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An Assessment of Soil Erosion in Madhya Pradesh

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Abstract

Land degradation is critically linked with sustainable development especially in agrarian economies like India. So, it is necessary to strike a balance between land use and development goals. If development is to be sustainable then the capacity of the land to produce food for future generation should be considered. The soil erosion is the result of reckless farm decision making. If, we provide sufficient information and feedback through frequent research and development activities, farmers themselves can bring revolutionary changes in the soil loss rate up to the desired level.

Keywords: *Soil Erosion, Crop Management, Agricultural Productivity Yield Gap*.

1. Introduction

Every living organism is a product of its biological heredity and its environment. To survive, it must be at least tolerably well adopted to the environment with which it regularly comes in contact. Land is one such natural resources of a nation. This is common to and linked with other resources like- water, forests etc. Chronic shortage of food in a large number of developing countries has focused world attention on the urgent need to increase agricultural production in order to provide more food for growing population.

Apart from this, developing economists have recognized that the performance of the agricultural sector is an extremely important factor in determining the overall success of a particular countries programme for development. As, agriculture is the largest sector of the Indian economy its growth and development is considered crucial for the growth of the non-agricultural sectors and the over all economy. Despite the structural change agriculture still remains a key sector, providing both employment and livelihood for more than seventy per cent of the country's population, who live in rural areas.

Developing countries have made uses and misuses of land resources causing land degradation. Land degradation is critically linked with sustainable development especially in agrarian economies like India. So, it is necessary to strike a balance between land use and development goals.

It has been of late recognized that the increasing efforts to raise agricultural growth has cost us dearly in the form of land and water degradation. If development is to be sustainable then the capacity of the land to produce food for future generation should be considered. Therefore, in this regard following issues need to be explored and answered at micro level;

- What is the degree of land degradation?
- How can we estimate the cost of degradation?
- What are the factors influencing land degradation?
- What is the impact of land degradation on the agricultural productivity?

The above issues are analyzed on the basis of the information collected from Ujjain district (M.P.)

2. Research Methodology

The physical and socio-economic environment of Ujjain district is characterized by great diversity. This is reflected in variations in rain fall, size of holding, literacy, cropping pattern and fertilizer use. Variations are also evident in the level of technology applied in agriculture. In such, a varied and complex socio-economic condition, land degradation, which is the function of above factor, is bound to vary in following manner:

Sampling frame:

For the proper understanding, all the blocks in the district have been taken into account. From each block three villages are selected. That mean's eighteen villages are selected from various blocks.

Unit of observation:

Farmers are the unit of observation. From each selected villages 10 farmers are randomly selected. Thus, from the Ujjain district 180 farmers have been selected for in depth study.

Data collection:

This study is mainly based on primary data. For collecting the primary data, a structured interview schedule was administered to the 180 farmers to get the information regarding their agricultural activities along with specification of their land.

Conceptual framework:

Land degradation refers to a decline in the over all quality of land. It is more complex than air & water pollution. It is caused by different forms of land use. Land is affected by physical, chemical and biological degradation. Some agricultural practices directly affected quality of land. The most significant forms of physical degradation of land are erosion, desertification, water-logging and compaction. Of these broad categories of degradation, erosion account for a major share. This increases decline in the productivity, over the years and finally leads to land abandonment.

It is always a difficult task to measure the loss due to land degradation. Loss of soil due to land degradation such as erosion or change in soil quality must be estimated in order to understand the cost of degradation. The universal soil loss equation (USLE) is the best known and widely used soil erosion model in the literature. This predicts the long term average annual rate of erosion on a field. The USLE can be used to compare soil losses from a particular field to "tolerable soil loss" (3 tonnes/ acre / year or 7.5 tonnes /hecter/ year).

In the literature, soil loss has been valued using productivity approach, preventive cost approach and replacement cost approach. The replacement cost refers to cost of nutrient in terms of NPK. As per the estimates of national bureau of soil survey and land use planning (1990) the average loss of topsoil due to erosion is 19.6 tones per hectare of which 1.39 per cent is actual nutrient loss in terms of NPK. In order to replace the nutrient losses through artificial fertiliser, the actual use of NPK should be 3.01 times of the nutrient losses.

Data processing:

Data collected are both qualitative as well as quantitative. The quantitative data has been interpreted with the help of F-test. The USLE model has been used for the estimation of soil erosion in the sample field. The USLE provides a convenient framework for calculating soil erosion. The equation is;

$$A = R\ K\ LS\ C\ P$$

Where, A = Soil Erosion (tones/hectare/year)
R = Rainfall/ Runoff factor
K = Soil Erodibility / quality of soil
LS = Slope coefficient
C = Crop management
P = Conservation/ farm practices.

Five major factors are used to calculate the soil loss for different size of holding. Each factor is the numerical estimate as per the USLE of a specific condition that affects the severity of soil erosion at a particular location. It is the noteworthy point that in the above equation the value of all the variables accept LS, is fixed due to the similarities of them across the district.

Apart from this, we have used the technique of multiple regressions to identify the impact of soil erosion on land productivity. An attempt is made to examine the relationships between the extent of total productivity on one hand and visible & invisible inputs on the other. For this purpose we have estimated the regression functions for sample. The variables functions are given below:

Y= F (Visible inputs, Invisible Inputs)

$$Y = \text{constant} + \sum_{J=1}^{5} b_j X_j + \sum_{K=1}^{6} C_k D_k + E_i$$

Where:

- Y = Total productivity per hectare (Rs.)
- X_1 = Fertiliser consumption per hectare (Kg.)
- X_2 = Wage distributed per hectare (Rs.)
- X_3 = Irrigated area per hectare (Percentage)
- X_4 = Expense on plant protection (per hectare (Rs.)
- X_5 = Soil Erosion per hectare (tonnes)
- D_1 = One, if farmer having size of agricultural holding more than 3 hectare, else zero.
- D_2 = One, if farmer literary is more than 5^{th} class, else zero.
- D_3 = One, if dependency ratio within farmers family is more then 50 percent, else zero.
- D_4 = One, if farmer family size is more than six members, else zero.
- D_5 = One, if farmer getting training for better farm practices, else zero.
- D_6 = One, if farmer decides fertiliser use by soil testing, else zero.

The different permutations and combinations has been used to analyze the variation in total productivity for district. The district model has been finalized on the basis of significance of variables in explains the variation in total productivity and over all significance of the model.

3. Yield Gap: A Tool for Measuring Land Degradation

No doubt the availability of region specific responsive varieties of crops and economically viable technology has helped in increasing the agricultural production but the production of these

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crops has not yet reached the optimum. One notices an awesome gap between the average yields obtained on farmer's field under scientifically designed general crop estimation surveys (GCES) and the existing crop yields & obtained under identical conditions with in the respective crops. (See table 1).

Table - 1 Yield Gap of Different Crops in Ujjain District 2000-01

Crops	Actual Yield	Potential Yield	Ratio	Yield Gap	Yield Efficiency (Percentage)
1	2	3	4	(2-3) 5	6
Rice	400	630	1.58	-230	63.49
Irrigated wheat	2322	2550	1.10	-228	91.06
Jowar	254	1120	4.41	-866	22.69
Maize	1122	1300	1.16	-178	86.30
Gram	852	820	0.96	+39	104.75
Tuar (Red gram)	422	850	2.01	-428	49.67
Groundnut	824	1210	1.47	-386	68.10
Alsi	354	480	1.36	-126	73.75
Til	300	340	1.33	-40	88.24
Soybean	611	1040	1.70	-429	58.75
Rapeseed Mustard	300	730	2.43	430	41.09
Source : Land record office & District statistical book - 2002					

It shows what is achievable by the farmers at the existing level of technology and what is being produced in general. The ratio (table 1, column 4) between the potential and that obtained by farmer on their field indicates the production potential of different crops in the district. The different between the two has been termed as 'yield gap'. It would be seen from table 1 column 5, that the gap is widest in the Jowar then followed by Soybean and Tuar (Red gram). It ranges between +39 to -866 kg per hectare. These gaps are indicative of the fact that there exists tremendous potentiality to increase the yield of different crops in the district.

The purpose of presenting yield gap is to demonstrate that improved technologies are already available for raising existing yield substantially. In all the crops except gram there is large yield gap for which yield information was available. In some crops technologies are available to double the actual yield. Generally, the management of inputs and the environmental parameter such as soil, temperature and rainfall accounted for a large proportion of the yield difference. The discussion shows that either the technologies having higher yield potential are not actually suitable at farmer's field or enough efforts is not made to reduce the impact of environmental factors on farmers field.

4. Land Degradation in Madhya Pradesh

Before spelling out the relationship between the soil erosion and land productivity, it appears appropriate to discuss about the status of land degradation in Madhya Pradesh. Table 2 presents the estimates of land degradation based on different types of degradation for the year 1985 and 1994 by the Department of Agriculture & Co-operation, Govt. of India.

A reverse trend is observed in land degradation. It witnessed a steep decrease of 80 lakh hectare from 1985 to 1994, which is a sign of better land utilization. However, the saline land in 1994 increased to 2.42 lakh hectare from 0.78 lakh hectare in 1985, witnessing an increase of 1.64 lakh hectare. Apart from this the same pattern is observed in case of water logging.

Table 2 Status of Land Degradation in Madhya Pradesh (Area in Lakh Ha)

Type of Degradation	**1985**	**1994**
Soil Erosion	155.1	72.6
Ravines	6.83	6.23
Saline	0.78	2.42
Sodic	1.64	-
Waterlogged/Marshy	0.57	0.67
Mine & Quarry Wastes	-	-
Shifting Cultivation	1.25	-
Degrade Forests	41	45.23
Total	**207.2**	**127.2**
Source: Draft Report on Status of Land Degradation in India. Dept. of Agriculture & Co-operation, Govt. of India.		
Coated from http://www.madhyapradeshstat.com/		

Of these broad categories of degradation, soil erosion account for a major share. It is observed that the land degradation due to soil erosion has decreased during 1985-94 period, but having the major share in the overall degraded land of Madhya Pradesh.

5. EXTENT OF SOIL EROSION IN THE SAMPLE FIELD

In many countries, there is considerable scope for bringing new areas under cultivation, but in Madhya Pradesh the scope for extension of cultivation to new lands is very limited. Therefore, we are depending only on yield to increase the agricultural production. As, yield is directly related with the quality of land, it is necessary to assess the degree of soil erosion.

Table 3 gives the number of farmers of Ujjain district classified on the basis of soil erosion rates. In Ujjain district only one-third farmers recorded tolerable soil rate that is 7.5 tones per hectare per year. 20 out of

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180 farmer account for 11.1 percent of the sample, having soil loss rate ranging from 7.5 to 12.5 tones per hectare per year. Where as, more than 54.4 percent farmers having soil loss rate of 12.5 to 37.5 tones per hectare per year. It is noticeable that 2 out of 180 farmers experienced a soil loss rate more than 37.5 tones.

Table 3 Soil Erosion Rates at Farmers Field (tones/hectare/year)

Soil Erosion Rate	Frequency	Percent
Up to 7.5	60	33.3
7.5 to 12.5	20	11.1
12.5 to 37.5	98	54.4
More than 37.5	2	1.1
Total	180	100.0
Source: as per the survey		

The loss rate of soil among the farmers is ranging up to the maximum extent of 52 tones with an average rate of 13.33 tones. However, the standard deviation of soil loss rate is 9.5 tones. This clearly depicts the fact that the soil erosion in the district has crossed the tolerable limits.

Table 4 Descriptive Statistics of Soil Erosion

Statistics	Soil Erosion
N	180
Minimum	0
Maximum	52.4618
Sum	2400.124
Mean	13.33402
Std. Deviation	9.463831
Source: as per the survey	

If we go through to block level analysis, it is observed that a soil loss rate varies sharply. As far as replacement cost of soil is concerned, it is approximately Rs. 1535 per hectare in Barnagar block followed by Ujjain and Ghatia block Rs 1169 and Rs 1039 respectively. The average soil rate of Barnagar, Ujjain and Ghatia block is more than the district level average while all other blocks are having the average less than that.

F-test results presented in table 5 shows that variation in soil erosion is statistically significant at five per cent level of significance. As, the loss of nutrient and their replacement cost are the multiple of soil loss rate, they are having a significant difference in the mean.

Table 5 Extent of Soil Erosion and their Cost across the block

Block	Static	Soil Erosion	Nutrient loss in Terms of NPK	Replacement of nutrient	Cost of land degradation
Barnagar	Sum	413.93	5.75	17.32	12122.90
	Mean	13.80	0.19	0.58	404.10
Khachrod	Sum	267.43	3.72	11.19	7832.39
	Mean	8.91	0.12	0.37	261.08
Mahidpur	Sum	391.02	5.44	16.36	11451.87
	Mean	13.03	0.18	0.55	381.73
Tarana	Sum	327.39	4.55	13.70	9588.42
	Mean	10.91	0.15	0.46	319.61
Ujjain	Sum	458.15	6.37	19.17	13418.00
	Mean	15.27	0.21	0.64	447.27
Ghatia	Sum	542.20	7.54	22.69	15879.56
	Mean	18.07	0.25	0.76	529.32
District	Sum	2400.12	33.36	100.42	70293.15
	Mean	13.33	0.19	0.56	390.52
F value		3.744*			
Source: as per the survey *Significant at 5% level					

6. Soil Erosion as a Factor of Land Productivity

In order to identify the impact of soil erosion on land productivity of the sample farms, an attempt is made to examine the relationships between the extent of total productivity on one hand and visible, invisible inputs and soil erosion on the other. This would help us not only in understanding the importance of factors of productivity but also in estimating the future loss due to soil erosion in total productivity. For this purpose we have estimate the regression functions for sample.

OLS estimated results are presented in table 6.

Table 6 OLS estimate for OLS Estimates of the equation Explaining the variation in Land productivity.

Variable	B	Std. Error	t-statistics
(Constant)	3.748	.849	4.414
Fertiliser consumption per hectare	7.411E-03	.001	5.006*
Wage distributed per hectare	9.461E-04	.000	2.148*
Irrigated area per hectare	2.811	.583	4.823*
Plant Protect expense per hectare	2.070E-04	.001	.304
Soil Erosion per hectare	5.274E-02	.034	1.532
R^2 = 41.7			
Dependent Variable: total per hectare productivity of farmer * significant at 5 % level of significant			

We have find out five variables namely X_1, X_2, X_3 X_4 and X_5, for explaining the variation in total productivity of Ujjain district. By these variables we are able to explain 43 percent variation in total productivity of farmer of Ujjain district. Out of these excluding X_4 & X_5 all the variables are significant. The results indicates that the marginal production of visible input in Ujjain district are 0.0073, 0.00094 and 2.811 gradually for fertiliser use per hectare, wage distributed per hectare and irrigated area per hectare. The important observation which emerges from the results is that the soil erosion having positive but insignificant impact on productivity. It means that the field does not have any negative impact of soil erosion. This may be due to high depth of soil in the sample field.

7. Conclusion

Given the scarcity of the land and the continued growth of population, there is no alternative but to continue intensifying agricultural production in Madhya Pradesh. Although, most of the increase in agricultural out put was brought about the yield growth (See Kumar P;2002 for details) and very few crops are much more higher than 75 to 80 percentage of yield potential in the developed area. Farmers still struggle with environmental concerns such as loss due to soil erosion.

As estimate of soil erosion for Ujjain district reveals that on an average 13.33 tones per hectare of top soil are eroded annually and its replacement cost is Rs. 390 per hectare. Our study has shown that productivity of land is dependent mainly on fertiliser use per hectare, wage distributed per hectare and irrigated area per hectare as their coefficients are significant. It is important to observe that the soil erosion is showing positive but insignificant impact on land productivity. However we are very close to tolerable soil loss rate.

Once you have assessed the erosion problem, there are various conservation practices and structures to choose from. Proper soil and crop management practices will reduce soil erosion rates. Crops and cutting action of ploughs breaks up the soil mass and may have favorable or adverse affects on the structure, depending on the soil quality. Since, the factors like rainfall/runoff, soil erodibility and slope coefficient are out of the control of farmers. We need to concentrate on crop management and farm practices. Therefore, well focused research is urgently needed to determine the impact of different crops and agricultural farm practices on soil erosion. The soil erosion is the result of reckless farm decision making. If, we provide sufficient information and feedback through frequent research and development activities, farmers themselves can bring revolutionary changes in the soil loss rate up to the desired level.

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