

Impact assessment of conservation measures in arid areas: a case study of Osian-Bigmi (Jodhpur) watershed

V. P. GUPTA

Professor, Department of Civil Engineering, M.B.M. Engineering College, J.N.V.U. Jodhpur 342 011, India

R. P. SHARMA

Assistant Engineer, State Soil Conservation Department, Jodhpur, India

R. K. GOYAL

Scientist, Central Arid Zone Research Institute, Jodhpur 342 003, India

Abstract

Impact evaluation of a watershed management programme is essential to know an overall assessment of the technical results of the different soil and water conservation measures adopted in any watershed area. It also helps in knowing the appropriateness of the method employed in carrying out the project activities and also to estimate the medium and long term social and economic benefits of the activities, efficiencies and impact of the project in the context of its stated objectives.

Keeping in view the importance of the post project evaluation a study was conducted to assess the impact of various soil and water conservation measures adopted in Osian-Bigmi watershed project. The paper presents a field study of impact evaluation of soil conservation measures in one of the watersheds of Jodhpur Regions. Osian-bigmi watershed is situated between 27° 37' N to 26°43' N latitude and 72°51'30" E to 72°56'E longitude in Jodhpur district at about 60 Km away from Jodhpur on Jodhpur Phalodi road. Watershed covers an area of 4667 ha and is bounded by low ridges of stony wastelands and sand dunes. The watershed area is characterised by arid climate with aridity index varying from 70 to 87 and increases from south east to northwest. Rainfall in watershed area is low(338 mm yr⁻¹) with high degree of variability in terms of distribution and quantum. Prior to start of watershed management project area were devoid of any kind of good vegetation. The area is predominantly covered by moderately deep to deep soil, underlying with loose lime concretionary horizon. The surface soil is coarse sand and loamy sand. As per land capability classification most of the area falls under land class IV and above leading to severe limitation of reduced choice of plants for conservation purposes. Soil erosion in different forms was another problem encountered in the watershed. Watershed area was treated as per land capability classification and various engineering and agronomical measures were adopted in watershed area.

Post project evaluation of the watershed area revealed that significant improvement in crop yield with an additional income of Rs., 2378 ha⁻¹ yr⁻¹. The rate of silt deposition was found to reduce by 3.68 m³ ha⁻¹ year⁻¹. The soil fertility have also changed in terms of increase in available Phosphorous, Potash and organic carbon. The ground water recharge in the watershed area and adjacent to watershed have reported of rising trend. Thus the benefit cost ratio was found to be more than 1.0 and showed that such a project is economically viable for arid region of Jodhpur district.

INTRODUCTION

Soil, water and plants are the world's greatest natural resources, gifted to the mankind. The kind of soil and water existing in an area and the skill with which they are managed

will determine whether people in that region have production and prosperity or destruction and adversity. Integrated watershed planning and management is an effective approach for the optimum utilization of available land and water resources for sustainable production. Impact evaluation of watershed management programme is also very essential to know the impact of various measures for their effectiveness. It also helps in knowing the appropriateness and efficiencies of the methods employed in carrying out the project activities in the context of its stated objectives. Keeping in view the importance of post project evaluation present study was undertaken at Osian-Bigmi watershed area.

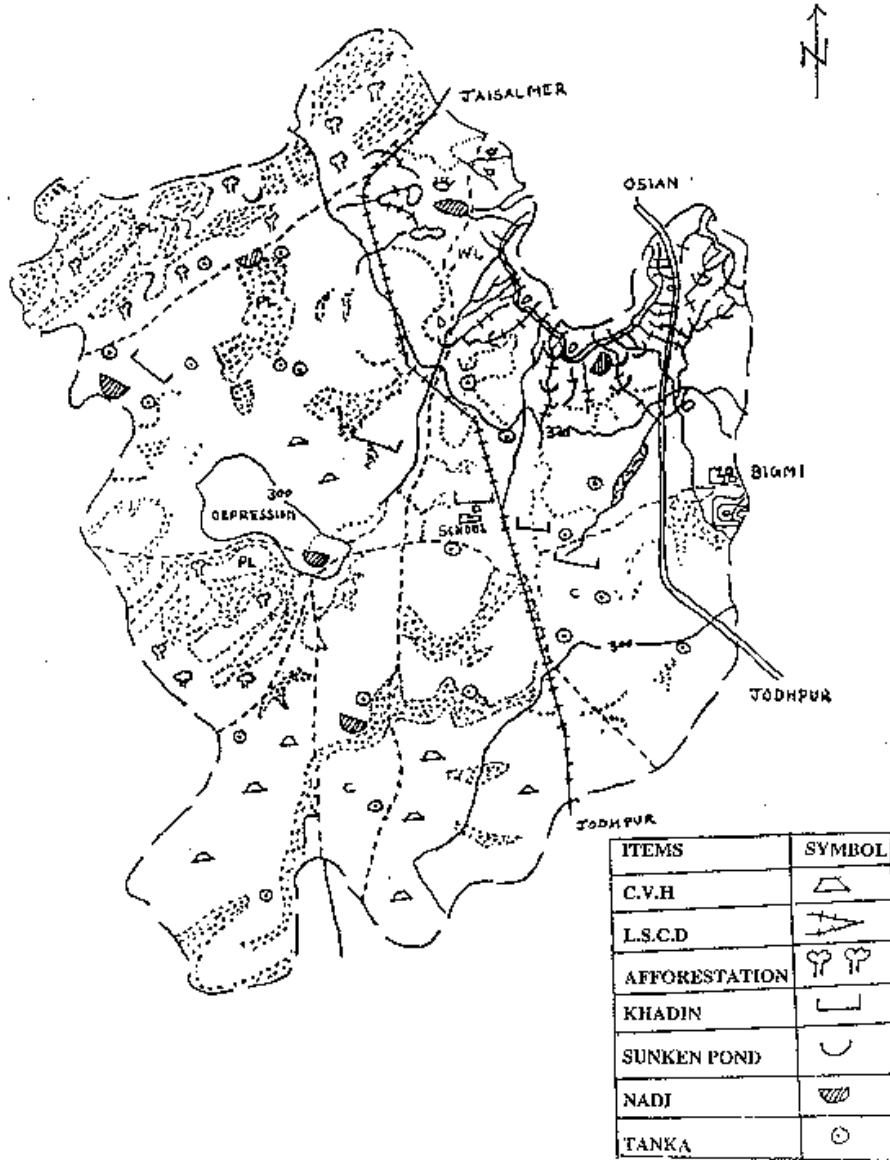


Figure 1. Location of conservation measures and other structures.
Objectives

To evaluate the overall impact of watershed treatment in relation to land resources development, sedimentation ground water recharge and conservation of soil and water

To study the variation of soil and water before and after the project implementation.

To study socio-economic benefits derived by the farmers and land use pattern affected by development and management technologies.

MATERIALS AND METHODS

General Description of Watershed area and its problems

Study was conducted at Osian-Bigmi watershed area situated between 26° 37' N to 26°43'N latitudes and 72°51'30"E to 72°56'E longitudes in Jodhpur district (Raj.) at about 60 km away from Jodhpur on Jodhpur-Phalodi road. It covers an area of 4667 ha and is bounded by low ridges of stony wasteland and sand dunes. The area is characterised by arid climate with average annual rainfall of 338 mm. The maximum and minimum temperature of the area are 42°C and 9.5°C. The watershed area comprises of sandy undulating over alluvial and hummocky plains; low sand dunes and inter hummocky plains; hills, rocky eroded pediments and pasture lands. The general slope of the area is from north-east to south-west direction. The slope of the area varies from 1 to 8 percent, while that on non-arable land including pasture and sand dunes is more than 4 percent. Hills are of 60 to 80 m height above ground level. Severe to very severe soil, erosion in form of sheet, rill and gully are the major limitation of the area.

Conservation measures adopted in watershed area

Looking to the physiography, geology and other watershed characteristics and plan of the area various soil and water conservation measures were planned & implemented. Out of the total geographical area of 4775 ha of watershed, most of the soil and water conservation works were completed in 4474 ha up to 1995-96 (Figure 1). The major soil conservation measures includes :

Contour vegetative hedge (CVH): This practice consists establishing a vegetative barrier of local plants on contours at suitable interval. Once established, such live bunds need almost no maintenance and continue to protect the land from erosion. These vegetative barriers also serve the purpose of guide lines for contour cultivation. When runoff water reaches the vegetative barriers it slows down, spread evenly, drops its silt load, and slowly passes through the hedge row. For better establishment in the initial stages a small cross sectional "V" ditch is also constructed along with plantation of vegetation. The design criteria includes horizontal spacing of rows which depends on slope. In general CVH is laid at an approximately horizontal interval of 40m (Figure 2 a).

Loose stone check dams (LSCD): This is a very common and adaptable practice in the local area. It consists of a terrace with stone wall barriers or check dams across the slope in the valleys or nallas. Generally waste weirs are not provided on LSCD's as during initial stage extra runoff could safely pass through structure at non erosive velocity and while after treatment of upper reaches the runoff concentration is reduced (Figure 2 b).

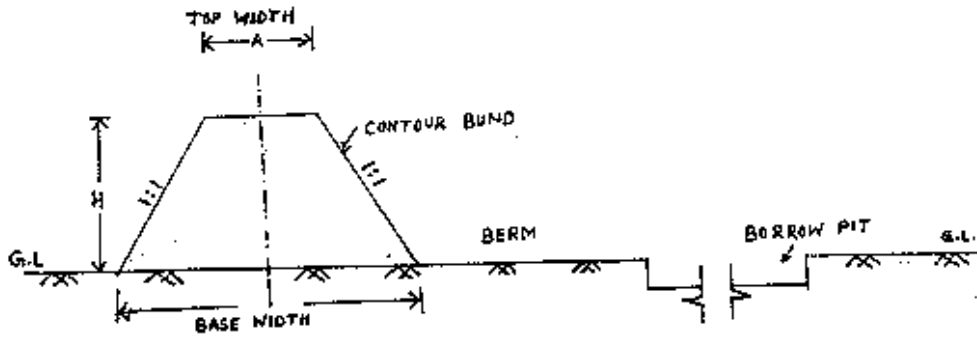


Figure 2a. Cross section of contour bund (C.V.H.).

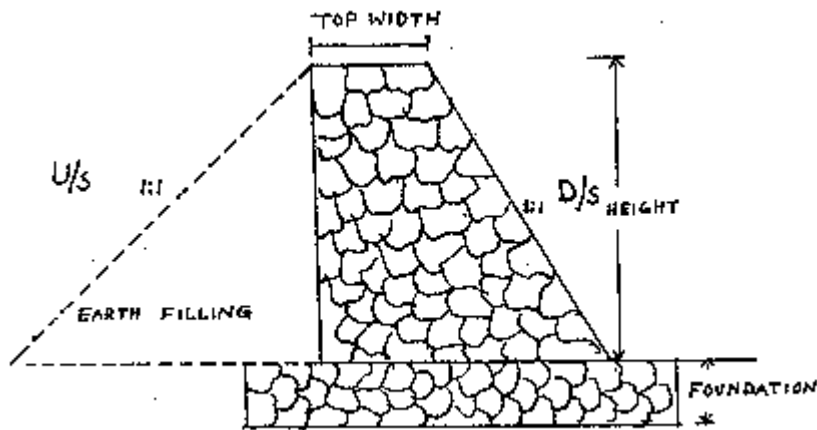


Figure 2b. Loose stone check dam (L.S.C.D.).

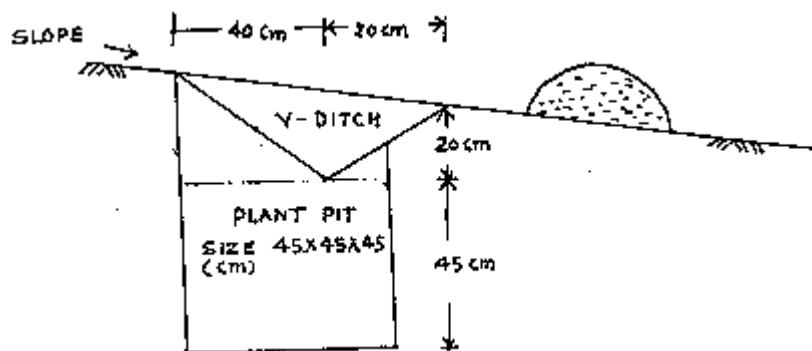


Figure 2c. Contour 'V' ditch.

Contour furrows and contour trenches: These structures were used for in-situ conservation of moisture. The cross section of contour furrow and trenches were kept 0.5 x 0.4 x 0.2 m and 0.3 x 0.3 m respectively. These were constructed at horizontal spacing of 10m on contours. About 150 trees per ha were planted after digging 0.45 x 0.45 x 0.45 m pits. Over seeding of grasses was also done particularly in between the contour furrow/trenches.

Afforestation : It is an intensive land use system which provides maximum sustained income from class VI and VII lands. Contour “V” ditches were constructed for planting under afforestation programme. These were constructed at a horizontal distance of 8-10 m. The ditch is dug in U/s side and excavated earth heaped on D/s so as to form a bund of about 25 cm. The pits of 45 x 45 x 45 cm were dug at a distance of 3 m and the berm is provided between the ditch and the bund (Figure 2 c).

Khadin: This practice consists of constructing a earthen bund across natural drainage line on lower side of a farm land or a natural depression or valley having potential to develop into farm land by sediment deposition to facilitate the collection and spreading of runoff water received from a catchment on the farm land for crop production particularly in winter season. The farm land along the bund on the upstream which is benefited by runoff spreading is called *Khadin* in local parlance.

Kana Bunding: This measure is adopted in the area facing the wind erosion problem. It is practised in light soil with rainfall less than 350 mm. Locally available dry vegetation like *Crotalaria burhia* are put in 3 tiers at about 25-30 m apart in rows across the wind direction. Soil is dumped on each of the layers separately. The dry vegetation get decomposed after rain and provides organic matters to the crop and at the same time provides the protection against wind erosion. This practice is locally known as *Kana bunding*.

The other conservation measures adopted in watershed area includes pasture development in degraded wastelands, Sunken ponds, repair of existing conservation works, farm ponds etc. Most of the area (about 77%) in the watershed is under dry land agriculture. The details of the soil and water conservation works done in the watershed area are given in Table 1. Total expenditure incurred in the development of the watershed is Rs.61.22 lakhs out of which 3.68 lakhs were spent on basic activities, 36.41 lakhs on arable land, 14.59 lakhs on non arable land, 5.66 lakhs on drainage line and 0.88 lakhs on live stock management.

RESULT AND DISCUSSION

Evaluation of various treatments adopted in watershed area were done through (a) a set of questionnaire (b) personal interviews of the resident farmers, (c) in depth survey of different measures and (d) direct quantification of different parameters in the field and laboratory.

Change in land use pattern

Post project evaluation of watershed area shows significant change in land use pattern. The net cultivated increased from 3581 ha to 3696 which were earlier lying as waste-land. An additional area of 260 ha and 311 ha were brought under afforestation and silvi-pasture respectively which were earlier community and private wastelands. The irrigated area increased from 25 ha to 148 ha (800%) due to additional irrigation facilities developed in the area.

Table 1. Physical Targets & Achievements of Soil Conservation works in Osian-Bigmi Watershed (1991-96)

S.No.	Activities	Target	Achievement	Expenditure Rs. Lakhs
A.	Basic Activities			
	Survey, Nursery Training, Building etc.	-	-	3.68
B.	Arable Land			
	1. Contour vegetative hedges	1588 ha	1533 ha	11.19
	2. Repair of existing conservation works	13 ha	13 ha	3.87
	3. Kana Bunding	1968 ha	1943 ha	11.10
	4. Khadins	50 ha	50 ha	4.07
	5. Incentive for opening contour dead furrow	110 no.	109 no.	0.05
	6. Demonstrations of crops	1200 no.	450 no.	1.52
	7. Agro-forestry (trees)	22000 no.	43000 no.	1.17
	8. Horticulture	4000 no.	12363 no.	0.86
	9. Farm pond/Tanka	16 no.	21 no.	2.11
	10. Caster seed demonstration	100000 no.	170000 no.	0.47
C.	Non Arable land			
	1. Fencing	12000 Rm	58000 Rm	0.93
	2. Micro-wind Break	200 ha	207 ha	1.40
	3. C.V.H. with trench	400 ha	253 ha	0.91
	4. Over seeding	-	260 ha	0.58
	5. Plantation of trees	70000 no.	115400 no.	10.41
	6. Plantation of shrubs	4000 no.	8000 no.	0.36
D.	Drainage line treatment			
	1. L.S.C.D.	250 No.	297 No.	2.93
	2. Sunken Ponds	9 No.	13 No.	2.73
E.	Live Stock Management			
	1. Population Control	-	-	0.33
	2. Fodder Production	-	-	0.41
	3. Gopal Activities	-	-	0.14
Total Rs.		61.22 Lakhs		

Cropped area and cropping intensity

With the adoption of various conservation measures the cropping intensity has been reported as a rise from 64.9% to 96.3%. Due to increased irrigation potential of the area dramatic rise in the cropped area of mustard and wheat took place (383% and 1380%) whereas considerable change in cropped area of chillies and fodder (100% and 150%) have been noticed.

Productivity status

Due to effect of soil conservation measures, CVH & Kana Bunding & particularly use of improved seeds, fertilizers, the crop yield has been almost doubled as compared to the base year (1991). The productivity increased by a minimum of 40% in guar and maximum of 129% in the pearl millet. Mustard, Moth, Til, Moong and wheat registered an increase of 116, 83, 77, 66 and 66 percent respectively. This is on account of controlled wind erosion by Kana bunding.

Effect of loose stone check-dams (LSCD)

About 260 ha area of watershed was treated with 297 LSCD in non-arable land. A representative area of 20 ha was selected for estimating the silt deposited volume. Actual dimensions viz. length, width and height at the upstream side of the check dams were measured which shows a total volume of 368.84 m³ silt has been deposited in 5 years. This indicate that 958.98 m³ yr⁻¹ silt was deposited in total treated area of the watershed at the rate of 3.68 m³ ha⁻¹hr⁻¹.

Changes in soil fertility

Analysis of soil sample collected from the different locations in watershed area shows reduction of soil pH value (8.5 to 7.5) to tolerable limits over a period of five years. This development serves as an index of increased productive potential of the soil. The increased vegetative cover on the soil led to the neutralization of alkaline effects of bicarbonates of the sodium in the soil. Electrical conductivity of all samples witnessed the decreasing trend (2.4 to 0.8). The increased amount of biomass in the soil rhizosphere caused washing down of the soluble salts from the surface soil. The content of organic carbon which is directly correlated to the Nitrogen contents of the soil increased 24 to 80% while available phosphorus (P₂O₅) has reported a rise from 36% to 85%.

Improvement in Pasture

The samples of dry forage production from quitrents of 1 m² were taken. After the implementation of the project the average grass production in the watershed area was found to be 1.97 tonnes ha⁻¹ from the land which was completely denuded before the implementation.

Performance of tree species under afforestation and silvipasture programme

These programmes were undertaken in the watershed area to meet the fuel and fodder requirement of the area and to maintain ecological balance. The different tree species planted during 1992-93 were *Acacia tortillis*, *Prosopis cineraria*, *Acacia senegal*, *Azdirachta indica*, *Dalbergia sisoo* and *Prosopis juliflora*. These tree species has reported a continuous increase in survival rate (49% to 71%) over different year (1991-1996).

Effect of soil and water conservation measure on ground water recharge

Recharge study was conducted through measurement of water levels in four well located inside the watershed area. Water level fluctuation in the pre monsoon and post monsoon were studied from the year 1991-96 and required data were collected by using water level indicator, in the month of April (for premonsoon) and October (for post monsoon).

Analysis of data over a period of 5 years shows a considerable rise in water table (upto to 1.10 m) of all wells from the base year indicating the effectivity of conservation measures for the recharge of ground water.

Employment generation

The project has provided tremendous employment opportunity to the local people. Due to the commencement of the project the percentage of farmers engaged in agriculture has increased from 44 to 52 per cent. Agriculture plus dairy has shown an increase from 8 to 16 per cent due to increased and secured fodder production from non arable lands.

Benefit cost analysis

The overall benefit cost ratio to evaluate the effectiveness of watershed management programme considering agriculture and dairy sector were found to be 1.419 (Table-2) which shows the economic feasibility of the project.

Table 2. Net returns and change in net returns due to crop and milk production before and after the project.

Enterprises	Net Returns (Rs. in Lakhs)		Change in net return (Rs. in lakhs)
	Before project	After project	
Crop Production	33.487	93.851	60.364
Milk Production	79.751	106.300	26.549
Benefit Cost Ratio =	<u>Net return from Watershed Area</u> Total Project Cost		
=	<u>Rs.86.913 Lakh</u>		
=	<u>Rs.61.22 Lakh</u>		
=	1.419		

CONCLUSIONS

The impact evaluation of soil conservation measures in the Osian-Bigmi Watershed revealed that there is a significant improvement in the overall productivity of the area. The benefit cost ratio being more than one showed that the project is economically viable for the arid region of Jodhpur district. This can be replicated for other part of the arid zone of India or elsewhere with similar climatic conditions.