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# Watersheds impact evaluation using time scale disparity index

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**ABSTRACT**

This study assessed the impacts of four watersheds namely Laxmipur, S. Venkatapur, Kakatiya and Shettihadapnur in Karimnagar, Medak, Warangal and Adilabad districts of Telangana region in Andhra Pradesh to derive logical macro-level policy inferences following time scale disparity index approach. This article, using data from the report of the impact evaluation study carried out by CRIDA and submitted to NABARD, attempts to evaluate the impacts of above watersheds in terms of relative contribution of pre-project (before) and post-project (after) periods on bio-physical and socio-economic aspects. Composite index (watershed impact index) used in this study will enable the policy makers and planners to understand and compare the overall impact of each watershed that will integrate the effect of all the parameters or indicators.

## 1. INTRODUCTION

The just concluded eleventh five year plan and the ongoing twelfth plan lay a greater focus on agricultural growth with a target of four percent growth on this sector. The country has recorded the food grains production of 244 mt in 2010-11 and which improved to 253 mt in the fiscal 2011-12. However, the country needs this level to rise to 307 MT by 2020. This gap can only be filled with higher contributions from rainfed areas. However, our rainfed agriculture is confronted with several crises like climate change, degradation of resources and other pressures. Therefore, the sustainable solution can only come from watershed interventions and productivity enhancement. In the past forty years or so, the government has introduced watershed programmes in different modes and the latest one under the common guidelines will be of great significance in this context. Parallel to the government efforts, the NABARD has been promoting watersheds individually (under watershed development fund) and in multinational collaboration (Indo German watershed development programme) almost since 1999-2000. The operations of watersheds programmes are spread in several states.

It is widely known that Integrated Watershed Management Programme (IWMP) in India has made strides in rainfed agriculture through registering significant increase in productivity, improvement in resource quality, diversification of production system and generation of additional employment. Watershed programmes have specifically resulted in yield increase significantly across the country (Palanisami *et al*. 2011; ISRO, 2011; Wani *et al*. 2003), the integrated watershed management programmes have shown a potential of 20 to 100 percent increase in the crop productivity from rainfed areas in addition to improving the natural resource-base and environmental benefits.

Although many programmes and projects under such programmes have been implemented, the level of impact and the sustainability of the same has not been that encouraging. Nevertheless, the process is a continuum since, no two projects or watersheds are similar or replication of the modules is difficult. To cite an example for generalization difficulties, the Watershed Development Fund Programme of NABARD in one watershed the cropping intensity increased by 10%, water table by 25% and maize productivity by 28% (CRIDA, 2010). Thus independent indicator or parameters could be valued or compared with such impact findings. However, there is absence of an integrated impact indicator for rating the watersheds.

Realizing this constraint, an attempt has been made in the present study using Time Scale Disparity Index ('Before'

and 'After' method) which is coined as watershed impact index (accounting the pooled effect of all indicators) to carry out the impact evaluation of four watersheds of Telangana region in Andhra Pradesh namely Laxmipur, S. Venkatapur, Kakatiya and Shettihadapnur in Karimnagar, Medak, Warangal and Adilabad districts, respectively in respect of major bio-physical and socio-economic indicators of watershed such as, ground water recharge, cropping intensity, biomass and fodder availability, crop and milk productivity, income derived, employment generation, credit absorption and level of migration. The main objectives of this study were to assess and compare the impact of Watershed Development Project activities /interventions on the identified indicators across the watersheds, and to evaluate and compare the total impact of WDP.

## 2. MATERIALS AND METHODS

### Database and Methodology

Indo-German Watershed Development Programme (IGWDP) is under implementation by NABARD since 2007-08 with financial support from KfW, a development bank of Germany. The projects are implemented by leading local based NGOs and are technically supported with expertise by other NGOs besides NABARD and line departments. The projects consist of qualifying *shramadan* during capacity building phase (CBP), a pilot phase, where the community along with the NGO demonstrate their implementation skills and only after satisfactory performance get eligible for full scale implementation of the project (FIP). About 36 projects are right now under implementation in different parts of Telangana region of Andhra Pradesh covering 41500 ha area. On the suggestion of IGWDP-AP, Central Research Institute for Dryland Agriculture (CRIDA) took up the impact evaluation study of these watersheds development programme during 2010-11 with a sample of four randomly selected projects. These are Laxmipur, S. Venkatapur, Kakatiya and Shettihadapnur in Karimnagar, Medak, Warangal and Adilabad districts of Telangana region of Andhra Pradesh, respectively. The primary data for the two respective periods – before (2006-07) and after (2010-11) were collected from the respondents' memory recall basis and from the bench mark survey data available with the Project Managers. As rainfall is the key factor that influence the agricultural trend in watersheds, the rainfall pattern in the sample watersheds is given in Table 1.

**Table:1**
**Rainfall Pattern in the studied watersheds (mm $yr^{-1}$)**

| Watershed | Normal | 2006 | 2010 |
|---|---|---|---|
| Laxmipur | 901 | 1375 | 1100 |
| S.Venkatapur | 759 | 728 | 757 |
| Kakatiya | 816 | 886 | 931 |
| Shettihadapnur | 1100 | 1237 | 1041 |

### Time Scale Disparity Index ('Before' and 'After') Approach

To study the contribution of watershed programme in the agricultural economy of a region, indicators such as ground water recharge, biomass and fodder availability, cropping intensity, crop and milk productivity, income derived, employment generated, institutional credit absorption and extent of migration, the technique of time scale disparity index ('before' and 'after' approach) is used. Primary data were collected from the farmers of the sample watersheds, which have almost completed their implementation period, through personal interviews. The sample consisted of 80 farmers with 40 under marginal and small farmers (< 2.0 ha) and another 40 in medium and large category farmers (> 2.0 ha) from each selected watershed.

The Model Let $X_{ij}$ (i= 1, 2,3,4; j = 1,2……..9) represents absolute difference in the amount of each of the nine major indicators chosen for this study before and after the WDP *viz.,* ground water recharge (GWR), biomass and fodder availability (BFA), cropping intensity (CIN), crop productivity (CPT), milk productivity (MPT), income derived (IND), employment generation (EMG), institutional credit absorption (ICA) and migration level (MIG) for the $i^{th}$ watershed.

To derive the measure mathematically, first, an index of disparity ($DI_{ij}$) in each of the nine indicators $X_{ij}$ relating to $i^{th}$ watershed is defined as below:

$$DI_{ij} = \frac{(X_{ij} - \underset{i}{\text{Minimum}}\, X_{ij})}{(\underset{i}{\text{Maximum}}\, X_{ij} - \underset{i}{\text{Minimum}}\, X_{ij})}$$

$$(i = 1,2,\ldots\ldots 4,\ j = 1,2,\ldots 9) \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

In particular, the absolute difference of each of the nine indicators between pre-and post-watershed programme for the $i^{th}$ watershed has been taken and combined to arrive at a composite index of time scale disparity ($\sum DI_{ij}$)

Then, an average index (overall impact) for the $i^{th}$ watershed is estimated by taking the average of nine indicators of watershed defined above to arrive at (Time Scale Disparity Index)$_i$

$$CDI_{ij} = \left(\sum_{j=1}^{9} DI_{ij}\right)/9 \quad i = (1,\ldots,4) \qquad \ldots\ldots\ldots\ldots (2)$$

Where, $CDI_{ij}$ also called as watershed impact index indicates time scale disparity (average/overall impact) for the $i^{th}$ watershed. A single index ($CDI_{ij}$) for each of the four watersheds reflects comparative status of sum of the impacts (time scale disparity *i.e.* before and after WDP) in a particular watershed on the basis of differences in the two points of time of different magnitudes of nine specified categories of activities. Evidently these indices are relative indices and may be used to reflect the comparative situation of disparity in two points of time for $i^{th}$ watershed among different watersheds.

## 3. RESULTS AND DISCUSSION

The results of the analysis are presented in two sections, first a comparison of the before and after status in terms of each of the indicator (parameter) followed by the individual indices and the composite disparity indices. Firstly, the parameter- wise impacts are presented below:

### (i) Ground Water Recharge

The watershed development activities have been found to have significant impact on the ground water recharge in all the four watersheds under study over the baseline period (before WDP) resulting in increased area and access to ground water (more number of irrigations per crop) which all led to crop yield improvement.

The average depth of ground water availability from ground level in the bore wells was found to be 59.2 m after the implementation of WDP compared to 85.1 m in the pre-watershed programme at Laxmipur watershed leading to an absolute difference ($X_{ij}$) of 25.9 m, a maximum improvement of ground water recharge followed by Kakatiya (21.4 m), Shettihadapnur (15.2 m) and S. Venkatapur (12.8 m) watersheds (Table 2).

**Table: 2**
**Change in ground water table**

| S. No. | Watershed | Water from ground level (m) | | |
|---|---|---|---|---|
| | | Before | After | Absolute difference ($\lvert X_{ij} \rvert$) |
| 1 | Laxmipur | 85.1 | 59.2 | 25.9 |
| 2 | S. Venkatapur | 68.9 | 56.1 | 12.8 |
| 3 | Kakatiya | 61.3 | 39.9 | 21.4 |
| 4 | Shettihadapnur | 76.2 | 61.0 | 15.2 |
| | Overall | 72.9 | 54.1 | 18.8 |

### (ii) Cropping Intensity

The cropping intensity also improved by 11% reflecting a growth of 9.9% in the four years period after the implementation of watershed development programmes compared to the baseline period (Table 3).

Among the four watersheds, Shettihadapnur watershed registered higher cropping intensity (128%) followed by Kakatiya (124%), S. Venkatapur (118%) and Laxmipur watershed (114%) while it was 119, 120, 96 and 102 percent before WDP, respectively. Thus, the impact of watershed programme on cropping intensity *i.e.* the absolute difference between the two points of time (before and after the project) was noticed to be higher in S. Venkatapur watershed (22%) followed by Laxmipur (12%), Shettihadapnur (9%) and Kakatiya watershed (4%). Higher impact of watersheds on cropping intensities registered in S. Venkatapur and Laxmipur watersheds is attributed to both paddy and vegetables during *rabi* season under irrigated conditions. This change in cropping pattern resulted in generation of more employment compared to the other two watersheds where only a single crop (paddy) dominated during the *rabi* season (Annex. 1). Higher cropping intensities led to addition of more crops to the existing cropping pattern/ programme during 2010-11 and also for production increases. Rainfall pattern and length of growing season decide the choice of crops and varieties in rainy season (*kharif*) while in post-rainy season (*rabi*), availability of water and residual soil moisture decide the choice of crops (Singh, 2006). Thus, cropping intensity was directly related to the extent of increase in area under the cultivation of paddy and/or vegetables in *rabi* season under irrigated conditions.

**Table: 3**
**Impact of watershed interventions on cropping intensity**
(Per cent)

| Watershed | Before | After | Absolute difference | Annual Growth (%) |
|---|---|---|---|---|
| Laxmipur | 102 | 114 | 12 | 11.8 |
| S. Venkatapur | 96 | 118 | 22 | 22.9 |
| Kakatiya | 120 | 124 | 4 | 3.0 |
| Shettihadapnur | 119 | 128 | 9 | 7.6 |
| Overall | 111 | 122 | 11 | 9.9 |

### (iii) Crop Productivity

Management of production systems with productivity enhancement has become a potential to minimize the yield gap of crops during post-watershed period in the four watersheds (Table 4). On an overall basis, crop productivity registered higher after the implementation of WDP than before the programme in all the four watersheds under study. Crop productivity ranged between 8.7 q $ha^{-1}$ at Shettihadapnur watershed (totally a tribal area) in Adilabad district and 38.2 q $ha^{-1}$ at S. Venkatapur watershed in Medak district after the WDP while before the programme, it varied from 6.8 to 28.6 q $ha^{-1}$ indicating a clear impact of WDPs. The absolute difference ($X_{ij}$) in crop productivity between the two points of time ('before' and 'after' the WDP) was found to be substantially higher at Kakatiya watershed (13.5 q $ha^{-1}$) followed by S. Venkatapur (9.6 q $ha^{-1}$), Laxmipur (6.2 q $ha^{-1}$) and Shettihadapnur (1.9 q $ha^{-1}$) watershed (Tables 3 and 10). Higher impact of WDP on crop productivity at Kakatiya watershed is attributed mainly due to the yield effect of maize crop due to adoption of zero till and hybrid seed in paddy fallows compared to the farmers' practice before WDP.

### (iv) Biomass and Fodder

The access to grazing resources was mostly met from biomass and fodder in the form of crop residues and cultivation of fodder crops. The overall impact (the absolute difference between pre-and post-project periods) of watershed interventions in the four watersheds resulted in increased availability of biomass and fodder to the extent of 25% that led to increased production and productivity of milk per milch animal (Tables 5 and 6).

**Table: 4**
**Impact of watershed interventions on productivity of crops** (q $ha^{-1}$)

| Sl.No. | Crops | Watersheds | | | |
|---|---|---|---|---|---|
| | | Laxmipur | S. Venkatapur | Kakatiya | Shettihadapnur |
| 1 | Cotton | | | | |
| | Before | 14.9 | 14.7 | 9.8 | 5.3 |
| | After | 19.7 | 20.2 | 13.3 | 7.1 |
| | % change | 32.0 | 38.0 | 35.7 | 34.0 |
| 2 | Rice (*kharif*) | | | | |
| | Before | 37.9 | 37.3 | 38.0 | 14.0 |
| | After | 41.0 | 44.0 | 55.4 | 18.5 |
| | % change | 8.2 | 20.0 | 45.8 | 32.0 |
| 3 | Maize | | | | |
| | Before | - | 31.2 | 23.2 | 6.0 |
| | After | - | 43.2 | 48.9 | 7.3 |
| | % change | - | 38.0 | 111.0 | 21.7 |
| 4 | Redgram | | | | |
| | Before | - | 10.8 | 7.8 | 4.2 |
| | After | - | 11.6 | 9.5 | 4.4 |
| | % change | - | 35.0 | 21.8 | 4.8 |
| 5 | Soybean | | | | |
| | Before | - | - | - | 7.4 |
| | After | - | - | - | 8.9 |
| | % change | - | - | - | 20.3 |
| 6 | Rice (*rabi*) | | | | |
| | Before | 39.6 | 32.0 | 42.3 | 17.0 |
| | After | 43.1 | 41.0 | 55.7 | 18.3 |
| | % change | 8.8 | 28.1 | 31.7 | 7.6 |
| 7 | Vegetables (*rabi*) | | | | |
| | Before | 54.0 | 100.0 | - | - |
| | After | 70.0 | 118.0 | - | - |
| | % change | 29.6 | 18.0 | - | - |
| | Overall crops | | | | |
| | Before | 24.1 | 28.6 | 23.8 | 6.8 |
| | After | 30.3 | 38.2 | 37.3 | 8.7 |
| | % change | 25.7 | 33.6 | 56.7 | 27.9 |

Obviously, the impact of WDP on biomass & fodder production (an absolute difference between the two points of time, *i.e.* 'before' and 'after' WDP) was found to be higher at Kakatiya watershed (40%) followed by Shettihadapnur (29%), Laxmipur and S. Venkatapur watersheds (each 15%) (Table 5). The availability of biomass/ fodder for livestock was quantified by relating the recommended requirement versus the actual quantity fed to the animals (of different categories) by the households. The gap in supply as related to the demand was taken as the availability percent.

**Table: 5**
**Impact of watershed interventions on extent of biomass and fodder availability** (Per cent)

| Watershed | Before | After | Absolute difference |
|---|---|---|---|
| Laxmipur | 60 | 75 | 15 |
| S. Venkatapur | 50 | 65 | 15 |
| Kakatiya | 60 | 100 | 40 |
| Shettihadapnur | 61 | 90 | 29 |
| Overall | 58 | 83 | 25 |

**(v) Milk Productivity**

Watershed interventions showed an impact on increased milk productivity per milch animal per year in all the four watersheds (Table 6). The impact of WDP on milk yield (absolute difference) registered higher at Shettihadapnur watershed (118 litres $yr^{-1}$ milch $animal^{-1}$) followed by Kakatiya (104 litres $yr^{-1}$ milch $animal^{-1}$), S. Venkatapur (60 litres $yr^{-1}$ milch $animal^{-1}$) and Laxmipur (55 litres $yr^{-1}$ milch $animal^{-1}$) as against overall impact of WDP on milk yield of 84 litres $yr^{-1}$ milch $animal^{-1}$. The highest milk productivity gain in Shettihadapnur was due to the increase in both fodder and crop residues besides water availability. It may be noted that there was no introduction of cross bred animals during the watershed project, the

growth was purely on account of management of fodder. The strengthening of linkages among different components of farming system, *viz.,* crop – fodder - livestock enhanced sustainability and economic viability of the rainfed agro-ecosystem.

**Table: 6**
**Impact of watershed interventions on milk productivity**

(litres $yr^{-1}$ milch $animal^{-1}$)

| Watershed | Before | After | Absolute difference |
|---|---|---|---|
| Laxmipur | 415 | 470 | 55 |
| S. Venkatapur | 320 | 380 | 60 |
| Kakatiya | 516 | 620 | 104 |
| Shettihadapnur | 365 | 483 | 118 |
| Overall | 404 | 488 | 84 |

**(vi) Annual Household Income**

Among the four watersheds, the real income change (the absolute difference between the two points of time, after adjusting to the inflation) was the highest (₹ 35483 $yr^{-1}$ $household^{-1}$) in Kakatiya watershed followed by Shettihadapnur (₹ 28453 $yr^{-1}$ $household^{-1}$), Laxmipur (₹ 12172 $yr^{-1}$ $household^{-1}$) and S. Venkatapur (₹ 7245 $yr^{-1}$ $household^{-1}$) watersheds (Table 10). Higher income change in case of Kakatiya and Shettihadapnur watersheds may be justified from the fact that higher annual rainfall (1250 and 917 mm, respectively) with better soils provide opportunity to harvest rain water and adopt improved cropping practices resulting in increased income. While lower annual rainfall in case of Laxmipur (702.1 mm) and S. Venkatapur (883 mm) with poor soils resulted in lower change in income (Table 7).

**(vii) Credit Absorption**

Institutional (banking sector) credit has shown an improvement after the implementation of WDP in the four watersheds in terms of outreach and socio-economic impact (Table 8). The impact (absolute difference) of WDP on absorption level of the institutional credit registered higher in case of Shettihadapnur and Kakatiya watersheds (49.1 and 25%, respectively) while the impact was meager in Laxmipur and S. Venktapur watersheds (8% and 3%, respectively). The impact of WDP on credit absorption level

**Table: 8**
**Impact of watershed development programme on institutional credit absorption** (% of households)

| Watershed | Before | After | Absolute difference |
|---|---|---|---|
| Laxmipur | 27.0 | 30.0 | 3.0 |
| S. Venkatapur | 71.0 | 79.0 | 8.0 |
| Kakatiya | 37.5 | 62.5 | 25.0 |
| Shettihadapnur | 35.9 | 85.0 | 49.1 |
| Overall | 42.9 | 64.1 | 21.2 |

**Table: 7**
**Impact of interventions on household income** (₹ $annum^{-1}$)

| Sl.No. | Source | Laxmipur | S. Venkatapur | Kakatiya | Shettihadapnur |
|---|---|---|---|---|---|
| 1 | Fruits/ vegetables | | | | |
| | Before | 2350 | 4879 | 3115 | -- |
| | After | 4700 | 6861 | 12100 | -- |
| | Change (%) | 100 | 41 | 288 | -- |
| 2 | Crops | | | | |
| | Before | 38500 | 23939 | 41336 | 35490 |
| | After | 53125 | 27952 | 51588 | 52315 |
| | Change (%) | 38 | 17 | 25 | 47 |
| 3 | Dairy | | | | |
| | Before | 4663 | 13809 | 12908 | -- |
| | After | 4702 | 11370 | 18996 | -- |
| | Change (%) | 0.8 | -18 | 47 | -- |
| 4 | Sheep / goats | | | | |
| | Before | 2125 | 667 | 9100 | 5000 |
| | After | 1462 | 1236 | 15000 | 5500 |
| | Change (%) | -31 | 85 | 65 | 10 |
| 5 | Wages/ salaries | | | | |
| | Before | 33528 | 13509 | 21688 | 18338 |
| | After | 29348 | 16630 | 25946 | 29466 |
| | Change (%) | -12.5 | 23 | 20 | 61 |
| | Total income | | | | |
| | Before | 81166 | 56803 | 88147 | 58828 |
| | After | 93337 | 64048 | 123630 | 87281 |
| | Change (%) | 15 | 13 | 40 | 48 |

is mainly due to deriving of higher income from crops that encourages the farmers to go-in-for more loans every season/year to further diversify and invest on commercial and horticultural crops. Therefore, it is being increasingly recognized that revitalizing of credit expansion requires a holistic approach.

**(viii) Employment Generation**

The direct impact of watershed interventions is evident on increased employment generation in the four watersheds to support agricultural labour for preventing them from migration through undertaking soil and water conservation measures like water absorption trenches (WATs) and continuous contour trenches (CCTs) in non-arable lands and new farm bunding (NFB) and dugout ponds in arable lands. Table 9 shows that the impact of WDP (absolute difference between the two points of time) on employment generation across all the households registered higher (21 person days $ha^{-1}$) in Kakatiya watershed followed by Shettihadapnur (19 person days $ha^{-1}$), Laxmipur (18 person days $ha^{-1}$) and S. Venkatapur (15 person days $ha^{-1}$). The study indicates that a sort of resilience had come for the systems from productivity enhancement, higher labour absorption in agriculture and newly initiated livelihood activities.

**Table: 9**
**Impact of watershed interventions on employment generation**

[person days across households (landless+farmers) $ha^{-1}$]

| Watershed | Before | After | Absolute difference |
|---|---|---|---|
| Laxmipur | 147.0 | 165.0 | 18.0 |
| S. Venkatapur | 153.0 | 168.0 | 15.0 |
| Kakatiya | 151.0 | 172.0 | 21.0 |
| Shettihadapnur | 165.0 | 184.0 | 19.0 |
| Overall | 154.0 | 172.0 | 18.0 |

**(ix) Migration**

The migration (out of the village) status of households has significantly come down from 70% (before WDP) to 18% (after WDP) *i.e.* a decrease of 52% in Kakatiya watershed in Warangal district followed by Shettihadapnur and Laxmipur (each registered 35% decrease) and S. Venkatapur watershed (22% decrease) (Table 10). This is attributed mainly due to the impact of watershed interventions that retained the farmers in farming round the year in terms of generating employment activities besides that of MGNREGS implementation. In their study, Osman *et al*. (2009) endorsed that the distressed and seasonal migration of agricultural labour during the lean period was curtailed because of higher opportunity for works and income through land use diversification.

**Table: 10**
**Impact of WDP on migration** (% of households)

| Watershed | Before | After | Absolute difference |
|---|---|---|---|
| Laxmipur | 48.0 | 13.0 | 35.0 |
| S. Venkatapur | 37.0 | 15.0 | 22.0 |
| Kakatiya | 70.0 | 18.0 | 52.0 |
| Shettihadapnur | 37.5 | 2.5 | 35.0 |
| Overall | 48.1 | 12.1 | 36.0 |

**Watershed Impact Index**

The total impact (Composite disparity index or simply watershed impact index, CDI or WII) of the nine activities of WDP was found to be the highest in Kakatiya watershed in Warangal district and least in S. Venkatapur watershed as indicated by the calculated values of composite indices of time scale disparity *viz.*, 0.77 and 0.21, respectively (Table 11).

Among the various activities undertaken in Kakatiya watershed, the disparity index ($D_{ij}$) registered maximum in case of crop productivity (1.00), biomass and fodder availability (1.00), employment generation (1.00), migration (1.00) and annual income derived (1.00); (ii) minimum impact in case of cropping intensity (0.00); (iii) moderate impact on institutional credit absorption (0.48) and (iv) moderately high impact on milk productivity (0.78) and ground water recharge (0.66) .

With regard to impact assessment of the four watersheds, S. Venkatapur was in bottom position. The disparity indices associated with ground water recharge, biomass and fodder availability, employment generation, farm income derived and level of migration of this watershed registered minimum impact (zero disparity) between the two points of time, *viz.*, 'before' and 'after' (Table 10). S. Venkatapur registered maximum impact (max. diversity index) on cropping intensity (1.00) among the four watersheds while the diversity indices associated with other indicators such as crop productivity, institutional credit absorption and milk productivity were measured as 0.66, 0.11 and 0.08, respectively.

Shettihadapnur watershed in Adilabad district showed maximum impact (maximum diversity index) on milk productivity (1.00) and institutional credit absorption (1.00) followed by farm income derived (0.75);, employment generation (0.67), biomass and fodder availability (0.56), migration (0.43), cropping intensity (0.28), ground water recharge (0.18) and minimum impact (0.00) on crop productivity. Laxmipur watershed in Karimnagar district registered disparity indices at varying levels between the two points of time, *viz*; 'before' and 'after' WDP on different indicators like ground water recharge (1.00), employment generation (0.50), cropping intensity (0.44), migration (0.43), crop productivity (0.37), farm income derived (0.17) but minimum impact (zero disparity) on biomass and fodder availability, milk productivity and institutional credit absorption (Table 11).

## 4. CONCLUSIONS

The composite index used in the study is very useful for the policy makers and planners to know and compare the

**Table: 11**
**Impact of watershed development on various development indicators and the watershed impact index**

| S.No. | Watersheds | Indicators | Before | After | Absolute difference ($\lvert X_{ij} \rvert$) | Disparity indices ($D_{ij}$) | Watershed impact index ($I_{ij}$) |
|---|---|---|---|---|---|---|---|
| 1 | Laxmipur | GWR | 85.1 | 59.2 | 25.9 | 1.00 | |
| | | BFA | 60.0 | 75.0 | 15.0 | 0.00 | |
| | | CIN | 102.0 | 114.0 | 12.0 | 0.44 | 0.32 |
| | | CPT | 24.1 | 30.3 | 6.2 | 0.37 | |
| | | MPT | 415.0 | 470 | 55.0 | 0.00 | |
| | | EMG | 147.0 | 165.0 | 18.0 | 0.50 | |
| | | ICA | 27.0 | 30.0 | 3.0 | 0.00 | |
| | | INC | 81165 | 93337 | 12172 | 0.17 | |
| | | MIG | 48.0 | 13.0 | 35.0 | 0.43 | |
| 2 | S. Venkatapur | GWR | 68.9 | 56.1 | 12.8 | 0.00 | |
| | | BFA | 50.0 | 65.0 | 15.0 | 0.00 | |
| | | CIN | 96.0 | 118.0 | 22.0 | 1.00 | |
| | | CPT | 28.6 | 38.2 | 9.6 | 0.66 | |
| | | MPT | 320.0 | 380.0 | 60.0 | 0.08 | 0.21 |
| | | EMG | 153.0 | 168.0 | 15.0 | 0.00 | |
| | | ICA | 71.0 | 79.0 | 8.0 | 0.11 | |
| | | INC | 56803 | 64048 | 7245 | 0.00 | |
| | | MIG | 37.0 | 15.0 | 22.0 | 0.00 | |
| 3 | Kakatiya | GWR | 61.3 | 39.9 | 21.4 | 0.66 | |
| | | BFA | 60.0 | 100.0 | 40.0 | 1.00 | |
| | | CIN | 120.0 | 124.0 | 4.0 | 0.00 | |
| | | CPT | 23.8 | 37.3 | 13.5 | 1.00 | |
| | | MPT | 516.0 | 620.0 | 104.0 | 0.78 | 0.77 |
| | | EMG | 151.0 | 172.0 | 21.0 | 1.00 | |
| | | ICA | 37.5 | 62.5 | 25.0 | 0.48 | |
| | | INC | 88147 | 123630 | 35483 | 1.00 | |
| | | MIG | 70.0 | 18.0 | 52.0 | 1.00 | |
| 4 | Shettihadapnur | GWR | 76.2 | 61.0 | 15.2 | 0.18 | |
| | | BFA | 61.0 | 90.0 | 29.0 | 0.56 | |
| | | CIN | 119.0 | 128.0 | 9.0 | 0.28 | |
| | | CPT | 6.8 | 8.7 | 1.9 | 0.00 | |
| | | MPT | 365.0 | 483.0 | 118.0 | 1.00 | 0.54 |
| | | EMG | 165.0 | 184.0 | 19.0 | 0.67 | |
| | | ICA | 35.9 | 85.0 | 49.1 | 1.00 | |
| | | INC | 58828 | 87281 | 28453.0 | 0.75 | |
| | | MIG | 37.5 | 2.5 | 35.0 | 0.43 | |

total impact (the combined effect of the nine activities) of each of the watershed among different watersheds in the state or country and take up necessary mid-term correction measures. The time scale disparity index vividly captured the journey of the four watersheds from a state of conventional farming technology to sustainable rainfed farming. The feedback from evaluation may help the planners and policy-makers to take appropriate measures for popularization of best-bet practices and land uses prioritized based on bio-physical and socio-economic resources. This may pave the way for enhancing farm returns with needed support mechanism for upscaling promising land uses besides providing employment to the agricultural wage earners.

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**Annex. 1.**
**Impact of watershed interventions on area under cultivation of major crops (ha)**

| Sl.No. | Area under crops (ha)* | Watersheds | | | |
|---|---|---|---|---|---|
| | | Laxmipur | S. Venkatapur | Kakatiya | Shettihadapnur |
| 1 | Cotton | | | | |
| | Before | 170.0 | 111.0 | 36.0 | 74.0 |
| | After | 182.0 | 135.0 | 38.8 | 78.0 |
| | % change | 7.1 | 21.6 | 7.8 | 5.4 |
| 2 | Rice (*kharif*) | | | | |
| | Before | 48.0 | 67.0 | 30.8 | 17.6 |
| | After | 53.0 | 113.0 | 40.2 | 18.8 |
| | % change | 10.4 | 68.7 | 30.5 | 6.8 |
| 3 | Maize | | | | |
| | Before | - | 78.0 | 5.4 | 6.0 |
| | After | - | 95.0 | 3.6 | 3.6 |
| | % change | - | 21.8 | -33.3 | -40.0 |
| 4 | Redgram | | | | |
| | Before | - | 15.0 | 13.2 | 26.8 |
| | After | - | 15.0 | 13.2 | 25.6 |
| | % change | - | 0.0 | 0.0 | -4.5 |
| 5 | Soybean | | | | |
| | Before | - | - | - | 26.4 |
| | After | - | - | - | 44.8 |
| | % change | - | - | - | 69.7 |
| 6 | Rice (*rabi*) | | | | |
| | Before | 20.0 | 47.0 | 15.0 | 3.6 |
| | After | 32.0 | 60.0 | 28.8 | 4.8 |
| | % change | 60.0 | 27.7 | 92.0 | 33.3 |
| 7 | Vegetables (*rabi*) | | | | |
| | Before | 20.0 | 12.0 | - | - |
| | After | 24.0 | 21.0 | - | - |
| | % change | 20.0 | 75.0 | - | - |
| | Overall crops | | | | |
| | Before | 258.0 | 330.0 | 100.4 | 154.4 |
| | After | 291.0 | 439.0 | 124.6 | 175.6 |
| | % change | 12.8 | 33.0 | 24.1 | 13.7 |

*served as an input for calculating weighted average of overall crop productivity