



# Impact Assessment of Soil and Water Conservation Measures at Gharat Watershed in Pindwara, Sirohi, India

J. M. Garhwal <sup>a\*</sup>, Akash Chouhan <sup>a</sup>, P. K. Singh <sup>a</sup>  
and S. R. Bhakar <sup>a</sup>

<sup>a</sup> Department of Soil and Water Engineering, College of Technology and Engineering, MPUAT, Udaipur – 313001, India.

## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/JEAI/2023/v45i102213

## **Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/107007>

**Original Research Article**

**Received: 18/07/2023**

**Accepted: 23/09/2023**

**Published: 27/09/2023**

## **ABSTRACT**

The study was carried out 2020-2021 at the Gharat watershed is located in Pindwara district. To evaluate the impact of various biological and physical soil and water conservation (SWC) measures, implemented in the Gharat watershed during 2011-12 in combating minimal land resource use, land degradation caused by soil erosion, and lack of implementation of agriculture technology. Therefore, evaluation is required to determine the success or failure of conservation measures and to alter future planning appropriately. Due to the implementation of the watershed program, arable area increased by 16.56 percent, irrigated area by 53 percent, and additional farm income increased by approximately 17 lakhs, according to data collected through field observation, survey, semi-structured interviews, and field measurements. SWC measures applied in this watershed, cropping intensity and irrigated area increased from 122.12 percent to 137.08 percent, 51ha to 78ha respectively. The understanding and adaption of soil and water conservation

\*Corresponding author: E-mail: [jhabarchoudharyctae@gmail.com](mailto:jhabarchoudharyctae@gmail.com);

strategies has a favorable influence on the overall development of the watershed. Existing SWC measures should be improved for continuing monitoring and extended as part of an integrated strategy to restore damaged regions to their full potential. It provides project planners and managers, programme leaders, and policymakers with details about actual project accomplishments in the format they need.

*Keywords: Impact assessment; soil and water conservation; Gharat watershed and soil fertility.*

## 1. INTRODUCTION

Land degradation is one of the most pressing global environmental issues, threatening global food security and reducing agricultural output. "Land degradation" has a wide range of implications, but it essentially refers to conditions in which the biological productivity of the land is reduced [1]

Rajasthan is the country's largest state by area, and it is located in the country's northwestern corner. It has a geographical size of 34.22 million hectares, accounting for 10.41% of the country's total area. The state's population is 68.62 million people, or 5.67 percent of India's total population. Rajasthan is second in the country in terms of livestock population, with 56.66 million animals. The most important land use is net sown area, which accounts for almost half of the state's entire geographical area (170.38 million hectare). It is critical in deciding agricultural prosperity in a long-term manner.

Wind erosion (44.2 percent) is the most significant cause to desertification or land degradation in Rajasthan, followed by water (112 percent), vegetal degradation (6.25 percent), and salinization (1.07 percent). As a result, the problem of soil degradation poses a major danger to long-term agricultural productivity. Massive unemployment, labour migration, regional and intergenerational inequality, loss of natural resource base, and ecological imbalance are all consequences of the deterioration [2].

Land degradation results in lower agricultural output indicated, economic loss and increasing societal stress [3]. Low soil moisture due to unpredictably and irregularly distributed rainfall, significant soil loss due to run-off and the associated low soil fertility are the main drivers of land degradation and low agricultural output. Furthermore, as the world's population rises, subsistence agriculture has spread to remote areas, producing land degradation and jeopardizing the environment's and agricultural production's long-term viability. The value of

grain lost due to soil erosion was estimated to be over 10 million Ethiopian Birr (1 USD 2 ETB at the time). Land degradation, in the form of soil erosion and poor soil quality, represents a serious danger to agricultural productivity and overall economic growth in the country. Soil and water conservation (SWC) strategies have been introduced to address these issues, reducing both the concerns of increased erosion and poor production [4-7]. Physical SWC measures have short- and long-term effects, depending on how long it takes for them to become effective against soil erosion. The reduction in slope length and the construction of retention basins for run-off and sediment are the short-term benefits of stone bunds. Overland flow quantity and erodibility are reduced as a result. Such impacts arise very quickly once the stone bunds are built. The formation of bench terraces, the growth of plant cover on the bunds and gullies, and changes in land management are all medium and long-term consequences.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out 2020-2021 at the Gharat watershed is located in Pindwara district. The project area is situated at latitudes of 24°43' 34 N" to 24° 47' 45N" and 73° 01' 57E" to 73° 08' 30E" longitudes. It is 15 kilometers from its block headquarters and 50 kilometers from its district headquarters. Gharat village is a micro watershed of these 11 villages with a total area of 962 ha that has been completely managed with soil and water conservation methods such as check dams, contour vegetative hedges, V-ditches, percolation tanks. The research area's climate is characterized as subtropical humid. The yearly rainfall averages 861.3mm. Rainfall is inconsistent, irregular, and fluctuates year to year. The months of June to October receive around 94 percent of total rainfall, whereas the remaining months of the year receive just 6% of total rainfall.

Maximum temperatures of 48°C to 31°C are usually observed in May and June, while low

temperatures of 23°C to 5°C are usually recorded in December and January. Temperatures range from 30°C to 35°C during the rainy season, with high relative humidity of 75–90%. In the research region, Kharif is the most significant growing season. During Kharif, the main crops include local grains and pulses, as well as oilseeds. Bajara, maize, and a variety of coarse grains are among the major cereals cultivated during the Kharif season. Crop production during Rabi is primarily restricted to areas with well-developed irrigation systems. The most significant Rabi cereal crop is wheat. The other produce in the Rabi season features Wheat, Gram, Mustard rapeseed and cotton.

## 2.2 Data Acquisition

The collection of primary and secondary data was required for the integrated effect evaluation of SWC measures in the watershed. Farmers' primary data, as well as field measurements and observations, were collected (transect walks, semi-structured questionnaire interviews, group discussions). During data collection, the methodologies mentioned in Table 1, such as before and after soil and water conservation measures, and comparisons of environmental effect indicators, were employed. Secondary data, such as climate, demographics, and other related information, was provided by the Department of Agriculture for this study.

The transect walk method was used to assess natural resources and present SWC measures in the watershed. Throughout the transect walk,

observations and evaluations of vegetation and density, the impact of current SWC measures, and levels of SWC measures at various points in the landscape were all recorded. Farmers were questioned informally utilizing semi-structured interviews, group discussions, and a variety of participatory rural appraisal (PRA) methods. Secondary data collected from Department of Agriculture supplement the focus group discussions.

A total of 25 household heads were interviewed in semi-structured interviews. Observations and informal participative talks with persons and groups representing men and women from varied socioeconomic backgrounds resulted in the formation of focus groups. During the holidays, these groups came together as a team for three days of discussions. The winners of each wealth category were picked at random. There was no significant difference in economic status or gender in this research.

## 2.3 Assessment of Soil Fertility

The present study deals with the analysis of soil samples which were collected in a period 2019-2021 from Gharat watershed. The soil samples were collected by standard procedure in polythene bags. The soil samples were collected at surface level (0-10 cm in depth) from the field. Air-dried soil samples were ground and sieved. Each sample was separated into two portions before sifting; one was sieved through a 2 mm sieve, while the other was sieved through muslin

**Table 1. Ideal and operational performance indicators for implementation of SWC measure at the Gharat watershed**

<b>Performance Criterion</b>	<b>Ideal indicator</b>	<b>Operational indicator used in the study</b>
<b>Status of soil erosion</b>	Measurement of erosion and associated yield loss Presence, expansion and development of new active erosion features by slope, soil and land use types	Impact on soil fertility and soil moisture through vegetative cover and yield indicators. Qualitative comparison of treated and untreated watershed with respect to soil fertility.
<b>Water recharge</b>	Surface water storage amount Ground water levels before and after SWC measures	Approximate change in the number of wells Change in irrigated area Change in village water supply
<b>Soil moisture retention</b>	Time series, intra and inter year Variations in soil moisture using measuring instruments	Change in cropping pattern Change in cropping intensity Relative change in yield and productivity
<b>Productivity of non-arable lands</b>	Change in production of plantation lands	Relative change in the farm land area Change in arable lands

fabric. Soil samples were suspended in distilled water (1:4 w/v) and allowed to settle down before being analyzed for physicochemical characteristics. A glass electrode pH meter (Equiptronics, India) was used to determine the pH of the suspension [8]. The electrical conductivity of the soil was evaluated using a conductivity meter and a saturation extract. The percentage of organic carbon (OC) in the sample was evaluated using the Walkley and Black technique and a diphenylamine indicator. Subbaiah and Asija described an alkaline permanganate technique for estimating available nitrogen [9]. The volumetric approach was used to determine the available phosphorus and potassium in the soil [10-13]. Titration with a standard KMnO<sub>4</sub> solution can be used to evaluate available calcium. The amounts of heavy metals (Cu, Fe, and Zn) were measured using an Atomic Absorption GBC Avanta version 1.31 Spectrophotometer and flame atomization [8].

### 3. RESULTS AND DISCUSSIONS

The results have been presented and discussed in the ensuing sections.

#### 3.1 Status of Farm Families

The total number of farm families is 490 and average size of family was (5-6) members. The literacy rate in the study area was 36.18%. The distribution of land holdings is shown in Table 2.

#### 3.2 Status of Land Use Pattern

Following the project's assessment, the watershed's arable and silvi-pasture land had

changed radically. The watershed's arable land, which was 372 ha in the base year out of 962 ha total land, has been increased to 433.66 ha. The Silvi-Pasture land, which was 175.47 hectares in the base year, has been increased to 288.65 hectares, with an additional 27 hectares irrigated [14-17]. Table 3 depicts the changes in land use trends in detail.

#### 3.3 Cropped Area and Cropping Intensity

In both the Kharif and Rabi crop seasons, a large area has been brought under cultivation due to the implementation of soil and water conservation initiatives, improved irrigation facilities, and the use of improved methods. Cropping intensity rose from 122.12 % in the base year to 137.08 % in the research year. The area planted in maize, wheat, jowar, gram, and mustard has increased. There has been a major improvement in wheat cropped area in Rabi season and maize cropped area in Kharif season due to increased irrigation facilities. Some crops were also introduced in the summer due to the availability of irrigation water in open wells and soil moisture (Table 4).

#### 3.4 Productivity Status

Crop yields have increased as a result of soil and water conservation measures, the use of improved seeds, and fertilizers. In the maize crop, productivity increased by a maximum of 55.40 percent and a minimum of 12.96 percent [18-21]. Wheat, mustard, and gram productivity all increased by 21.62, 31.33, and 19.07 percent (Table 5).

**Table 2. Status of farm families in study area**

Size Group	No. of Farmers	Percentage
Landless	26	5.30%
Marginal Holding (0-1) ha	387	78.97%
Small Holding (1-2) ha	42	8.57%
Medium Holding (2-3) ha	31	6.32%
Large Holding (>4) ha	4	0.84%

**Table 3. Change in land use pattern before and after the project implementation**

S.No.	Particulars	Before the Project (ha)	After the project (ha)	% change in Area
1.	Arable land	372	433.6	+16.56%
2.	Irrigated area	51	78	+53%
3.	Non arable land	496	407.34	-17.87%
	Private waste land	55.53	23.69	-57.34%
	Govt. waste land	265	135	-49.05%
	Silvi-pasture	175.47	258.65	+47.40%
4.	Others	43	43	-
<b>Total</b>		<b>962</b>	<b>962</b>	<b>-</b>



Fig. 1. Small-scale irrigation facilities in the watershed

Table 4. Area under different crop and cropping intensity before and after the project implementation

S.No.	Crops	Before the project (ha)	After the project (ha)	% change in Area
1.	<b>Kharif crop</b>			
	Maize	213	262	+23%
	Jowar	142	168	+18.31%
	Paddy	5	5.5	+10%
	Black gram	9	16	+77.77%
2.	<b>Rabi crop</b>			
	Wheat	55.8	75	+34.41%
	Gram	20.5	42.5	+107.32%
	Mustard	4.5	15	+233.33%
	Jow	1.5	6.5	+330%
3.	<b>Summer crop</b>			
	Vegetables	1.5	4	+166.66%
	Green gram	3	9	+200%
<b>Total</b>		<b>454.3</b>	<b>594.5</b>	-
<b>Cropping Intensity</b>		<b>122.12%</b>	<b>137.08%</b>	-

Table 5. Productivity status of different crops

S.No.	Crops	Yield before the project (ha)	Yield after the project (ha)	% change in Yield
1.	<b>Kharif crop</b>			
	Maize	7.40	11.5	+55.40%
	Jowar	3.50	4.32	+23.42%
	Paddy	8.25	9.32	+12.96%
	Black gram	3.30	4.82	+46.60%
2.	<b>Rabi crop</b>			
	Wheat	18.50	22.50	+21.62%
	Gram	8.23	9.80	+19.07%
	Mustard	4.82	6.33	+31.33%
	Jow	14.50	20.20	+39.31%
3.	<b>Summer crop</b>			
	Vegetables	13	17.5	+34.61%
	Green gram	6.5	7.8	+20%

### 3.5 Maximization of Farm Income

The total additional income was as Rs. 1704250 which is the average additional income in the watershed area. Average additional income per hectare in the area was Rs. 4581 which highlights the direct benefits of soil and water conservation works [20-23]. The maximum return was reported from maize followed by mustard and gram (Table 6).

### 3.6 Irrigation Potentiality

During the study period, the number of open wells in the watershed raised from 47 to 58. Furthermore, these wells, which had a low volume of water prior to the project, now have a sufficient volume of water due to recharging and deepening, and are now used for irrigation. The supply of water in the wells was about 6-7 months at the start of the project, but after it was implemented, water was available for the whole

year. After the project, the irrigated area, which was previously 51 ha, has increased to 78 ha. As a result, the improvement in groundwater recharge has brought farmers prosperity [24,25].

### 3.7 Status of Soil Fertility

The organic carbon content was a measure of available nitrogen in the soil. The organic carbon in treated area (7.45) was high as compared to untreated area (5.99) indicating accumulation of high organic matter clearly indicating impact of soil and water conservation measures. The electrical conductivity which indicates measures of soluble salts was high in treated area (0.52) as compared to untreated area (0.11). The average pH value of both treated (7.38) and untreated area (7.80) were in neutral conditions [26]. Others parameters such as organic carbon, available Nitrogen, Phosphorus, Potassium, Zinc, Manganese, Copper and Iron are shown in (Table 7).

**Table 6. Increase in the agriculture income after implementation of project in Gharat watershed**

S.No.	Crop	Yield increased (q/ha)	Maximized farm total land income
1.	<b>Kharif crop</b>		
	Maize	4.1	371665
	Jowar	0.82	56285
	Paddy	1.07	6000
2.	<b>Rabi crop</b>		
	Black gram	1.52	163840
	Wheat	4	151680
	Gram	1.57	276154
3.	<b>Summer crop</b>		
	Mustard	1.51	273725
	Jow	5.7	45600
	Vegetables	4.5	112500
	Green gram	1.3	246800
<b>Total</b>			<b>1704250</b>

**Table 7. Soil fertility in treated and untreated area**

S.No.	Parameters	Treated watershed	Untreated watershed
1.	pH	7.38	7.80
2.	EC (dS/m)	0.52	0.11
3.	Organic Carbon (g/kg)	7.45	5.99
4.	CaCO <sub>3</sub> (g/kg)	67.33	58.66
5.	Available N (kg/ha)	224.88	188.57
6.	Available P (kg/ha)	24.6	18.8
7.	Available K (kg/ha)	247	233
8.	Available Fe (ppm)	4.794	3.227
9.	Available Cu (ppm)	1.620	0.787
10.	Available Zn (ppm)	0.952	0.611

#### 4. CONCLUSION

The watershed management practices benefited nearly all farmers in terms of water management and increased crop yield, but it was reported that, medium farmers benefited more than the small farmers. Cropping intensity has increased from 122.12% to 137.08% in the maximized farm income also increased to 17 lakhs in the study period due to implementation of soil and water conservation measures. Moisture conservation practices i.e., contour trenches, staggered trenches etc. were found to establish good grass cover on non-arable area. The soil fertility of treated area increased as compared to untreated area. The organic carbon percentage was higher in the treated area than that of untreated area of the watershed. The irrigated area which was 51ha before the project implementation has been increased up to 78ha which shows that due to project interventions, the irrigation potential of the area, livelihood status of local people increased considerably. The migration of locals towards urban city reduced effectively. So, implementation of project has improved the overall conditions of watershed as well as locals. This study will also provide information about the local environment and assist the policy makers to plan a suitable scheme for sustainable development of study area.

#### CONSENT

As per international standard or university standard, participants' written consent has been collected and preserved by the author(s).

#### ACKNOWLEDGEMENTS

Authors are thankful to Department of Soil and Water Engineering, C.T.A.E, MPUAT, Udaipur-313001, Rajasthan, India, CTAE, Maharana Pratap University of Agriculture and Technology, Udaipur 313001, Rajasthan, India.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Sharma H, Burark SS, Meena GL. Land degradation and sustainable agriculture in Rajasthan, India. *J Indus Pollution Control*. 2015;31(1):7-11.
2. Salvati L. Economic Causes and Consequences of Desertification. In Oxford Research Encyclopedia of Environmental Science; 2021.
3. Gautam VK, Awasthi MK, Trivedi A. Optimum Allocation of Water and Land Resource for Maximizing Farm Income of Jabalpur District, Madhya Pradesh. *International Journal of Environment and Climate Change*. 2020;10(12):224-232. Available: <https://doi.org/10.9734/ijecc/2020/v10i1230299>
4. Bojo JP, Cassels D. Land degradation and rehabilitation in Ethiopia: A Reassessment. 1995;14957:1-0)
5. Bosshart UP. Catchment discharge and suspended sediment transport as indicators of physical soil and water conservation in the Minchet Catchment, Anjeni Research Unit: A case study in the north-western highlands of Ethiopia. University of Bern; 1997.
6. Dinesh Chand Meena, CA Rama Rao, BL Dhyani, Pradeep Dogra, Josily Samuel, Ravi Dupdal, SK Dubey, PK Mishra. Socio-Economic and Environment Benefits of Soil and Water Conservation Technologies in India: A Critical Review. *International Journal of Current Microbiology and Applied Sciences*. 2020;9(4):2867-2881. Available: <https://doi.org/10.20546/ijcmas.2020.904.336>
7. HYSH Nugroho, MK Sallata, W Isnani, M Saad, Hermawan A. Effectiveness of soil and water conservation structures in increasing community perception and controlling erosion and sedimentation. *Earth and Environmental Science*. 2021;874:012012. Available: <http://doi:10.1088/1755-1315/874/1/012012>
8. Lark BS, Mahajan RK, Walia TP. Determination of metals of toxicological significance in sewage irrigated vegetables by using atomic absorption spectrometry and anodic stripping voltammetry. *Indian Journal of Environmental Health*. 2002; 44(2):164-167.
9. Subbaiah BV. A rapid procedure for estimation of available nitrogen in soil. *Curr. Sci*. 1956;25:259-260.
10. Ifenna I, Osuji LC. Physico-chemical characteristics of soils within the vicinity of a hot mix asphalt (HMA) plant in Obigbo, Port Harcourt, Nigeria. *Archives of Applied Science Research*. 2013;5(3):184-192.
11. Arya SL, Yadav RP. Economic viability of rainwater harvesting by renovating village ponds in small agricultural watershed of

- Johranpur (HP). Agricultural Economics Research Review. 2006;19(347-2016-16765):71-82.
12. Gautam VK, Awasthi MK. Evaluation of water resources demand and supply for the districts of central Narmada valley zone. International Journal of Current Microbiology and Applied Science. 2020; 9(1):30433050. Available:https://doi.org/10.20546/ijcmas.2020.902.350
  13. Aytnew M, Kibret K. Assessment of soil fertility status at Dawja watershed in Enebe Sar Midir district, Northwestern Ethiopia. International Journal of Plant & Soil Science. 2016;11(2):1-13.
  14. Nigam GK, Pandey VK, Tripathi MP, Sinha J. Assessment of macro and micro nutrients of soil in a small Agricultural watershed. International Journal of Chem Tech Research. 2014;6(7):3658-3664.
  15. Osman M, Haffis S, Kareemulla K, Mishra PK, Kumar KS. Watersheds impact evaluation using time scale disparity index. Indian Journal of Soil Conservation. 2013;41(2):192-199.
  16. Palanisami K, Kumar S. Impact evaluation of soil and water conservation measures on two watersheds of Coimbatore districts of Tamil Nadu state viz. Kattampatti-1 and Kodangipalayam-2. Indian Journal of Agricultural Economics. 2004;68:126-134
  17. Pawar AD. Analysis of Physicochemical Parameter, Heavy Metals and Micronutrients of Soil Sample of Kundal Village, Sangli District, Maharashtra; 2021.
  18. Pathak P, Chourasia AK, Wani SP, Sudi R. Multiple impact of integrated watershed management in low rainfall semi-arid region: A case study from eastern Rajasthan, India. Journal of Water Resource and Protection. 2013;5(1):27-36.
  19. Rahul Shelar, Sachin Nandgude, Mukesh Tiwari, Sunil Gorantiwar, Atul Atre. Impact Assessment of Soil and Water Conservation Measures on Carbon Sequestration: A Case Study for the Tropical Watershed Using Advanced Geospatial Techniques. Sustainability. 2023;15-531. Available:https://doi.org/10.3390/su15010531
  20. Rathod T, Rathod MK. Impact of integrated watershed management programme on yield and economic parameters of farmers in Wardha district. Indian Journal of Soil Conservation. 2017;45(1):117-122.
  21. Sashikala G, Naidu MVS, Ramana KV, Nagamadhuri KV, Kumar AP, Reddy P, Krishna TG. Characterization and Classification of Soils in Semi-arid Region of Tatrakallu Village of Anantapuramu District in Andhra Pradesh. Journal of the Indian Society of Soil Science. 2019; 67(4):389-401.
  22. Shukla JP, Impact Evaluation of Soil and Water Conservation Measures in Suawato Ka Guda Watershed of Udaipur Region (Doctoral dissertation, MPUAT, Udaipur).
  23. Singh K. Post project assessment of soil and water conservation measures in Meghraj-Modasa watershed of Aravali district. M.Tech Unpublished thesis, CTAE, MPUAT, Udaipur; 2015.
  24. Singh SB, Prakash N. Socio-economic impact of watershed development project in Manipur. Indian Research Journal of Extension Education. 2016;10(1):78-82.
  25. Sudhishrf S, Dass A. Study on the impact and adoption of soil and water conservation technologies in Eastern Ghats of India. Journal of Agricultural Engineering. 2012;49(1):51-59.
  26. Worku H. Impact of physical soil and water conservation structure on selected soil physicochemical properties in Gondar Zuriya Woreda. Resource Environment. 2017;7(2):40-48.

© 2023 Garhwal et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<https://www.sdiarticle5.com/review-history/107007>