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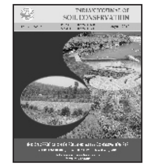

# Socio-economic impact of reclamation of Chambal ravines through anicuts and afforestation

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## ABSTRACT

Chambal ravines have challenged all efforts made so far to control and reclamation. Recently the Department of Forestry, Government of Madhya Pradesh, undertook a project to manage ravine land through construction of anicuts and afforestation, which not only reclaimed the ravine land but also saved farmers cultivated land downwards in two village *viz*. Bindwa and Himmatpur. The construction of anicuts and afforestation had a great impact on the economy of both these villages. The impact was assessed by collecting socio-economic data through pre-tested questionnaires and interviews. As a result of the project work, the net cultivated area increased 13% in Bindwa village and 6.5% in Himmatpur. There was rise in water-table in both villages and consequently the irrigated area and cropping intensity in these villages increased by 73% in Bindwa village and 45% in Himmatpur. Farmers started raising more remunerative crops including vegetables as well as fodder for milch animals and consequently their annual income increased more than 3 times. Also, there was a significantly higher employment generation and overall prosperity.

## 1. INTRODUCTION

Out of 328.0 Million ha (M ha) geographical area India, nearly 114.01 M ha was degraded and wastelands, 23.62 M ha water eroded including 2.06 M ha under ravine land (Maji *et al.*, 2010). Krishna Rao *et al.*, 2014 reported that stream bank erosion is a major cause of land degradation, leading to deteriorated drainage systems, which ultimately govern natural calamities in terms of floods, and nonpoint source pollution in ravine lands of India. Chambal ravines represent the most degraded form of once cultivated fertile land. The ravine land was severely eroded by run-off water and very poor in physicochemical properties. It was almost completely unsuitable for agricultural production (Singh *et al.*, 2014). This not only resulted in loss of non-renewable land and soil resource but also led to other processes destructive to national economy such as floods in rivers, siltation of water reservoirs and the consequent loss in their storage capacity, choking of estuaries and harbours, damage to railway lines, roads and other public properties. These ravines have encroached upon the inhabited villages which had to be shifted to new sites to avoid loss of lives. Besides these, an important socio-economic and unemployment problem created by these ravines in Madhya Pradesh, Uttar Pradesh and Rajasthan was shelter to dacoits and consequently making the area dacoit-infested. The problem had been extremely serious and did not miss the attention of the State and the National Government, and International Agencies such as World Bank, European Economic Communities (now European Union), and so on (Verma and Singh, 2009). Under Gwalior State rule (before Independence) huge masonry structures to serve as submersible check dams were constructed where big *nalas* met the main river Sank, a tributary of river Chambal. These were too wide apart to be helpful and also not designed properly. Further, these gave up due to lack of maintenance. In Mahi ravines bamboo based interventions in gullies lands and grass filters in crop lands has significantly reduce the runoff and soil loss (Krishna Rao *et al.*, 2015 and 2018). Government of Madhya Pradesh executed several ravine reclamation projects in Chambal Valley during 1955-79, with World Bank Aid in 1980 and under Anti Dacoity Programme during 1988-92. While these projects were of pioneering nature, the benefits derived from these were not commensurate with investments.

Recently (in 2007-08), Department of Forestry, Government of Madhya Pradesh undertook a project on management of Chambal ravines through construction of anicuts and afforestation. Scientists of RVSKVV, working on this problem, were keen to know about the strength and weaknesses of the programme executed by the Forest Department. Accordingly, an impact study was initiated in July 2014 and results are presented in this paper.

## 2. MATERIALS AND METHODS

### Location and Climate

The study was carried out in two villages: (i) Bindwa, block Joura, district Morena, and (ii) Himmatpur, block Ater, district Bhind of Madhya Pradesh (Fig. 1). The geographical locations of Bindwa and Himmatpur villages are 26°45'N latitude and 77°30'E longitude and 26°54'N latitude and 78°12'E longitude, respectively. The altitudes of these villages were 224 and 190 m above mean sea level (msl), respectively. Both villages fell under the agro climatic zone Gird which is a part of the vast Indo-Gangetic plains. The region has subtropical climate with three distinct seasons in the year, *viz.* hot and dry summer, cold and dry winter and the monsoon (rainy) season. The summer has maximum temperatures up to 49°C and the winter has minimum as low as 0°C on some days. The average humidity values in morning and evening ranged from 84 to 98% and 21 to 34%, respectively. The average annual rainfall of Tang Ghati Pilot Project, Bindwa village, Morena and Pilot Project, Himmatpur, Bhind are 700 mm and 758 mm, respectively. The range of annual rainfall and number of rainy days from 2007-08 to 2013-14 of Tang Ghati Pilot Project, Bindwa village, Morena were 379 to 1030 mm and 32 to 68 days, respectively, whereas the same for Pilot Project, Himmatpur, Bhind were 471 to 1238 mm and 33 to 65 days, respectively (Fig. 2).

### Soil

This region has alluvial soil with very high dispersion coefficient and fragile in nature. Surface (0-20 cm) soil samples were collected for determining soil properties. The soil samples were air dried and ground to pass through a 2 mm sieve. Analysis of soil samples for sand, silt and clay fractions were done by method of Gee and Bauder (1986). The texture of Bindwa village soil was loam, while that of Himmatpur soil sandy loam. Bindwa village soil contained 48.8% sand, 36.3% silt and 14.9% clay, while Himmatpur soil

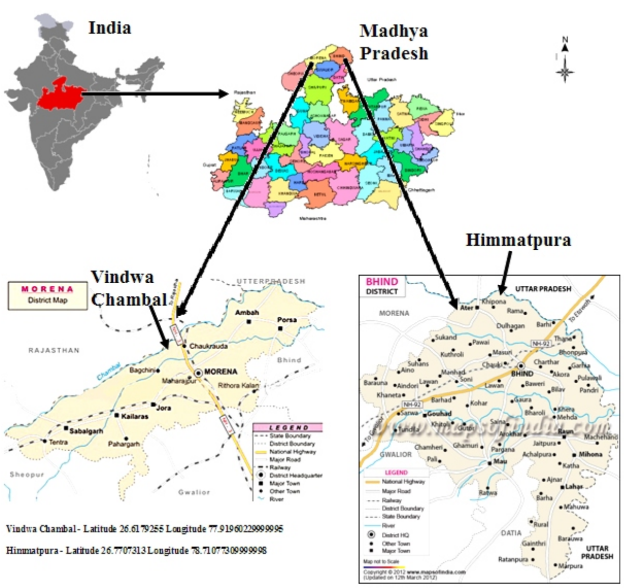


Fig. 1. Locations of the study sites

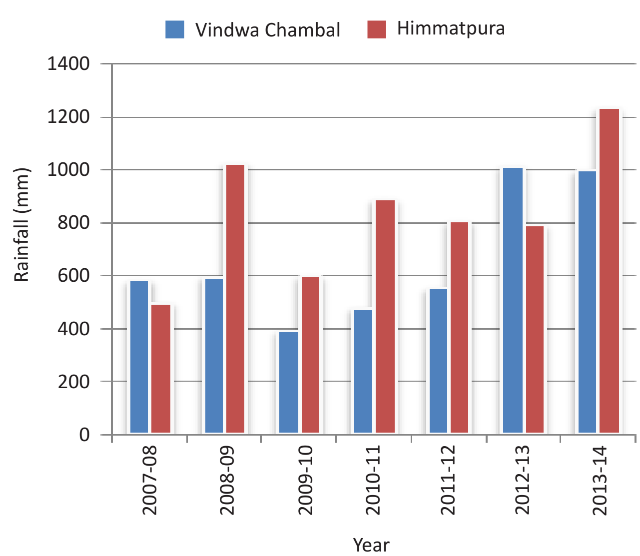


Fig. 2. Rainfall status (mm) of Bindwa and Himmatpur villages

had 55.2% sand, 33.6% silt and 11.2% clay. The soil was more or less neutral in reaction, had normal salt content and was slightly calcareous in nature (containing 1.6 to 2.2% $CaCO_3$) due to alleviation of silt and clay particles from upper layers. The soil had normal bulk density (1.52 to 1.58 Mg $m^{-3}$) but high permeability infiltration rate varying from 28.1 to 35.9 mm $hr^{-1}$ was measured using a double-ring infiltrometer. The soil is low in organic matter content - 0.34% on average (Walkley and Black, 1934). Due to severe erosion, the soil has been depleted of organic matter. With high dispersion coefficient, the soil is highly erodible. Uncontrolled run-off degrades the land into gullies, sub gullies and sub-sub gullies and ultimately into a net-work of gullies-ravines, which are getting deeper with time attaining depths up to 20-25 meters.

**Natural Vegetation**

The ravine land at selected sites has several types of natural grasses, herbs, shrubs, climbers and plants. The natural vegetation in patches consists of grasses such as doob (*Cynodon dactylon*), anjana (*Canchrus ciliaris*), sama (*Panicum sumatrense*), bhanjura (*Apluda mulica*), dab (*Chinensis cynosuroide*), *etc*., of shrubs like kareel (*Capparis decidus*), inni (*Clerodendrum pholomidis*), chabeni (*Grewia asiatica*), Heens (*Capparis sepiaria*) *etc*., of herbs such as Bhrangraj (*Eclipta prostrata*) Sankhpuspi *(Evolvulus alsinoides)*, *etc*., and of climbers *e.g*. Satabar (*Asparagus racemosus*) and Kakora (*Luffaechinata*). Most of these have disappeared leaving only some trees of Gugal (*Commiphora wightii*), Birbira (*Dichrostachys cinerea*), Chenkur (*Prosopis cineraria*), Gurjan (*Dipterocarpus turbinatus*), Remja (*Acacia lencophloea*), Semal (*Bombax ceiba*) Bilayati babool (*Prosopis juliflora*), *etc*. due to overgrazing by animals and exploitation by human beings who have no other means of living as they lost their once very productive land. The area gives a very deserted and fearful look.

**Works Executed**

Construction of anicuts and afforestation of the ravine land were the main activities undertaken for the management of ravines during January, 2007 to November, 2008. Afforestation of ravines in Bindwa village was taken up under "Tang Ghati (Narrow valley) Plantation Project", while that in village Himmatpur was undertaken as a "Pilot Project on Ravine Reclamation". The Tang Ghati Project area (20 ha) was revenue land and afforestation was done by seeding on 20 ha land. The Himmatpur Pilot Project area was 83.0 ha, belonging to forest department, but under scrub forest due to overexploitation by local people. Plantation through seeding was done on 72 ha in Pilot Project. The tree species planted by seeding in both locations were: Deshi babool (*Acacia nilotica*), Shisham (*Dalbergia sissoo*), Bilayati babool (*Prosopis juliflora*), Neem (*Azadirachta indica*), Hingote (*Balantea egyptiaca*), Kher (*Acacia catechu*) and Soobabool (*Leucaena leucocephala*) during the month of July, 2007.

**Anicuts**

Anicut is a Tamil language word, meaning 'river bund', *i.e.* a bund across the stream. Anicut is an earthen bund constructed against the land slope to store run-off against it. It is so constructed as to hold all the run-off and silt against it without any surplusing arrangement. Gully plugging construction of six waste weirs was done in the *Tang Ghaati* Plantation Project area. The anicuts were spaced suitably, and their dimensions (length, width and height) are kept big enough to stand against the run-off. Obviously, the size of anicuts depended on site situation, size of ravine, its catchment area and the expected run-off in a season.

Twenty-three anicuts were constructed in *Tang Ghaati* Pilot Project area covering 20 ha land in revenue department lands and privately owned lands. The average size of anicuts in this project was 30.03 m in length, 8.54 m in width at bottom, 3.15 m in width at top and a height of 2.51 m. The lengths of various anicuts varied from 6.5 to 80.0 m with an average value of 30.03 m. The width of anicuts at bottom varied from 3.0 to 13.5 m with an average of 8.54 m. The height of anicuts varied from 1.03 to 7.02 m with an average of 2.51 m. The volume of earth work undertaken varied from 40.86 to 1048.06 $m^3$. In addition to the anicuts, 6 waste weirs and 20 gully plugs were also constructed above the larger anicuts. The cost of construction of works/anicuts varied from ₹ 1,115 to ₹ 23,581/anicut. The total investment on all the 23 anicuts was ₹ 2,59,800, *i.e.* about ₹ 2.6 lakhs approximately at this site.

In Himmatpur Pilot Project area, 12 big anicuts were constructed in the forest department lands and privately owned lands. The size of each anicut was 14.5 m in length, 30.0 m in width at bottom, 6.0 m in width at top and a height of 5.5 m. The anicuts were big enough to hold all the run-off against them, and, therefore, no waste weir was provided on any anicuts at this site. However, many gully plugs were constructed above each anicut to retain some run-off against them. In all, 150 gully plugs were provided on all anicuts in the whole project area of 83 ha. Since these anicuts were big, ring trenches along the anicut band on upstream side were also dug to trap silt in run-off before the run-off could reach the anicut. The total length of ring trenches was 3000 m. The total cost of anicut construction and gully plugging at this site was ₹ 8.89 lakhs. The details of works done at the two sites are presented in Table 1.

**Impact Assessment**

Socio-economic data in terms of contribution, change in income, change in land use pattern, cropping patterns, cropping intensity, productivity, employment generation, income from different sources, annual income of villagers per family, *etc.* of erosion affected villages were collected through pre-tested questionnaires and interviews. The cost of cultivation for both the projects was calculated based on input costs of the projects (expenditure ₹ $ha^{-1}$). Also, outputs in terms of money at existing market price were collected for shrubs, herbs, climbers, trees, *etc*. Similarly data on food crops, dairy and horticultural crops were collected for the farmers' land below forest land in the adjoining villages, which was protected from erosion worked out by controlling. The economics was worked out by calculating the cost of inputs, human labor, tillage, seed, seeding, irrigation, fertilizer, pesticides, weeding, harvesting, *etc*. gross returns (GRs) were calculated by multiplying the yields of food crops, dairy and horticultural crops with minimum support price offered by the Government of India for various crops (Economic Survey of India, 2013), milk price of *Sanchi dugdha sangh* and existing market rates for vegetables and straw, *etc*. Net returns (NRs) were calculated as the difference between gross returns and total cost of cultivation (NR = GR − TCC). The benefit/cost ratio was computed by dividing the net return by the total cost of cultivation (TCC).

The absolute and relative changes were worked out of land use pattern, area of major crops, productivity and employment generation of the base year (July, 2007) and study period (July, 2014) for better compression analysis by formula:

Absolute change = $Yn - Yo$

Where, $Yn$ = All over average of current period, $Yo$ = All over average of beginning period.

$$\text{Relative change} = \frac{Yn - Yo}{Yo} \times 100$$

Where, $Yn$ = Current year, $Yo$ = Base year.

## 3. RESULTS AND DISCUSSION

**Changes in Land-use Pattern**

Construction of anicuts stabilized by tree plantation and rejuvenation of natural vegetation

**Table: 1**
**Details of project and activities taken on ravine land management through anicuts and afforestation**

| S.No. | Treatment/Units | Work sanctioned | |
|---|---|---|---|
| | | Location Bindwa, Morena | Location Himmatpur (Jamsara), Bhind |
| 1. | Name of project | Tang Ghati Pilot Project (Pariyojana) | Pilot Project on Ravine Reclamation |
| 2. | Implementing agency | Forest Department, Morena (MP) | Forest Department, Bhind (MP) |
| 3. | Budget allotted and spent (lakhs ₹) | 2.6875 | 8.89 |
| 4. | Period of activities implementation | January, 2007 to October 2008 | January, 2007 to November, 2008 |
| 5. | Chambal ravine area taken for activity (ha) | 20.0 revenue land | 83.0 forest land |
| 6. | Slope of sides of ravine bank (%) | 39% (2 to 95%) | 24% (2 to 75%) |
| 7. | Soil texture | Loam | Sandy loam |
| 8. | Earth works | | |
| 8.1 | Anicuts | 23 (size 30.03 m L x 8.54 m W at base; 2.51 H from base to top x 3.15 m W at top) | 12(size 14.5 m L x 30.0 m W at base; 5.5 m H from base to top x 6.0 m W at top) |
| 8.2 | Waste weir | 06 | - |
| 8.3 | Gully plugs (m) | 20 | 150 |
| 8.4 | Ring trench (m) | Nil | 3000 |
| 8.5 | Bunding of fields by farmers (m) | 12,000 | 21,000 |
| 9. | Afforestation through seeding (ha) in 2007-08 | 20.0 | 72.0 |
| 10. | Impact analysis time | July, 2014 | July, 2014 |

including grasses and trees held up almost all the run-off in Bindwa village Tangghati Project area, as breaches, if any, in the anicuts were taken care of immediately. The anicuts along with ring trenches completely stopped the run-off within Himmatpur Pilot Project area. As a result, free flow of run-off from Project areas to fields of farmers in the adjoining areas down-stream, which was eroding farmers' fields into ravines previously, was checked completely. The farmers were encouraged to smoothen their land and construct field-bunds to hold all the rain-water falling on their fields. The farmers constructed a total of 12000 m long field-bunds in Bindwa village area and 21000 m long field bunds in Himmatpur village area. This work brought about many good changes in cultivators' land as shown in Table 2.

The data presented in Table 2 shows that 26 farm families in Bindwa village and 55 in Himmatnagar village were benefitted by the project work. The ravine land reclaimed was 15 ha in Bindwa village and 18 ha in Himmatpur and consequently, the net cultivated areas increased. The rise in water table was 3 m in Bindwa village and 1.5 m in Himmatpur. The number of tube wells increased by 56% in Bindwa village, and 36% in Himmatpur. The result was that irrigated area increased by 72.2% in Bindwa and to 76.4% in Himmatpur village (Table 2). With increase in irrigated area, cropping intensity of Bindwa village increased by 72.7%, while that of Himmatpur village by 45.2%. Due to greater intensive farming, bullock power was replaced by tractors, the number of which doubled in just 2 years. The tractors were available for custom-hire service and therefore, the tractor power was available to other farmers also who did not own one. There was an increase in the number of large animals as well as small ones, indicating increased prosperity of farmers of both villages.

**Changes in cropping pattern**

Due to increase in irrigated area, not only cropped area increased but there was a change in cropping pattern too (Table 3). Long duration pigeonpea acreage was reduced in both villages. In Bindwa village, it was replaced by short duration varieties of pigeon pea, sesame, green gram, and cluster bean, whereas in Himmatpur by sesame and cluster bean. In both villages, area under pearl millet increased but increase was much more in Bindwa village. As regards *rabi* crops acreage, it increased considerably in case of wheat, chickpea and fodder crop berseem but moderately in case of mustard in Bindwa village. In Himmatpur village, acreage of wheat, mustard and fodder crop berseem increased while that of chickpea got reduced. The positive impact of irrigation on increased of higher water requiring crops. These findings were confirmed by Singh (2011).

**Change in Productivity of Major Crops**

As a result of the execution of works in project area, the degree and extent of soil erosion was reduced and soil fertility status was improved. The improvement in crop productivity was observed on the protected farmers' land below forest land in the adjoining villages. Consequently, the productivity of

**Table: 2**
**Change in land use pattern in villages of project area**

| Change in land use pattern | Pre-project status | | After project status | | Absolute change | | Relative change (%) | |
|---|---|---|---|---|---|---|---|---|
| | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur |
| Total geographical area (ha) | 176 | 305 | 176 | 305 | - | - | - | - |
| Ravine land | 34.8 | 46.0 | 19.8 | 28.0 | -15 | -18 | -43 | -39 |
| Agricultural land | 120 | 251 | 135 | 269 | +15 | +18 | +13 | +7 |
| Net cultivated area (ha) | 108 | 246 | 122 | 262 | +14 | +16 | +13 | +7 |
| Pasture land (ha) | 10 | 04 | 10 | 04 | - | - | - | - |
| Irrigated land (ha) | 64.8 | 106 | 111.6 | 187 | +47 | +81 | +72 | +76 |
| No of tube wells | 16 | 25 | 31 | 42 | +10 | +13 | +56 | +36 |
| Rainfed area (ha) | 43.2 | 145 | 11.4 | 101 | -32 | -44 | -74 | -30 |
| Total farmers family | 26 | 55 | 31 | 62 | +5 | +7 | +19 | +13 |
| Change in cropping intensity (%) | 110 | 115 | 190 | 167 | +80 | +52 | +73 | +45 |
| No of tractors | 1 | 2 | 2 | 4 | +1 | +2 | +100 | +100 |
| No of bullocks | 6 | 14 | 0 | 2 | -6 | -12 | -100 | -143 |
| Large animals | 101 | 175 | 133 | 225 | +31 | +50 | +32 | +29 |
| Small animals | 11 | 132 | 30 | 224 | +19 | +92 | +173 | +70 |
| Water table (m) | 42.4 | 53.1 | 38.3 | 50.6 | +4 | +3 | +10 | +5 |

all *kharif* and *rabi* crops was higher as shown by the data in Table 4. The increase in productivity of pigeon pea was the least, while that of seasame was the highest, followed by that of green gram. The increase in productivity of cluster bean and mustard were much higher in Himmantpur than Bindwa villages. But increase in productivity of wheat crop was much higher in Bindwa village as compared to that in Himmatpur village. Similar findings were also reported by Singh *et al.,* 2005 and Tomar *et al.,* 2015.

## Generation of Employment

The data on average employment of farmers' families in both villages are presented in Table 5. The increase in employment in crop production activities was 9.0% in Himmatpur village and 10.2% in Bindwa village, whereas the increase in employment in dairy sector was 46.5% in Himmatpur and 50.0% in Bindwa villages. Less increase in employment in crop production in comparison with dairy, vegetable production, *etc*. was due to increased level of mechani-zation in both the villages. Greater employment generation in vegetable production took place because the farming became more intensive, requiring more man days in operations such as sowing, harvesting and packaging, *etc.* as compared to pre-project previous years. Similarly, due to the increase in fodder production, including berseem (*Trifolium alexandrinum*), dairy development was faster. The dairy and other animals increased in number, which created more work and employment.

## Annual Income

Better crop yields and higher milk and vegetable production added significantly to the annual income of the households in both Bindwa and Himmatpur villages (Table 6). Overall, the annual income per household of Bindwa village increased from ₹ 30,777 to ₹ 1,27,326 and in Himmatpur villages from ₹ 41,646

**Table: 3**
**Change in area of major crops in villages after implementation of project**

| Major crops | Pre-project status (ha) | | Post-project status (ha) | | Absolute change | | Relative change (%) | |
|---|---|---|---|---|---|---|---|---|
| | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur |
| *kharif* crops | | | | | | | | |
| Pearlmillet | 21 | 81 | 90 | 125 | +69 | +44 | +329 | +54 |
| Long duration pigeonpea | 14 | 17 | 2 | 12 | -12 | -5 | -86 | -29 |
| Short duration pigeonpea | - | - | 7 | - | +7 | - | - | - |
| Sesame | 7 | 11 | 11 | 38 | +4 | +27 | +57 | +246 |
| Greengram | 2 | 12 | 3 | 10 | +1 | -2 | +50 | -17 |
| Clusterbean | 8 | 14 | 9 | 36 | +1 | +22 | +12 | +157 |
| *rabi* crops | | | | | | | | |
| Wheat | 20 | 42 | 51 | 87 | +31 | +45 | +155 | +107 |
| Mustard | 41 | 72 | 54 | 104 | +13 | +32 | +32 | +44 |
| Chickpea | 10 | 25 | 2 | 11 | -8 | -14 | +80 | -56 |
| Berseem | 2 | 19 | 4 | 15 | +2 | +6 | +100 | +67 |

**Table: 4**
**Change in productivity of major crops of villages after implementation of works of ravine land management**

| Major crops | Pre-project status (q $ha^{-1}$) | | Post project status (q $ha^{-1}$) | | Absolute change | | Relative change (%) | |
|---|---|---|---|---|---|---|---|---|
| | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur |
| *Kharif* crops | | | | | | | | |
| Pearlmillet | 13.4 | 14.0 | 24.3 | 23.8 | +10.9 | +9.8 | +81.3 | +69.6 |
| Long duration pigeonpea | 12.5 | 14.3 | 13.9 | 16.3 | +1.4 | +2.0 | +11.2 | +14.0 |
| Sesame | 2.5 | 2.7 | 3.5 | 3.9 | +1.0 | +1.3 | +42.3 | +47.2 |
| Greengram | 4.0 | 3.6 | 5.5 | 6.2 | +1.5 | +2.6 | +37.5 | +37.2 |
| Clusterbean | 15.5 | 12.8 | 17.0 | 16.7 | +1.5 | +3.9 | +9.7 | +30.5 |
| *Rabi* crops | | | | | | | | |
| Wheat | 36.6 | 38.4 | 46.4 | 40.1 | +9.8 | +1.8 | +26.7 | +4.51 |
| Mustard | 18.8 | 13.4 | 22.1 | 17.5 | +3.3 | +4.1 | +17.6 | +30.4 |
| Chickpea | 14.5 | 15.3 | 18.1 | 19.3 | +3.6 | +4.0 | +24.8 | +26.2 |
| Berseem | 349 | 408 | 455 | 512 | +106 | +104 | +30.4 | +25.5 |

**Table: 5**
**Average employment (days/household/year) per farmer's family**

| Particular | Pre-project status of employment | | Post-project status of employment | | Absolute change | | Relative change (%) | |
|---|---|---|---|---|---|---|---|---|
| | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur |
| Crop production | 440 | 610 | 485 | 665 | +45 | +55 | 10.2 | 9.0 |
| Dairy | 180 | 215 | 270 | 315 | +90 | +100 | 50.0 | 46.5 |
| Vegetables | - | - | 58* | 85** | +58 | +85 | - | - |
| Fuel wood[3] | 95 | - | 120 | - | +25 | - | 26.3 | - |
| Custom hire service[5] | 75 | 160 | 220 | 415 | +145 | +60 | 193.3 | 159.4 |
| Over all | 627 | 831 | 775 | 1014 | +148 | +183 | 23.6 | 22.0 |

**Only one farmer family engaged in cucurbits cultivation, **Five farmers families engaged in potato cultivation, [3]One family engaged in collection of wood and marketing, [4]Two families in Bindwa village and four families in Himmatpur engaged in custom hire service*

**Table: 6**
**Impact on annual income per house hold of villages (₹ $family^{-1}$)**

| Sources | Pre-project status | | After project status | | % change | |
|---|---|---|---|---|---|---|
| | Bindwa | Himmatpur | Bindwa | Himmatpur | Bindwa | Himmatpur |
| Crops | 18,550 | 24,000 | 65,500 | 85,400 | 253.1 | 255.8 |
| Vegetables | - | - | 9,500 | 1,16,000 | - | - |
| Dairy | 11,250 | 16,500 | 56,000 | 75,000 | 397.8 | 354.55 |
| Sale of fire wood | 3,400 | - | 20,000 | - | 488.2 | - |
| Custom hire service | 22,000 | 31,500 | 80,300 | 94,000 | 363.0 | 198.4 |
| Over all | 30,777 | 41,646 | 1,27,326 | 1,75,819 | 313.7 | 322.2 |

to ₹ 1,75,819 (an average increase in the order of more than 300%) in both the cases. High increase in annual income was due to introduction of more remunerative crops, like vegetables, more intensive farming and increased yield of crops and milk as a result of protection of land from water erosion.

## 4. CONCLUSIONS

Afforestation and construction of anicuts undertaken in forest land not only improved the productivity of forest land by reclamation of ravine land but also protected farmers' land below forest land in the adjoining villages by controlling the run-off. This resulted in increase in irrigated areas due to increase in water level. It also increased the cropping intensity, yield, annual income of farmers resulting in restraining the migration due to generation of employment. These models are highly successful for a specific situation.

It could be concluded that the level of household income and employment of ravine areas can be increased by better planning on watershed basis. The macro-watershed could be divided in to a number of micro-watersheds for suitable implementation. The huge anicuts could be replaced by smaller anicuts in each micro-watershed. Also construction of tanks at suitable sites (gully heads) should have been tried. Our experience is that afforestation/tree plantation alone does not check the advancement of deep gullies. Slight land-shaping in micro-watersheds appears to be the right approach. Construction of an anicut and tree plantations for stabilization of anicut to the extent of land shaping will be related to depth of ravines. This experience of anicut construction and afforestation needs to be extended and tested on farmers' fields in other macro-watersheds.

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