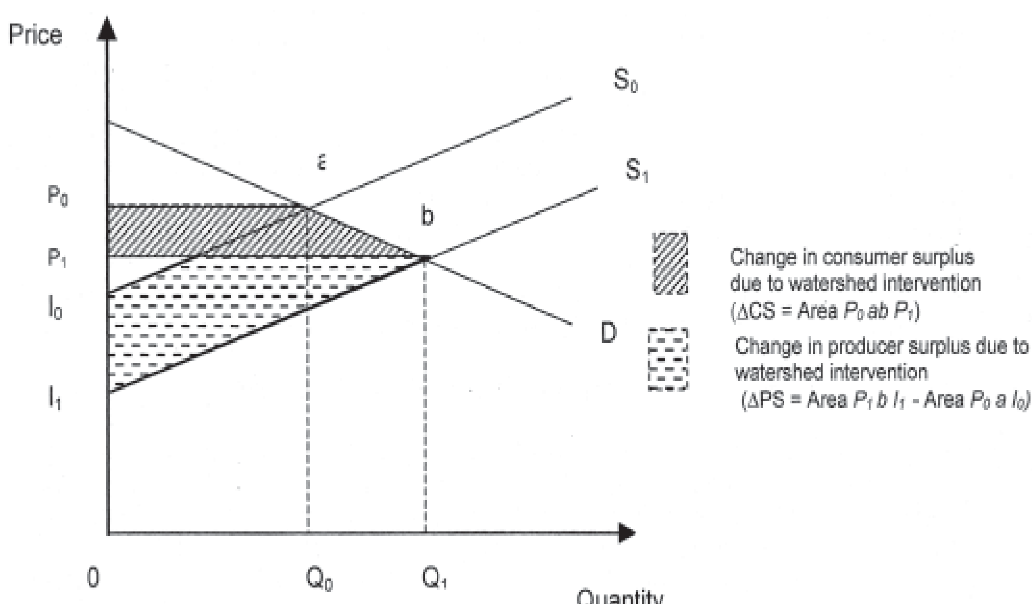


**Figure-1:** Graphical representation of economic surplus[6]

**This programme intervention affects agricultural producers in two ways:** i. Lower marginal costs (according to the theory, the supply curve corresponds to the curve of marginal costs as of the minimum value of the curve of average variable costs), and ii. Lower market price ($P_0$ is reduced to $P_1$). Thus, the producers surplus is defined as the Area $P_1bl_1$ - Area $P_0al_0$.

The supply function for a product market was assumed that supply curve is of the following functional form:

$$S_0 = c\,(P_0 - Pl_0)^d \quad (1)$$

Where: $S_0$ = Initial supply before watershed intervention; c, d = Constants; $P_0$ = Product price; and $Pl_0$ = Minimum price that producers are willing to offer.

**Application of Economic Surplus Method to Watershed Evaluation:** i. They play a dual role of safeguarding the interest of the producers as well as consumers, as in several locations, the drought-proofing aspects of the watershed programs are easily felt[7]. ii. In the case of producers, they can change the crop pattern due to increased water levels in their wells, conserving moisture in the soil, increase water use for the fodder production. In the case of consumers, the increased crop production in the watershed results in availability of produce at lower prices. iii. There will be a change in the cost of production of the commodities in the watershed and also an increase in technology adoption due to watershed programmes. iv. The consumption levels also get increased among the consumers. v. Following IEG, World Bank, 2008, the demand curve is assumed to be log-linear with constant elasticity. Thus, the demand equation for this demand function can be written as:

$$P = gQ^{\eta} \quad (2)$$

Where: $\eta$ is the elasticity and g is a constant.

Once, the parameters $\eta$ and g are estimated, then consumer surplus could be estimated by Equation (3):

$$CS = Q_0\int gQ^{\eta}dQ - (Q_1 - Q_0)P_1 \quad (3)$$

**Estimation of Benefits: T**he theory of demand and supply equilibrium, total surplus (benefits) as a result of watershed development intervention is measured by Equation (4):

$$B = K * P_0 * A_0 * Y_0 * (1 + 0.5\,Z * \varepsilon_d) \quad (4)$$

Where: K is the supply shift due to watershed intervention.

The supply shift due to watershed intervention can be mathematically represented by Equation (5):

$$K = \forall * \rho * \Psi * \Omega \quad (5)$$

Where: K denotes the vertical shift of supply due to intervention of watershed development technologies and is expressed as a proportion of initial price. $\forall$ is the net cost change which is defined as the difference between reduction in marginal cost and reduction in unit cost.

The reduction in marginal cost is defined as the ratio of relative change in yield to price elasticity of supply ($\varepsilon_s$). Reduction in unit cost is defined as the ratio of change in cost of inputs per hectare to (1+change in yield). $\rho$ is the probability of success in watershed development implementation; $\psi$ represents adoption rate of technologies; and $\Omega$ is the depreciation rate of technologies; Z represents the change in price due to watershed interventions.

In mathematical form Z can be defined by Equation (6).

$$Z = K * \frac{\varepsilon_s}{(\varepsilon_d + \varepsilon_s)}$$

Where: $P_0$, $A_0$, and $Y_0$ represent prices of output, area and yield of different crops in the watershed before implementation of the programme.

## Bio-econometric Modelling

i. These link economic behavioural models with biophysical data to evaluate potential effects of new technologies, policies and market incentives on human welfare and the sustainability of the environment or natural resources[8]. ii. It helps the researchers in the selection of technologies that may improve the farmers economic efficiency and welfare as well as the condition of the natural resource base over time. iii. This can also be used to account for the externalities if the generation of externalities can be linked with NRM and economic factors. This model have been applied at household, village and watershed levels and for the agricultural sector.

## Meta Analysis

i. It is effectively an analysis of analyses. It is relatively a new methodology and its main purpose is to collect and combine the research findings from the previous studies, and distill them for broad conclusions. ii. It is helpful to policymakers, who may be confronted by numerous conflicting conclusions. iii. Earlier it was applied to assess the returns on investment in education and understand the implications of certain medical treatments on offspring and the returns to research investment at the global level.

Table-2 gives that the Econometric models serves as best method for assessing the impact of water shed programmes since all the sectors are included and it gives optimization.

The Table-3 tells us that where > 50% soil erosion was reduced are the best performing states and the worst ones are those where there is an increase in soil erosion. Around 73% of the soil erosion has reduced between 25 and 50% where as in 27%it is beyond 50%.

UP and TN are the best performing states. Overall impact is that the where area treatments are taken the community noted that reduction in soil reduction as compared to pre watershed situation.

**Table-2:** A comparison of methods for impact of watershed programmes[9].

| Methods | Major Advantage | Major Limitations |
|---|---|---|
| Conventional Analysis | Fast and easy to estimate | Sensitive to discount rate (i) and number of years of the project (n) |
| Econometric Models | It includes all the sectors | Both demand and supply elasticities are sensitive |
| Bio - Economic Models | Aggregate type; Optimization | Too much experimental details are required |
| Meta Analysis | Provides a macro picture | Aggregation bias |

**Table-3:** Impact of WDPs on soil erosion reduction in different States across schemes[10]**.**

| States | Schemes | Reduction of soil erosion (%) | | |
|---|---|---|---|---|
| | | >50% | Upto 50% | Not reduced |
| UP | DPAP | 11 (26.8) | 25 (61) | 5 (12.2) |
| | IWDP | 7 (15.2) | 32 (69.6) | 7 (15.2) |
| MP | DPAP | 0 | 46 (100) | 0 |
| | IWDP | 0 | 48 (100) | 0 |
| Gujarat | DPAP | 21 (70) | 9 (30) | 0 |
| | IWDP | 6 (30) | 13 (65) | 1 (5) |
| TN | DPAP | 8 (80) | 2 (20) | 0 |
| | IWDP | 12 (27) | 33 (73) | 0 |

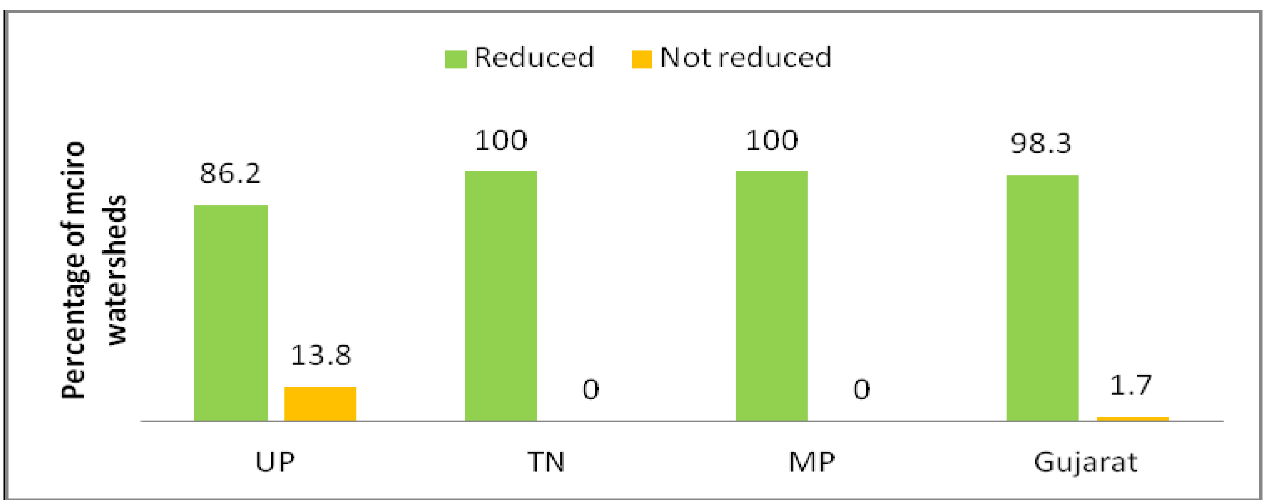


**Figure-2:** Overall affect of WDPs on soil erosion in different states[10].

Figure-2 shows that there was 100% reduction in soil erosion in MP and TN where as in Gujarat the soil erosion was reduced to 98.3% followed by 86.2% reduction in soil erosion in UP.

Figure-3 reveals that in Rajasthan more than 50 per cent of the farmers have reported that the reduction in soil erosion was to the extent of more than 25 percent. The study reveals that 87% respondents have noticed positive change in reduction of soil erosion under IWDP, 73% respondents have viewed positive change in soil erosion reduction under DPAP and only 59% respondents viewed positively in DDP projects.

Table-4 reveals that after implementation of the Watershed Development Programme Rajasthan has shown a very positive change in land use pattern. Among the 3 districts mentioned Jhalawar district has undergone a phase of transformation with more areas from an average of 426 Ha during pre watershed period to 490.22 Ha in post watershed period since the area is being covered under cultivation with better irrigation facilities and an increase of 41.67 Ha in the average area irrigated during post watershed period.

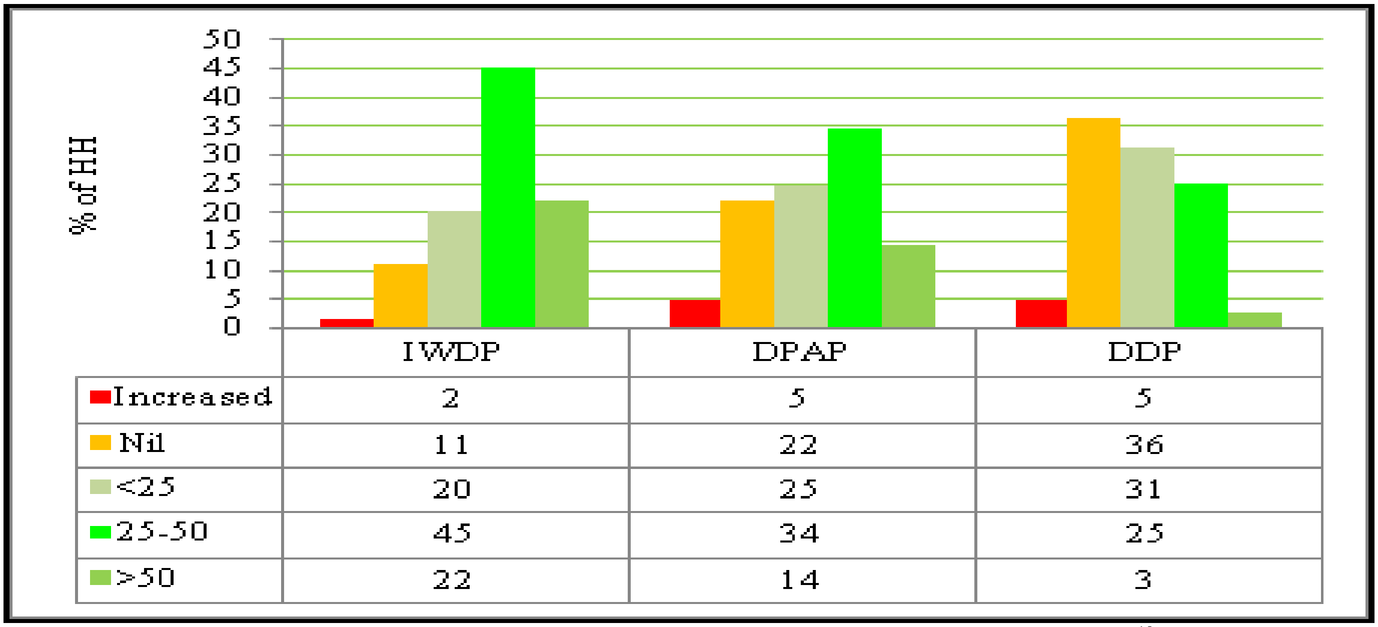


**Figure-3:** Affect of WDPs on reduction in soil erosion across schemes in Rajasthan[10].

**Table-4:** Increase in net sown area after WDPs implementation in Rajasthan[10]

| Districts | Pre-watershed (Net sown area in Ha) | Post watershed (Net sown area in Ha) |
|---|---|---|
| Baran | 274.8 | 309.65 |
| Jaipur | 333.29 | 346.71 |
| Jhalawar | **426.0** | **490.22** |

**Table-5:** Raise in the net cultivated area as well as the twice sown area under the DPAP in Madhya Pradesh[10].

| Districts | Min (in Ha) | Max (in Ha) |
|---|---|---|
| Chhindwara | 10 | 80 |
| Damoh | 10 | 104 |
| Jabalpur | 7 | 20 |
| Seoni | 7 | 65 |
| Shahdol | 18 | 178 |
| Umaria | 40 | 109 |

The study reported that there was raise in the net cultivated area as well as the twice sown area under the DPAP. The average area raised was noticed to be minimum5 Ha and maximum 25 Ha respectively. However the complete report indicates Min 18 Ha and Max 178Ha inShahdol, and Min 40 Ha and Max109 Ha in Umaria. The average area sown more than once has shown a positive increase in Umaria and Shahdol (Table-5).

Figure-4 shows that the quality of water harvesting structures were found to be good and very good. Gujarat and Tamil Nadu are the two better performing states to maintain quality of harvesting structure. States like UP and MP have mostly good and average performance in quality of water harvesting structures. It was found that in Gujarat more than 84% of watersheds had structures and they can be placed in either good or very good category and hardly any watershed was found to be under "poor" category. Thus, 73.56% of watershed structures were found to be either good or satisfactory. Further analysis shows that as far as water harvesting structures are concerned the DPAP is found comparatively better than IWDP.

Figure-5 shows that majority of watersheds have reported marginal increase in ground water level even after WDPs in Andhra Pradesh. The one of the major reasons for this marginal increase or to some extent reduction in deep percolation was that Uttar Pradesh faced severe drought conditions even after the completion of watershed program. In Gujarat, Madhya Pradesh and Tamil Nadu WDPs resulted in moderate increase in deep percolation level.

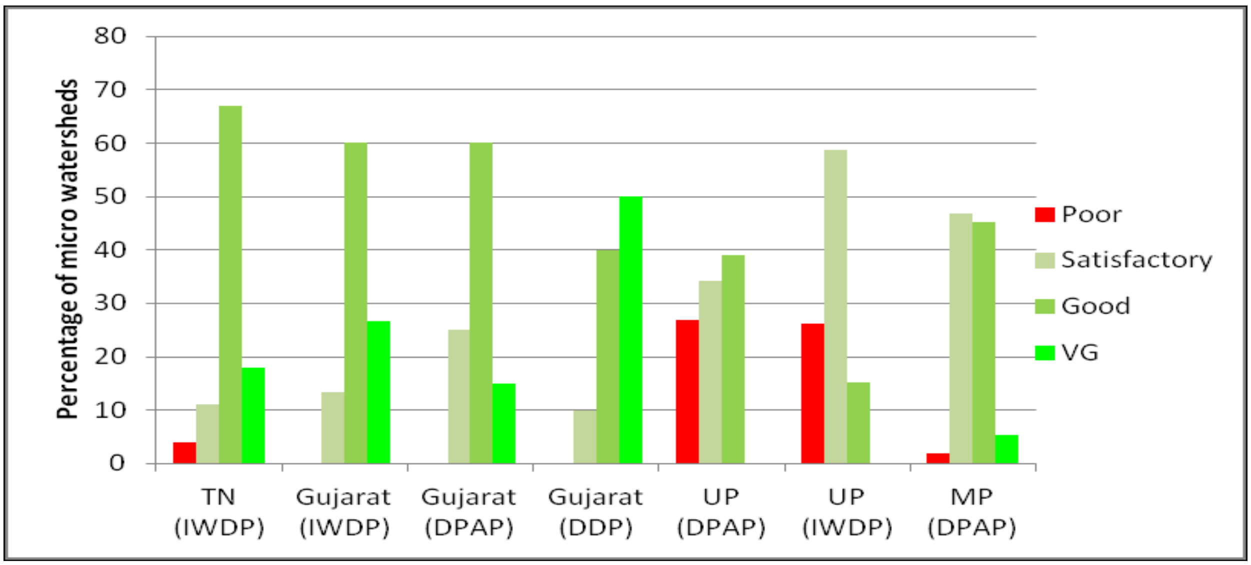


**Figure-4:** Quality of Water Harvesting Structures (Scheme wise)[10].

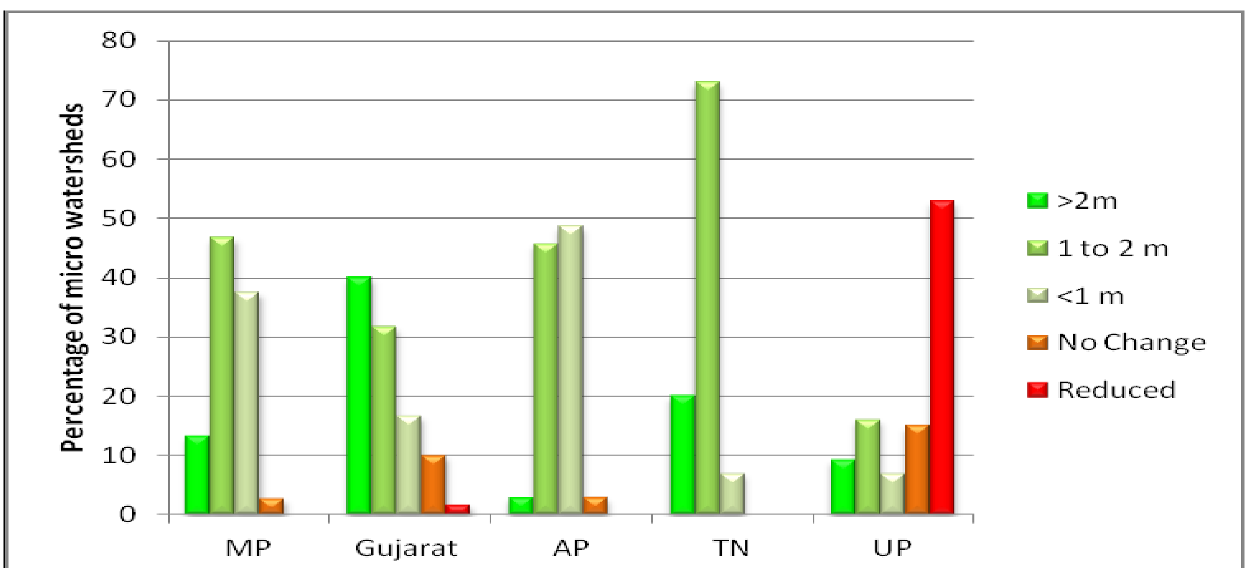


**Figure-5:** Change in deep percolation after WDPs in different states[10].

Table-6 shows that in both the watersheds there was increase in net cropped area, gross cropped area and cropping intensity. The cropping intensity was worked out to be 146.9 per cent in the watershed village, which is higher than in the control village (133.3 per cent).The value of crop diversification index (CDI) increases with the decrease in concentration and rises with the number of crops/ activities. The value of CDI was found to be higher in case of watershed treated villages than control villages, confirming that watershed treatment activities help for diversification in crop and farm activities.

**Table-6:** Affect of watershed on cropped area, cropping intensity and crop diversification[11].

| Particulars | Watershed Villages | | Control Villages | |
|---|---|---|---|---|
| | Before | After | Before | After |
| Net area irrigated | 1.08 | 1.10*** | 1.68 | 1.62 |
| Gross area irrigated | 1.25 | 1.35** | 1.84 | 1.62 |
| Irrigation intensity | 115.74 | 122.73** | 109.52 | 100.00 |
| Net cropped area (ha) | 1.15 | 1.28** | 1.78 | 1.62 |
| Gross cropped area (ha) | 1.38 | 1.88** | 2.43 | 2.16 |
| Cropping intensity (%) | 120.00 | 146.88 | 136.52 | 133.33 |
| Crop Diversification Index (CDI) | 1.0 | | 0.97 | |

Note: ** and *** indicate that values were significantly different at 1% and 5% levels from the corresponding values of control village.

**Table-7:** Affect of watershed development activities on the village economy[11].

| Crops/Enterprises | Total benefits due to watershed intervention (B) | | |
|---|---|---|---|
| | Change in Total Surplus (ΔTS) | Change in Consumer Surplus (ΔCS) | Change in Producer Surplus (ΔPS) |
| Sorghum | 2931773.3 | 113616.3 | 179541.0 |
| | (100.00) | (38.8) | **(61.2)** |
| Maize | 177774.2 | 85424.0 | 92350.2 |
| | (100.0) | (48.1) | (51.9) |
| Pulses | 25777.5 | 12580.3 | 13197.2 |
| | (100.000) | (48.8) | (51.2) |
| Vegetables | 29663.6 | 10627.5 | 19036.1 |
| | (100.00) | (35.8) | (64.2) |
| Milk | 176878.5 | 105974.1 | 70904.4 |
| | (100.0) | **(59.9)** | (40.1) |

Note: The figures within brackets indicate the percentage in respective rows.

Table-7 indicates that the change in total surplus in the village economy due to watershed intervention was decomposed into change in consumer surplus and change in producer surplus. It was found that the producer surplus was higher than the consumer surplus in all the crops. In sorghum the producer surplus was worked out to be 61.2 per cent. Thus watershed activities benefited the agricultural producers more. The decomposition analysis revealed that watershed development activities generated more consumer surplus in milk production.

Table indicates that the watershed activities work was mostly influenced bythe cropland areas in all watersheds thereby benefiting only the land owning households. In the hill watersheds, especially in WS-IV, however, higher proportions of community wastelands have been developed by way of community plantations, etc., the benefit from which would also be available to the non-landholders.

**Table-8:** Details of land types developed under watershed programme % of total watershed area

| Activity Type | Watershed No. | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| Crop land area | 92.2 | 100 | 86.9 | 68.1 |
| Community land area | 7.8 | 0 | 12.1 | 31.9 |
| Total watershed area (Area in ha) | 100 (500) | 100 (650) | 100 (489) | 100 (495) |

Source: PDI Survey(2001), Gujarat.

**Table-9:** Results of economic analysis employing economic surplus method[11].

| Particulars | Economic Surplus Method | Conventional Method |
|---|---|---|
| Benefit- Cost Ratio (BCR) | 1.93 | 1.23 |
| Internal Rate of Return (%) | 25 | 14 |
| Net Present Value (Rs.) | 2271021 | 567912 |

Table-9 indicates that the overall affect of different watershed treatment activities was assessed in terms of NPV, BCR and IRR and the NPV, BCR and IRR were worked out by using the economic surplus methodology assuming 10 per cent discount rate and 15 years life period. The BCR was found to be more than one, which implies that the returns to public investment on activities like watershed development were feasible. Similarly, the IRR was worked out to be 25 per cent, which is higher than the long-term loan interest rate by commercial banks indicating the worthiness of the government investment on watershed development. In economic surplus method the NPV was worked out to be Rs. 2271021 and from this table it is found that the economic surplus method is found to be feasible for watershed evaluation.

Table-10 shows that the frequencies of occurrence of farmers indicated that only 17 per cent and 16 per cent of the farmers had TE of less than 0.50 for wheat and gram respectively in the watershed areas; while in the control areas the corresponding values were quite high at 32 per cent and 60 per centre spectively.

**Table-10:** A comparison of TE among the farmers at watershed and control villages[12].

| Crop | Watershed Villages | | | | Control Villages | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Max | Min | Mean | S.D. | Max | Min |
| Wheat | 0.65 | 0.16 | 0.98 | 0.38 | 0.57 | 0.14 | 0.92 | 0.33 |
| Gram | 0.67 | 0.17 | 1.00 | 0.37 | 0.49 | 0.19 | 1.00 | 0.16 |
| Lentil | 0.76 | 0.16 | 0.97 | 0.38 | 0.52 | 0.18 | 0.89 | 0.16 |
| Urad | 0.61 | 0.17 | 0.98 | 0.34 | 0.44 | 0.18 | 0.98 | 0.18 |
| Paddy | 0.92 | 0.03 | 0.97 | 0.84 | 0.66 | 0.18 | 0.94 | 0.20 |
| Soybean | 0.45 | 0.18 | 1.00 | 0.20 | 0.23 | 0.08 | 0.53 | 0.16 |

Table-11 shows that in watershed areas the farmers were operating with medium-to-high level of technical efficiency for most of the crops, and in control areas they were operating with medium level of TE. But, in case of soybean, farmers were found to have medium level of TE in watersheds and low-to-medium level of TE in control areas. Therefore, from the study it reveals that there is sufficient potential of increasing the level of production using existing level of inputs and technology.

**Table-11:** Farms Distribution into TE categories at watershed and control villages[12].

| Crop | Watershed villages | | | | Control Villages | | | |
|---|---|---|---|---|---|---|---|---|
| | Low | Medium | Moderately High | High | Low | Medium | Moderately High | High |
| Wheat | 0 | 17 | 51 | 32 | 0 | 32 | 49 | 19 |
| Gram | 0 | 16 | 44 | 40 | 15 | 45 | 23 | 17 |
| Lentil | 0 | 7 | 24 | 69 | 12 | 34 | 38 | 16 |
| Urad | 0 | 31 | 42 | 27 | 24 | 46 | 20 | 10 |
| Paddy | 0 | 0 | 0 | 100 | 6 | 12 | 29 | 53 |
| Soybean | 15 | 58 | 16 | 11 | 39 | 59 | 2 | 0 |

**Table-12:** Change in carrying capacity of natural resources due to watershed[13].

| | 1991 | 2000 | Change | |
|---|---|---|---|---|
| (A) Forest Area (ha) | | | Absolute | % |
| 1.Production level | 6,033 | 5,811 | -222 | (3.7) |
| 2. Carrying capacity | 2,194 | 2,113 | -81 | (3.7) |
| 3.Poulation (Household) | 4,127 | 4,522 | 395 | (9.6) |
| 4. Burden (Household/yr) | 1,933 | 2,409 | 476 | (24.6) |
| (B) Fodder | | | | |
| 1.Production level | 59,770 | 62,423 | 2,653 | (4.4) |
| 2. Carrying capacity (cowhead/yr) | 13,048 | 13,871 | 823 | (6.3) |
| 3. Population (cowheads) | 28,141 | 30,682 | 2,541 | (9) |
| 4.Burden (Household/yr) | 15,093 | 16,811 | 1,718 | (11.4) |
| (C) Food grains | | | | |
| 1.Production level (M. T/yr) | 5,081 | 5,116 | 35 | (0.7) |
| 2. Carrying capacity (persons/M.T/yr) | 26,464 | 26,647 | 183 | (0.7) |
| 3. Population (persons) | 28,890 | 30,419 | 1,529 | (5.3) |
| 4.Burden (persons) | 2,426 | 3,772 | 1,346 | (55.5) |

Note: Figures in brackets show percentage change from base year.

Table-12 reveals that the carrying capacity estimates of natural resources in terms of fuel wood has decreased by 81 households and the burden on natural resources namely for fuel wood has increased by 476 households due to increase in population. In terms of fodder the carrying capacity improved by 823 households but the burden on land for fodder also increased by 1,718 cow heads outstripping the improvement in carrying capacity. The Total Food grain Production (TFP) increased resulting in improvement in the carrying capacity situation by 183 persons but the burden on land for food grains was increased by 1,346 persons during this period due to increase in population.

From the Table-13 it is shown that the mean agricultural productivity was found to be 28.89%, the employment generated was 164 person days/ha/yr, the cropping intensity was found to be 24.67% and the reduction in soil loss was noticed to be 63%.

**Table-13:** Impact of indicators from the reviewed watershed studies in North-Eastern States (N=37)[14].

| Indicator | Particulars | Unit | Mean | Min | Max |
|---|---|---|---|---|---|
| Efficiency | B/C Ratio | Ratio | 1.79 | 1 | 4.04 |
| | IRR | Per cent | 19.40 | 10.5 | 39.25 |
| | Agricultural yield | Per cent | 28.89 | 1.75 | 73 |
| Equity | Employment | Person days/ha/yr | 164 | 21 | 795 |
| Sustainability | Irrigated area | Per cent | 60.25 | 11.5 | 122.72 |
| | Cropping Intensity | Per cent | 24.67 | 1 | 65 |
| | Redn.in shifting cultivation | Per cent | 33.69 | 2 | 90 |
| | Redn. in soil loss | Per cent | 63 | 32 | 97 |

**Table-14:** Average borewell yield of sampling station $S_2$, $S_5$ and $S_7$ in Totaganti micro-watershed[15].

| Sl. No. | Sampling station $S_2$ (Upper reaches) | | Sampling station $S_5$ (Middle reaches) | | Sampling station $S_7$ (Lower reaches) | |
|---|---|---|---|---|---|---|
| | Time (s) | Water stored (ltrs) | Time (s) | Water stored (ltrs) | Time (s) | Water stored (ltrs) |
| 1 | 2.5 | 5.5 | 2.8 | 6.2 | 3.0 | 6.5 |
| 2 | 3.0 | 6.5 | 3.3 | 7.5 | 3.5 | 8.0 |
| 3 | 2.0 | 6.0 | 2.2 | 5.5 | 2.5 | 6.0 |
| 4 | 3.5 | 7.5 | 3.1 | 6.5 | 3.0 | 7.0 |
| 5 | 4.0 | 9.5 | 2.1 | 5.8 | 2.0 | 6.0 |
| 6 | 3.0 | 7.0 | 2.8 | 7.8 | 3.0 | 8.0 |
| 7 | 2.5 | 6.5 | 1.9 | 4.9 | 2.0 | 5.0 |
| 8 | 2.0 | 5.5 | 2.9 | 6.9 | 3.0 | 7.0 |
| 9 | 3.5 | 8.0 | 3.4 | 8.0 | 3.5 | 8.5 |
| 10 | 4.0 | 8.5 | 3.9 | 9.0 | 4.0 | 10.0 |
| Total | 30 | 70.5 | 28.4 | 68.1 | 29.0 | 72.0 |
| Avg. Yld | 2.35 ltr/sec | | 2.391/sec | | 2.48 ltr/sec | |

Table-14 gives us the average bore well yield of three sampling stations namely $S_2$, $S_5$ and $S_7$ respectively. In Sampling station S7 it was found that the average bore well yield was highest and it was found to be 2.48 ltr / sec since it is the lower reaches of the watershed and the water reaches very fast as compared to middle and upper reaches.

Table-15 reveals that after watershed treatment the functioning of tank, open well and bore well got increased to 2, 3 and 100 respectively. It was found that before watershed treatment the non-functioning of bore wells was found to be 45 and after watershed treatment the non-functioning of bore wells got decreased to 10.

Table-16 shows that before watershed intervention the average productivity of different crops was lesser and after watershed development programme the average productivity of Jowar, Maize, Cotton, Grondnut and Redgram were increased and were 3.7 q/acre, 3.2 q/acre, 3.3 q/acre, 3.2 q/acre and 2.5 q/acre respectively.

**Table-15:** Status of irrigation sources before and after watershed treatment in Totagantimicro-watershed[15].

| Particulars | Before watershed treatment | | After watershed treatment | |
|---|---|---|---|---|
| | Functioning | Non-functioning | Functioning | Non-functioning |
| Tank | 0 | 2 | 2 | 0 |
| Open well | 0 | 3 | 3 | 0 |
| Bore well | 65 | 45 | 100 | 10 |
| Total | 65 | 50 | 105 | 10 |

**Table-16:** Average productivity of different crops by beneficiaries of watershed project[15].

| Crops | Before watershed programme (q/acre) | After watershed development programme (q/acre) |
|---|---|---|
| Jowar | 3.0 | 3.7 |
| Maize | 2.9 | 3.2 |
| Cotton | 2.62 | 3.3 |
| Groundnut | 2.26 | 3.2 |
| Redgram | 2.1 | 2.5 |

**Table-17:** Poverty indices* during pre- and post-watershed intervention in Gokulpura-Goverdhanpura villages, Bundi, Rajasthan, India[16]

| | Pre watershed invention | | | | | Post watershed invention | | | |
|---|---|---|---|---|---|---|---|---|---|
| Indicators | Land holding (ha)* | | | | | | | | |
| | Reflection | <1 | 1-2 | 2-4 | >4 | <1 | 1-2 | 2-4 | >4 |
| No. of household | | 152 | 125 | 36 | 21 | 208 | 173 | 23 | 14 |
| Head count ratio | Incidence | 0.13 | 0.09 | 0.05 | 0.03 | 0.006 | 0.04 | 0.03 | 0.01 |
| Poverty gap index | Depth | 0.065 | 0.048 | 0.028 | 0.014 | 0.024 | 0.014 | 0.007 | 0.001 |
| Square poverty gap index | Severity | 0.034 | 0.023 | 0.009 | 0.002 | 0.010 | 0.005 | 0.001 | 0.00 |

*Farmers category based on land holdings: Marginal = < 1 ha; Small = 1 - 2 ha; Medium = 2 - 4 ha; Large = > 4 ha.

Table-17 tells us that there was change in poverty indices during pre and post watershed intervention in Rajasthan. Before watershed invention the head count ratio and poverty gap index was found to be 0.13 and 0.09 in marginal and small farmers. After watershed invention the head count ratio was reduced to 0.006 and 0.04 in marginal and small farmers. The poverty gap index before watershed invention was 0.065 and 0.048 respectively. The poverty gap index was reduced to 0.024 and 0.014 after watershed invention.

## Conclusion

The watershed development programme have showed a positive change in the land use pattern in most of the regions. More waste land was converted for efficient and productive use by the farmers. This has resulted in increase in net sown area in majority of the states. Further, better land use pattern has helped to increase agricultural intensification and thus improve the agricultural production. There was a net raise in the irrigation sources due to increase in the groundwater recharge through water harvesting structures. The long term improvements in the environment including availability of fuel wood, fodder, timber, drinking water, quality of life etc., done by the a forestation during the project period would further improved the rates of returns to such investments. Equity, in sharing the benefits is considered important for effective community participation. The long term sustainability of the watershed will rely on how the market opportunities are integrated with the watershed development activities. The value of CDI will be high with the decrease in concentration and rises with the number of crops/ activities and the watershed treatment activities help in diversification in crop and farm activities.

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