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Dayakar Peddi and K.S. Kavi Kumar

Abstract

Soil erosion is a major problem of agriculture in India. The objective of this study is to investigate how farmers perceive the severity of soil erosion in the rain fed watershed areas of Telangana, India. The study is based on a detailed survey of 400 households in two sub-watershed areas. The study findings suggest that farmer’s perception of soil erosion severity corresponds well with expectations of soil erosion determined by site specific factors such as slope of the plot, soil depth, soil texture, road connectivity, irrigation, crop intensity, and type of crops. The findings from the study also corroborate well with the several empirical studies from different parts of the world. Given this correspondence, it is argued that farmer’s expertise is important while assessing soil erosion severity. The farmer’s knowledge of the plot level soil erosion could complement the assessments made through secondary sources. The study findings further highlight the importance of using participatory approaches when working to reduce soil erosion.

Key words: *Land degradation, Soil erosion, Soil conservation*
JEL Codes: *Q5, Q15, Q51, Q57*

INTRODUCTION

Land is one of the complex biological resources and it plays a significant role in the earth's life support system through providing multiple essential ecosystem services to the environment and human beings (Barrios, 2007; Sukhdev et.el., 2010). The land ecosystem is a backbone for the rural livelihood. Unsustainable land management practices are leading to extensive land degradation over the past half a century and have affected the ability of this important ecosystem in providing its services (Assessment M.E, 2005; Brevik *et. al.*, 2015). Land degradation is recognised as a global challenge now, and soil erosion is a major contributor to total land degradation at regional as well as global level. The impact of soil erosion is more sever in developing countries practicing rain-fed agriculture. The soil erosion cost was estimated as $26 billion per year at global level, with $12 billion dollars attributed to developing countries (UNEP, 1992).

Soil erosion has been recognized as an important challenge in India, Desertification and Land Degradation Atlas of India (SAC/ISRO, 2016) reported that 11 percent of Total Geographical Area (TGA) has been degraded by water erosion alone in 2011-13. More recently, the Land Degradation Atlas of India (NRSC, 2018) estimated that about 16 percent to TGA is degraded by water erosion alone in 2015-16. Soil erosion is a major threat to agriculture in India and has significant economic cost. TERI (2018) estimated the total economic cost of soil erosion in cropland area alone is about 0.35 percent of GDP in 2014-15. Continuous soil erosion diminishes land productivity hence threatens livelihood options especially in rain-fed areas (Tilahun et.al, 2018).

Combating soil erosion by formulating effective mitigating/adoption policies requires identification of causes of soil erosion. Literature has identified several anthropogenic and natural factors responsible for land degradation at regional and global level

(Alisher Mirzabaev *et. al.*, 2016). Few studies have analysed determinants of land degradation in Indian context. Reddy (2003) analysed the causes of land degradation at state and district level using NRSA data. On the other hand, Mythili and Goedecke (2016) assessed the influence of various factors on wasteland area at state level reported in the land-use statistics. Dependence on secondary data sources could bias the findings of these studies as they fail to take into account the local and indigenous knowledge of the farmers (Kumar *et. al*., 2015).

Literature suggests that the adoption of appropriate soil and water conservation practices would prevent soil erosion and improve the land quality (Wani *et. al.*, 2003; Kassie *et. al*., 2008; Chandan, 2017). Over the years, Government, non-Government and international organisations have been trying to support better land use and promote soil and water conservation (SWC) technologies at community and watershed level to prevent soil erosion, improve agriculture, and facilitate better livelihoods in rural areas in India (Hanumantha Rao, 2000; Kerr et.al, 2002; Reddy, 2004; Sreedevi et.al, 2006; Hope, 2007; Wani *et. al.*, 2008; Garg *et. al.*, 2012; Datta, 2015 and Anantha et.al, 2016). However, as mentioned above, notwithstanding the measures taken by various agencies the extent of soil erosion and land degradation is showing increasing trend in India. This necessitates a more integrated approach towards soil conservation that involves all the concerned stakeholders including the farmers. Farmers are main stakeholders who adopt soil and water conservation measures based on perceived level of soil degradation in their plots. A growing body of literature suggests that farmers have considerable knowledge to identify and classify soil erosion severity on their plots. Similarly, land management and conservation measures undertaken by the farmers depend on their understanding of the extent of erosion and factors contributing towards the same (Shiferaw and Holden, 1998; Bewket and Sterk, 2002; Tefera and Sterk, 2010; Assefa and Hans-Rudolf, 2016, and Keshavarz and Karami, 2016). Thus, for effective planning towards soil conservation it is imperative that policy formulation integrates the farmers' perceptions and their indigenous knowledge. In India, like in other countries, the information about land degradation and soil erosion is generated typically through top-down processes. If it can be established that farmer's perception of soil erosion reasonably matches with other objective measures at the plot and/or community level, then the perception based assessments can complement the top-down assessments. Further, involving farmers would make the top-down SWC planning process relatively more interactive and participatory (Nigussie *et. al*., 2017). This will also enable integration of traditional knowledge in to the SWC planning and provide scope for overcoming the behavioural constraints faced while advocating top-down SWC measures.

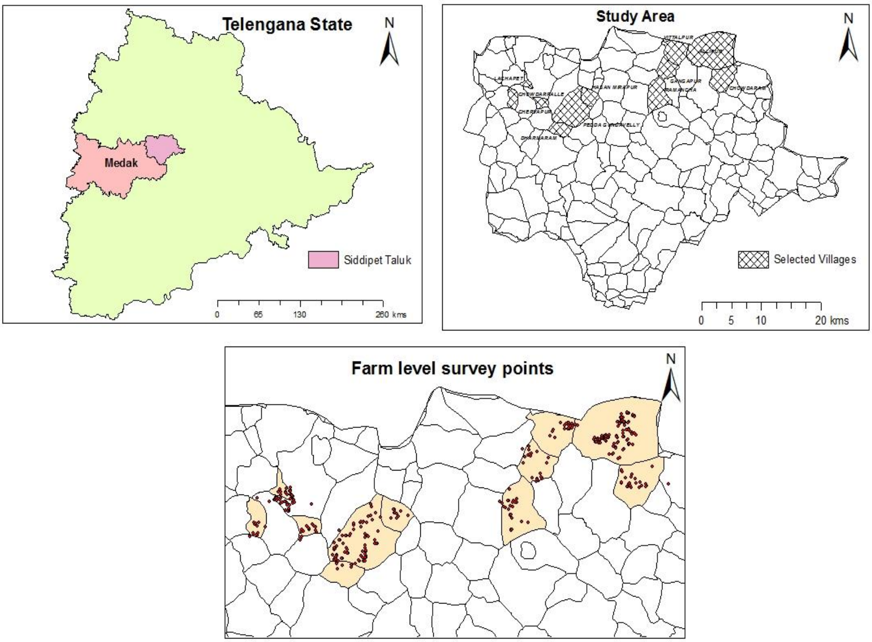
Against this background, the present study with an aim to help in formulating effective policies to prevent soil erosion particularly in rain-fed areas of India, focuses on the following two objectives: (i) to assess whether farmer's perception of soil erosion matches with other objective measures; and (ii) to examine the factors that shape farmer's perception of soil erosion, which in turn influence the soil conservation measures undertaken by the farmers. The farmer's perception of soil erosion and the factors influencing the perception are analysed through a case study of rain-fed watershed area in Telangana, India. Telangana is the youngest state in India, situated in the central stretch of the eastern seaboard of the Indian Peninsula. The topography is characterised by undulating uplands with small hills and depressions. Telangana experiences dry tropical climate with temperature ranging between 10^0C and 45^0C accompanied with low-rainfall. Telangana is among most affected states due to soil erosion in India, with about 26 percent of cropland degraded in 2011-13 (SAC, 2016).

DATA COLLECTION AND METHODOLOGY

Study Area

The study was undertaken in two mandals of Siddipet district in Telangana, India (see Fig. 1). The area lies approximately 130 km north of Hyderabad, the capital of Telangana state. The selected area falls within the region highly vulnerable to drought with annual average rainfall of 650 mm, over 80 percent of which is received during the monsoon months June to September (Government of Telangana, 2015). The area comes under Godavari river basin with low and moderate level of soil erosion assessed through satellite data (Bhuvan & Department of Land Resources, 2017).

Figure 1: Location of Study Villages in Telangana



Purposive sampling method was followed to select study area and villages, to account for wide variation across villages in terms of soil and water conservation technology experience, state of soil erosion, and socio-economic heterogeneity. Twelve villages are selected from *Chinnakodur* and *Dubbak* mandals for the field study; six villages are located in *Dubbak* and *Chinnakodur* sub-watershed areas and are part of Integrated Watershed Management Program (IWMP) Under IWMP programs numerous activities are undertaken to restore the ecological balance by harnessing, conserving, and developing degraded natural sources such as soil, vegetation cover and water. Other six villages are also located in the same *Dubbak* and *Chinnakodur* sub-watershed areas, but not covered by the IWMP program. Biophysical, topographical and hydrological conditions are broadly similar among selected villages. Selected villages are dominated with red loamy, red sand loamy, saline and black soils. Paddy, maize, cotton, red gram and vegetables are major crops cultivated in the area. Soil erosion leads to nutrient loss, which ultimately reduce the agriculture productivity and yield. Therefore, farmers traditionally practice soil and water conservation measures to control their perceived level of soil erosion (Kumar *et. al.*, 2015). Field level observations reveal that farmers adopt counter ploughing, grass bund, soil bund, drainage ditch, silt application and plantation to prevent soil erosion.

Data Sampling

The data used in the study came from detailed household and plot level surveys of 400 farmers in two mandals of Siddipet district in Telangana. The survey was conducted during January-March 2018. The census data (2011) showed that the geographical and population characteristics differ across the villages. The number of households selected for survey in the villages is based on the proportion of households in each village to the aggregate number of household across all the selected villages. Thus, the total number of sampled households from the villages ranged between 13 and 67. In each village the list of households has been compiled from revenue and agricultural departmental data sets. Once the number of households is finalized, the specific survey households were selected based on simple random sampling. The final sample consists of 206 households from the villages covered by IWMP and 197 households from the villages not covered by the IWMP. Across the entire sample, about 85 percent of households had adopted at least one soil conservation measure on their plots.

Empirical Model

The determinants of farmer's perception of plot-level soil erosion severity can be analysed using qualitative response statistical models. The farmers rate the perceived level of soil erosion severity of their plot on a scale that takes different discrete ordinal values. In the present case, farmers were asked to answer two questions; (a) whether they perceived soil erosion problem in past five years, and if yes, (b) rate the extent of soil erosion problem along the scale: "very low", "low", "medium", high and "very high". These ratings are then converted into numeric score, from 1 (very low) to 5 (very high). These values are clearly ordered but not measures on the interval scale (Nigussie et.al., 2017). Treating them as ordered categorical responses, the analysis followed ordered-response model. A typical approach can use the standard ordered logit or probit models (Weisburd & Britt, 2014). Here, the ordered probit model has been used. The underlying assumption is that the probability of a farmer perceiving a particular severity of soil erosion is equal to the probability that the function describing the perception falls in a range around the specific value and the random disturbances in the perception function follow a normal distribution.

The ordinal regression model commonly analyzed through the latent variable model. Defining $y*$ as a latent variable ranging from -∞ to ∞, the model can be specified as follows:

$$y^* = \gamma' x_i + \varepsilon_i \qquad \text{… (1)}$$

where x is a vector of covariates, γ is a vector of parameters, and ε is error term normally distributed across observations. The measurement model for binary outcomes is expected to divide y^* into J ordinal categories:

$$y_i = m \ \ if\ c_{m-1} \leq y^* < c_m \text{ for } m = 1\ to\ J \qquad \text{... (2)}$$

The underlying continuous variable can be severity of degradation. In such models, it is assumed that the scores represent ordered segments. In the present case respondents scored a level of soil erosion severity in a given plot in a particular ordered category, and driven by a latent, unobserved variable y^*, which represents the farmers ordering of the plot-level severity of soil erosion. Instead of this latent variable y^*, the survey observed 'y', a variable that falls into one of 'J' ordered categories (which in the present analysis ranges from 1 to 5). The observed response categories are coupled to the latent variable by the measurement model:

$$y_i = \begin{Bmatrix} 1 \Rightarrow verylow c_0 = -\infty \leq y^* < c_1 \\ 2 \Rightarrow low\ c_1 = c_1 \leq y^* < c_2 \\ 3 \Rightarrow medium c_2 = c_2 \leq y^* < c_3 \\ 4 \Rightarrow high\ c_3 = c_3 \leq y^* < c_4 \\ 5 \Rightarrow very\ high\ c_4 = c_4 \leq y^* < c_5 \end{Bmatrix} \qquad \text{... (3)}$$

Here, the standard model as follows (Green, 2018):

$$pr(y = m|x) = F(\, c_m - x\beta) - F(\, c_{m-1} - x\beta) \qquad \text{... (4)}$$

where F is the Cumulative Distribution Function (CDF) for ε in the model. In ordered probit model, F is normal distribution with Var (ε) = 1. It may be noted that for y = 1, the second term on the right drops out since $F(-\infty - x\beta) = 0$, and for y = J, the first term equals $F(\infty - x\beta) = 1$. The literature cites that there is a possibility of heteroscedasticity with ordered logit/probit models. An extensively used approach to test for heteroscedasticity is to test whether βs are constant across the different levels of response 'J'. The assumption of constant β values is referred in the literature as "proportional odds", "parallel regressions", and "parallel lines" assumption (Long and Freese, 2006; Xindong et.al, 2016). These assumptions are tested using '*omodel*' and '*test*' commands in Stata software and in the present study the dataset did not violate the assumptions. Therefore, the analysis in the present study sticks with simple ordered probit model. Interpreting the coefficients of intermediate categories requires caution because the direction of the effect is not always determined by the sign of the estimations. Therefore, marginal effects are considered in the interpretation of the variables.

RESULTS AND DISCUSSION

Previous studies analysed determinants of land degradation primarily through economic and land use change models (Burt, 1981; Walker, 1982; Magrath and Arens, 1989 and Oldman, 1992). These studies have not considered socioeconomic, demographic and institutional variables, and hence the estimated results may yield biased results. The recent empirical studies on the other hand analysed factors influencing soil erosion through integrated socio-economic approaches/models based on detailed survey tools (Tegene, 1992; Shiferaw and Holden, 1998; Mbaga-Semgalawe and Folmer, 2000; Tefera and Sterk, 2010; Tesfaye *et. al.*, 2014; Teshome *et. al.*, 2016; Nigussie et.al., 2017). The present study used the perceived level of soil erosion as dependent variable, and explanatory variables included (a) plot-level characteristics such as area of the plot, total area owned, soil slope, soil depth, type of soil, and crop intensity (i.e., ratio of grass cropped area to net cropped area); (b) socioeconomic characteristics including age of household head, sex of household head, formal years of education of the household head, source of irrigation, and social status; (c) connectivity factors including distance to the dwelling, road connectivity, and distance between the plot and the market, and (d) village level characteristics such as percentage of pastures in the total village area, percentage of current fallow land to the total village area, and annual total rainfall received by the village. The definition of explanatory variables, hypothesis of direction of their influence and their descriptive statistical properties are presented in table 1 below. It may be noted that barring the slope of the plot and soil depth, for all other variables the hypothesis of direction of influence has been given as either positive or negative. This is in line with the empirical literature with different studies reporting different directions of influence of the explanatory variables on the farmer's perception of the soil erosion.

The slope of the plot and depth of the soil are two important physical variables relevant for validating the severity of soil erosion perceived by the farmer. Ideally these variables should have been measured objectively. However, due to lack of appropriate means to measure, the survey depended on the assessment provided by the farmer. However, care has been taken to ensure that the assessments provided by the individual farmers on these variables in each village are vetted by the neighbouring farmers and the villagers in general during the focus group discussions. Further to reduce the extent of bias and ensure objectivity in the assessment provided by the farmer, the slope of the plot has been referred either as 'steep' or 'flat', and similarly the soil depth variable has been measured either as 'good' or 'shallow'. The expected sign of slope of the plot and soil depth of the plot variables are positive and negative, respectively as steeper plots and shallower could lead to higher soil erosion compared to the flatter plots and plots with deep soils.

The summary statistics suggest that the average area of cultivation is 3.37 acres while average total area of the surveyed households is 4.60 acres. The respondents thus own multiple plots and have a basis for comparison across the plots they own while responding to the survey questions. On an average there is intensive cultivation of same crop on the plots with sample average of crop intensity as high as 122. The average age of household is 49 years with about 5 years of school education. Due to low levels of income among the surveyed households, the average household size is close to 5 with low variability across the sample. The average distance from dwelling to the plot is 1.46 km and the plots on an average have poor road connectivity. The plots in the surveyed villages receive about 650 mm rainfall during the monsoon period.

Table 1: Summary Statistics and Description of the Variables Used in the Analysis

Variable	Definition of the Variable	H_0 sign	Mean	Std. Dev.
Plot level characteristics				
Area of the plot	Cultivated area (in acres)	+/-	3.37	2.48
Soil type	Texture of soil (1=red loamy; 2=red sand loamy; 3=black soils)	+/-	1.86	0.88
Slope of the plot	Slope of the plot (1=steep;0=flat)	+	0.80	0.40
Depth of soil	Soil depth (1= good; 0=shallow)	-	0.89	0.32
Irrigation	Irrigation status (1=yes; 0=no)	+/-	0.81	0.39
Crop intensity	Intensity of same crop cultivation (numbers)	+/-	121.80	35.42
Socioeconomic variables				
Age	Age of the household (in years)	+/-	49.45	14.10
Sex	Gender of the household (1=male;0=female)	+/-	0.89	0.32
Caste	Social status (1=socially forward class ; 0=socially backward classes)	+/-	0.23	0.42
Education	Years of education of household head (in years)	+/-	5.29	5.57
Total area owned	Total area owned (in acres)	+/-	4.60	3.77
Household size	Size of the household (numbers)	+/-	4.52	1.93
Market access variables				
Distance	Distance to dwelling (in km)	+/-	1.46	1.35
Road	Road connectivity of the plot (1=yes; 0=no)	+/-	0.32	0.47
Distance to market	Distance to the market from the plot (in km)	+/-	8.16	9.46
Village level characteristics				
Permanent pasture	Percentage of permanent pastures to total geographical area of the village (percent)	+/-	0.67	1.10
Current fallow	Percentage of current fallow lands to total geographical area of the village (percent)	+/-	7.19	6.12
Rainfall	Total rainfall received by the village during monsoon (in mm)	-/+	650	9.05

Source: Data from primary survey.

Farmers' Perceptions of Soil Erosion Severity

Farmer's perception of the soil erosion severity differs significantly across the survey villages. Across all the villages around 21 percent of the farmers perceive the soil erosion severity to be 'very low', whereas little over 10 percent of the farmers perceive the severity of soil erosion as 'high' and 'very high'.

Almost equal percentages of farmers (about 33 percent) perceive the soil erosion severity as either 'low' or 'medium'. As mentioned in the previous section, about half of the survey villages received intervention from either the government or the non-governmental organizations through IWMP, whereas the remaining six villages didn't receive any such intervention. The villages are selected for IWMP interventions based on a variety of considerations including the level of soil erosion severity. If the farmers are able to perceive the soil erosion severity accurately, one would expect higher percentage of farmers belonging to IWMP villages to report high level soil erosion compared to their counterparts in the non-IWMP villages. Table 2 below shows the soil erosion severity perceptions expressed by the farmers across the IWMP villages and non-IWMP villages. Close to 50 percent of farmers from IWMP villages perceived the soil erosion severity on their plots to be either 'medium', 'high', or 'very high', whereas only 39.5 percent of farmers from non-IWMP villages reported the soil erosion severity on their plots in these categories.

Table 2: Farmer's Perception of Soil Erosion Severity

Perceived Soil Erosion Level	IWMP Villages	Non-IWMP Villages	Total
Very Low	36 (17.5)	48 (24)	84 (21)
Low	68 (33)	71 (36)	139 (34)
Medium	73 (35)	61 (31)	134 (33)
High	27 (13)	14 (7)	41 (10)
Very High	2 (1)	3 (15)	5 (1)

Note: Figures are number of farmers; values in parentheses are percentages.

Water erosion is the most widespread form of degradation in the study area. The secondary data identifies wide range of water erosion categories including sheet erosion, rill erosion, gully erosion, loss of top soil dunes, partially stabilised dunes and un-stabilised dunes. The sheet erosion is dominant cause of soil erosion in the study area (Bhuvan, 2006). It is a common problem resulting in loss of top soil. The soil particles are removed from the soil surface on a fairly uniform basis in the form of thin layers. The severity of the problem is often difficult to visualize with naked eyes in the field. Using remote sensing data NRSA (2018) has categorized the soil erosion into three broad severity classes - slight, moderate and high with soil loss of 10-20, 20-40 and >40 tons/ha/year, respectively. Based on the NRSA data, the villages in the study area fall into either 'slight' or 'moderate' soil erosion categories.

Being the main stakeholders to prevent soil erosion, the farmer's perception matters significantly and could complement the soil erosion severity assessed through secondary sources including the remote sensing. Notwithstanding the categorical scales used for comparison, it is pertinent to note that Table 3 below show significant overlap between the soil erosion severities assessed through *Bhuvan* and the level of soil erosion perceived by the farmers.

Table 3: Level of Soil Erosion Severity at Village Level - Farmer's Perception and Data from Secondary Sources

Village	Category of Soil Erosion Severity: Based on Secondary Data	Perception Category of Soil Erosion Severity – Percentage of Farmers in the Village	
		Low level erosion	High level erosion
Allipur	Moderate	61.9	38.1
Chervapur	Slight	78.95	21.05
Chowdaram	Moderate	26.92	73.08
Chowdarpally	Slight	69.23	30.77
Darmaram	Moderate	37.04	62.96
Gangapur	Moderate	45.83	54.17
Hasanmeerapur	Moderate	57.14	42.86
Kammarlapally	Moderate	32.76	67.24
Lachapet	Slight	71.67	28.33
Peddagundavelli	Moderate	65.15	34.85
Ramancha	Slight	79.31	20.69
Vittalapur	Moderate	36	64

Source: Based on Bhuvan data and field survey.

Determinants of Farmer's Perception of Soil Erosion Severity

As mentioned in the previous section, the proportional adds assumption has been tested using '*omodel*' test (in Stata 14.2 software). The results suggest that the assumption is not violated (Prob > chi2 = 0.284). Hence, the analysis has been carried out using standard ordered probit model. While the model considered various plot level characteristics, village level characteristics and the socio-economic variables of the household to influence the farmer's perception of soil erosion severity, the results suggest that plot and village level characteristics broadly serve as the determinants of farmer's perception. Table 4 and 5 provide the estimated coefficients and the marginal effects, respectively.

One of the primary objectives of the study is to see whether farmer's perception of soil erosion severity tallies with the physical variables like slope of the plot and soil depth. The model estimates suggest that farmers owning steeper plots are more likely perceive soil erosion on their plots (coef. =0.926, Z=5.84). Similarly, better soil depth (as against shallow soils) will lead to lower perception of soil erosion (coef. =-0.495, z=-2.49). Several studies have shown that high slope with shallow soil depth would lead to more soil erosion (Lal R, 1976; Barthes and Roose, 2002; and Gebrernichael *et. al.*, 2005). The results from the present study corroborate these findings. Further, these results indicate that the farmer's perception could complement the physical assessment of soil erosion severity, in line with the evidence provided by Nigussie *et. al*. (2017) for Ethiopia.

Further, the results indicate that farmers owning plots with red loamy and black soils are likely to perceive lesser soil erosion compared to those who own red sand loamy soils. The type of crop cultivated also influences the soil erosion severity perception. Maize and paddy cultivated areas are less likely to be perceived as prone to soil erosion compared to the areas cultivating cotton (coef. = -0.323, z=-1.81; coff. =-0.402, z=-2.25). Previous studies argued that the level of erosion is more sever in red sand loamy plots (Dunaway 1994; Eldridge, & Leys, 2003). The findings from this study provide further evidence in this regard and show that in black and red loamy soils surface run off is lower compared to the red sand loamy soils. With cultivation practices differing between crops, one could expect soil erosion severity perception to be influenced by the primary crop cultivated on a given plot. The results suggest that farmers perceive more soil erosion in plots where cotton is cultivated compared to plots where paddy and maize are cultivated.

Theoretical and empirical studies have extensively discussed the impact of irrigation on soil erosion and indicate that irrigation may have positive or negative impact on soil erosion depending on the nature of irrigation and plot characteristics (Reddy, 2003). Specifically, the method of irrigation plays a key role in determining soil erosion with furrow irrigation on steeper plots leading to more soil erosion (Berg and Carter, 1980; Boulal, *et. al*., 2011; Zhao et.al, 2013; Guzmán et.al, 2015; and

Raeisi-Vanani et.al., 2017). The present analysis based on the information whether the plot has irrigation facility or not argues that farmers perceive lower soil erosion severity in the presence of irrigation (coef = -1.403, z=-2.49). It is possible that plots having access to irrigation facility are also ones that receive more soil conservation measures and hence could lead to lower soil erosion severity perception among farmers.

Table 4: Perceived Soil Erosion Severity: Ordered Probit Model Estimates

Explanatory variables	Estimated Coefficient	Z value
Plot level characteristics		
Slope of the plot	0.926***	5.84
Soil depth	-0.495**	-2.49
Soil Texture: Red loamy soil	-0.393***	-3.16
Soil Texture: Black soil	-0.556***	-3.19
Road connectivity of the plot	-0.371***	-2.83
Irrigation	-1.403**	-2.49
Crop intensity	-0.0134***	-3.03
Primary crop cultivated: Maize	-0.323*	-1.81
Primary crop cultivated: Paddy	-0.402**	-2.25
Irrigation*Crop intensity	0.0121**	2.52
Socio economic variables		
Age of the household head	-0.00511	-1.18
Sex household head	-0.0150	-0.08
Caste of the household	-0.111	-0.73
Years of formal education	-0.00231	-0.22
Area of the plot	0.00149	0.06
Household size	-0.0153	-0.48
Village level characteristics		
Permanent pasture (percent to TGA)	-0.173***	-2.94
Current fallow (percent to TGA)	0.00175	0.16
Monsoon Rainfall	0.00350	0.61
Constant	-0.975	-0.25
Constant	0.127	0.03
Constant	1.325	0.34
Constant	2.546	0.65
Observations	380	
r2_p	0.101	
chi2	101.1	
p	3.45e-13	

Note: Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The results also suggest that farmers are less likely to perceive soil erosion if their plots are connected to the road. In contrast to the finding of Mythili and Goedecke (2016) that crop intensity does not influence soil erosion in the Indian context, the results from this study suggest that intensive cultivation is likely to lead to lower soil erosion perception (coef. =-0.013, z=-3.03), probably due to less exposure of the soil to the natural forces. Further, plots that attract intensive cultivation could also be one receiving more soil conservation measures, leading again to lower perception of soil erosion severity. However, irrigation coupled with crop intensity is likely to lead to higher perception of soil erosion (coef.=0.0121, z=2.52).

The results also indicate that most of socio-economic variables do not influence the farmer's perception of the soil erosion severity. Though some studies have argued that the socio-economic variables influence the farmer's perception (Bewket and Sterk, 2002; 2003; Reddy, 2003; Adimassu *et. al.*, 2016; Nigussie et.al., 2017), it is difficult to make the case for the same. For instance, with more years of formal education it is argued that farmers are less likely to perceive severe soil erosion in their plots compared to the less educated farmers (Nigussie *et. al.*, 2017). The underlying argument appears to be that the educated farmers are more balanced in their perceptions and hence do not overreact. However, argument can also be made that educated farmers are more sensitive and hence are likely to perceive the soil erosion to be severe. In light of these conflicting possibilities, the insignificant influence of the socio-economic variables reported here seem more meaningful.

The results further suggest that village level characteristics such as permanent pastures (as percentage of total geographic area of the village) have significant influence on the farmer's perception of soil erosion severity.

Table 5: Marginal Effects for different Soil Erosion Severity Levels

Explanatory variables	Soil Erosion Severity Levels									
	Very Low	Z-Value	Low	Z-Value	Moderate	Z-Value	High	Z-Value	Very High	Z-Value
Plot level characteristics										
Slope of the plot	-0.22***	-6.18	-0.09***	-4.66	0.15***	5.84	0.14***	5.01	0.03**	2.35
Soil depth	0.12***	2.50	0.05**	2.44	-0.08***	-2.47	-0.07***	-2.46	-0.01*	-1.78
Soil Texture: Red loamy soil	0.09***	3.11	0.04***	2.99	-0.07***	-2.99	-0.06***	-3.06	-0.01**	-2.08
Soil Texture: Black soil	0.14***	2.91	0.05***	3.53	-0.10***	-2.77	-0.08***	-3.50	-0.01**	-2.19
Road connectivity of the plot	0.09***	2.82	0.04***	2.81	-0.06***	-2.84	-0.06***	-2.76	-0.01*	-1.89
Irrigation	-0.03	-0.79	0.02	1.32	0.02	0.65	-0.01	-0.24	0.00	-0.47
Crop intensity	0.00*	1.73	0.00**	1.97	0.00	-1.57	0.00**	-1.95	0.00	-1.62
Primary crop cultivated: Maize	0.07*	1.86	0.04**	1.68	-0.05*	-1.92	-0.05*	-1.70	-0.01	-1.39
Primary crop cultivated: Paddy	0.09**	2.31	0.05**	2.01	-0.06**	-2.37	-0.06**	-2.06	-0.01	-1.58
Socio economic variables										
Age of the household head	0.00	1.17	0.00	1.17	0.00	-1.18	0.00	-1.16	0.00	-1.06
Sex household head	0.00	0.08	0.00	0.08	0.00	-0.08	0.00	-0.08	0.00	-0.08
Caste of the household	0.03	0.73	0.01	0.73	-0.02	-0.73	-0.02	-0.73	0.00	-0.70
Years of formal education	0.00	0.22	0.00	0.22	0.00	-0.22	0.00	-0.22	0.00	-0.22
Area of the plot	0.00	-0.06	0.00	-0.06	0.00	0.06	0.00	0.06	0.00	0.06
Household size	0.00	0.48	0.00	0.48	0.00	-0.48	0.00	-0.48	0.00	-0.47
Village level characteristics										
Permanent pasture (percent to TGA)	0.04***	2.93	0.02***	2.82	-0.03***	-2.88	-0.03***	-2.86	0.00**	-1.93
Current fallow (percent to TGA)	0.00	-0.16	0.00	-0.16	0.00	0.16	0.00	0.16	0.00	0.16
Rainfall_monsoon	0.00	-0.61	0.00	-0.61	0.00	0.61	0.00	0.61	0.00	0.60

Note: Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

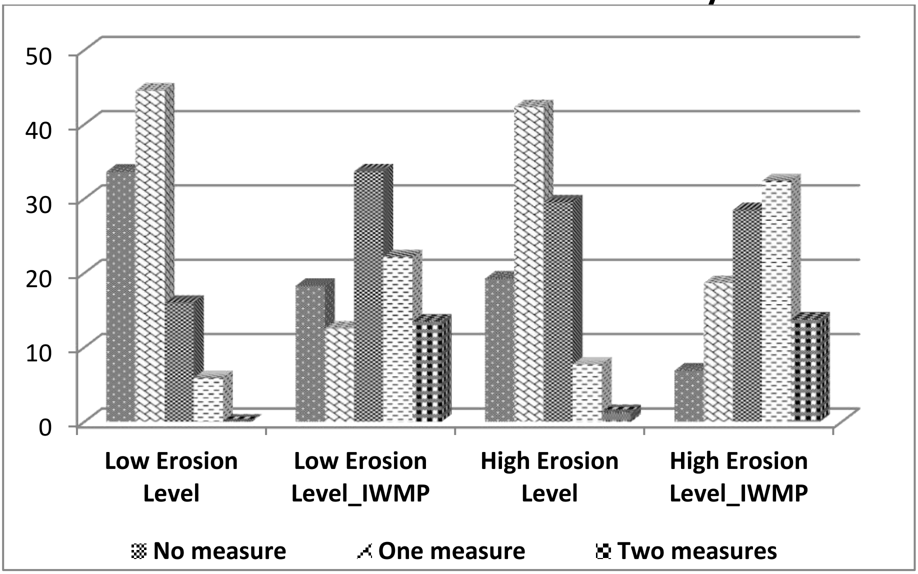
Higher percentage of permanent pastures will lead to lower perception of soil erosion by the farmers (coef. = -0.173, z = -2.94). Monsoon rainfall did not show significant influence on farmer's perception of soil erosion – probably due to use of aggregate mandal-level data in the analysis as village-level rainfall data was not available. The determinants of farmer's perception of soil erosion are by and large similar across the sub-samples of villages that received IWMP intervention and that did not receive any such intervention.

CONCLUSION

This study based on a field survey of farmers in Telangana, India argues that farmer's perception of soil erosion severity corresponds well with expectations of soil erosion determined by site specific factors such as plot slope, soil depth, soil texture, road connectivity, irrigation, crop intensity, and type of crops. The findings from the study also corroborate well with the several empirical studies from different parts of the world. Given this correspondence, it is argued that farmer's expertise is important while assessing soil erosion severity. The farmer's knowledge of the plot level soil erosion could complement the assessments made through secondary sources. The study findings further highlight the importance of using participatory approaches when working to reduce soil erosion.

Farmers implement soil conservation measures based on their perception of soil erosion severity. Figure 2 below shows the percentage of farmers undertaking different numbers of soil conservation measures under 'low' and 'high' levels of soil erosion. Clearly, there is tendency to implement more number of soil conservation measures if the perceived level of soil erosion severity is high.

Figure 2: Distribution of Soil Conservation Measures cross Different Levels of Soil Erosion Severity



Note: Data from field survey.

Further it can be seen from Figure 2 that farmers from villages that received IWMP intervention have shown greater inclination towards undertaking more number of measures to prevent land degradation on their plots. Such plot level soil conservation measures are often considered as supplemental to the measures implemented on common/private lands by the Government/Non-government agencies under the IWMP programme.

Farmers belonging to villages where IWMP is implement, have undertaken more number of soil conservation measures than their counterparts in the villages not covered by the IWMP. As shown in figure 2, larger percentage of farmers in watershed covered villages have undertaken more than three soil conservation measures compared to the farmers in the non-watershed implemented villages, suggesting farmers have more awareness and complementarity between farm level soil conservation measures and the sub-watershed level interventions to prevent soil erosion. While formulating policies to address soil erosion problem in developing countries the integration of local traditional knowledge in to the SWC planning provides scope for overcoming the behavioural constraints faced while advocating top-down SWC measures.

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