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FARMERS' PERCEPTIONS OF SOIL EROSION AND MANAGEMENT STRATEGIES IN SOUTH BENGAL IN INDIA

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Abstract

Soil erosion is an imperative environmental deterioration that leads to serious impact on physical, economical and ecological in developing countries. Present study investigates farmers' views of soil erosion problems and their conservation knowledge and practices in the Kangsaboti watershed (South Bengal, India) to understand the complex inter-relationships between perception of farmers' knowledge and soil water conservation (SWC). Data was obtained from a survey of 540 farm households and informal discussions selected by stratified random sampling from upper, middle and lower catchment at Paschim Medinipur, Bankura and Purulia districts respectively. The analysis reveals that farmer age, farming experience, farm training, education and numbers of economically active household members are positively responsible to soil erosion and SWC in the study area. Consequently, potential knowledge of farmers is to be harnessed effectively to mitigate the problem through perception of benefits from conservation of natural resources.

Keywords: *Soil erosion; Farmers' view; Households survey; Natural resource conservation.*

1. INTRODUCTION

Dilapidation of land due to water is the foremost predicament in India. Among many environmental hazards, checking land degradation of outmost importance as it has direct bearing on decline in productivity on arable and non-arable lands. Earlier study carried out by the National Bureau of Soil Survey and Land Use Planning in India, 57% geographical area (187 Million ha) is subjected to environmental degradation (The Ministry of Agriculture, Govt. of India, 2000). The land degradation associated with the soil erosion is one of the major

challenges of India (Sharda et al. 2007). Dhruvnarayana and Rambabu (1983) reported that an average soil erosion rate was 16.35 tons/ha/year in India. Soil degradation is a delicate process, reluctantly evident to farmers' unit. Growing constraints of land and water by rapidly growing population has resulted in over exploitation of natural resources that has inflicted severe damage to soil environment. Deforestation, mismanagement of wastelands and indiscriminate usage of cultivable land have collectively induced soil erosion resulting in ecological imbalances. As per harmonized database on land degradation, 120.72 million hectare area is affected by various forms of land degradation in India with water erosion being the chief contributor (64.4%) (Maji, 2007; Nasre et al., 2013). In West Bengal, about 14% of the area is affected by water erosion (Pandey et al. 2011). One of the major negative onsite effects of soil erosion is the loss of soil fertility status leading to decline in productivity. It is estimated that India suffers an annual loss of 13.4 million tonnes in the production of major cereal, oilseed and pulse crops due to water erosion equivalent to about $ 2.51 billion (Sharda et al. 2010). Land deprivation due to water and soil fertility exhaustion is an extensive farming dilemma in India (Pender and Gebremedhin, 2007; Shards et al. 2010). Particularly in West Bengal, agriculture is the key source of employment of its inhabitants. Currently, degradation of land is a solemn predicament intimidating food safety and agricultural efficiency (Nandi 2012). Soil erosion creates severe limitations to sustainable agricultural land use, as it reduces on-farm soil productivity and causes food insecurity (Moges and Holden 2007, Bewket 2007).

Various studies have been demonstrated on soil erosion in India. The hypothesis that farmers have an underprivileged discernment in relation to land degradation and inadequate management practices has contributed to the peripheral expansion of preservation technologies. However, erosion and management cannot be stated without learning how local people utilize the land and the reckoning that steers their verdicts about land use (Stocking and Murnaghan, 2001, Haghjou et al. 2014). Farms in the Kangsaboti watershed (West Bengal, India) suffer from severe soil erosion, with rills-gullies and their deleterious effects increasee at alarming rate. Basic natural resources like soil, water and vegetative cover in the watershed are deteriorating. Farmers are not satisfied with the status of their current land holding. Therefore, the present study explores to assess farmer awareness of the soil erosion problem and explores its extent, in an attempt to understand management knowledge and practices of the farmers.

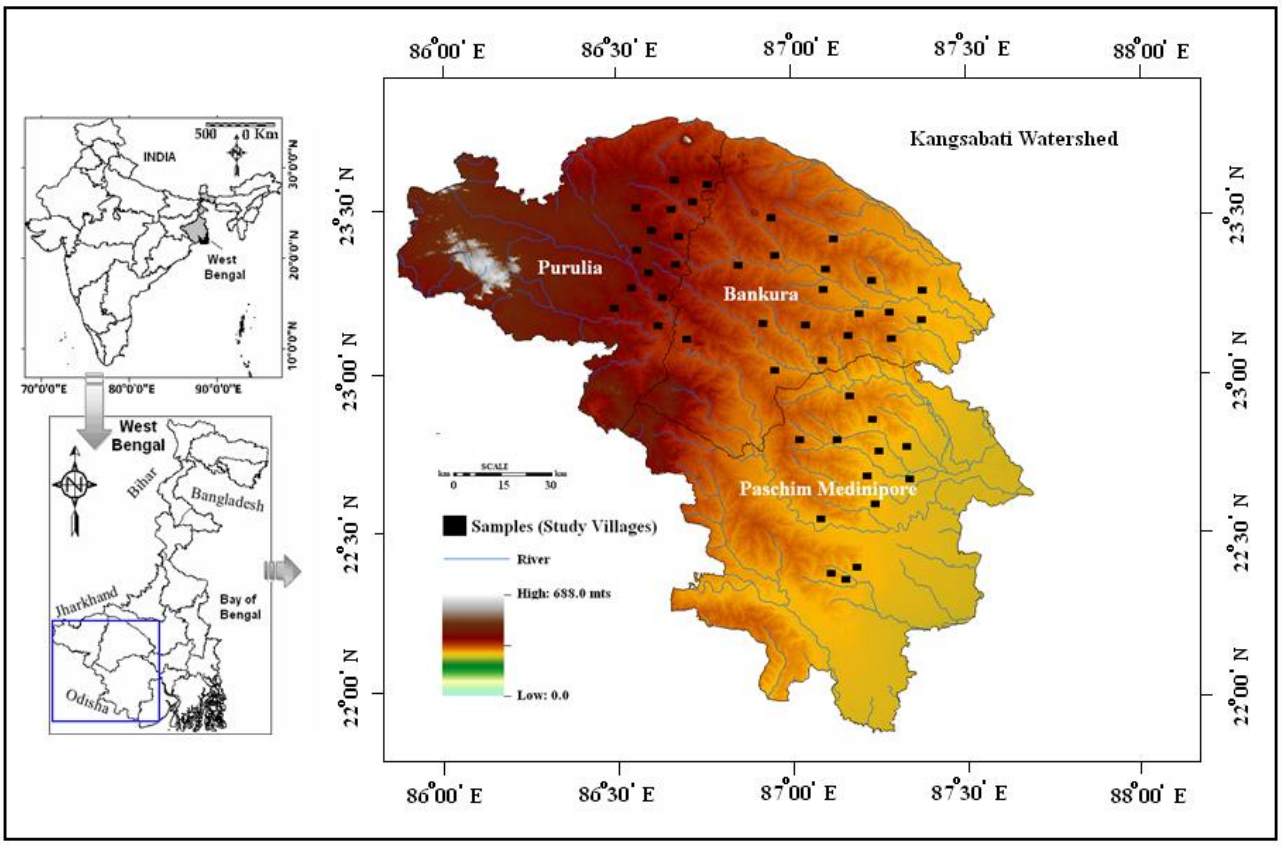

Figure 1. Location of the study area (Kangsaboti watershed, West Bengal, India)

2. DESCRIPTION OF THE STUDY AREA

The Kangsaboti watershed is a part of Chattonagpur plateau and the lower Ganga basin (Fig. 1) with an area of 5,796 km^2, extended between 87º32´E to 85 º 57´E longitudes and 22º18´N to 23º28´ N latitude. The study was conducted into three districts like, Purulia; Bankura and Paschim Medinipur district. Geomorphologically, the study area is illustrated by rolling topography and gentle slopes. The mean annual temperature is about 28.4° C with an average annual rainfall of about 1850 mm. The rainfall erosivity factor (*R)* varies between 1200 and 1500 MJ mm ha^{-1} h^{-1} year^{-1}. The area is predominantly associated with rainfed farming practice with soil erosion and low crop productivity (Shit et al. 2012, 2013). The soil of the region is characterized by lateritic, older and younger alluvial soil. The primary activity of farmers in the Kangsaboti watershed of West Bengal is mixed agriculture consisting of paddy crops and animals.

Figure 2. Partial view of the Kangsaboti River; (a, b) Overgrazing by livestock animals; (c, d) Gully erosion near of the Kangsaboti River at Rangamati, Paschim Medinipur.

Table 1. Major characteristic of three districts in the Kangsaboti watershed of the West Bengal (Source: District Census Report, 2011; West Bengal State Marketing Board and Bureau of Applied Economics and Statistics, 2007)

Characteristics of Districts	Purulia	Bankura	Paschim Medinipur
Area (ha)	625646	687998	928581
Topography	Steep - undulating	Undulating – flat	Fairly flat
Mean elevation (m)	300	78	29
Mean slope (%)	17.43	7.90	4.50
Major Soils	Loamy soils (59%) and Coarse loamy to fine loamy red soils (40%)	Loamy (74.7 %) and Gravelly clay loamy (16.24%)	Loamy (84%) and Clayey loamy (12%)
Annual rainfall (mm)	1614	1803	2111
Temperature (^{o}C)	Max. 43^{0} C, Min. 08^{0} C	Max. 43^{0} C, Min.07^{0} C	Max.42^{0} C, Min.10^{0} C

Agricultural Land (%)	49.60	50.10	59.80
Area under soil erosion by water (%)	52.42	28.93	23.48
Major soil erosion process	Rill-gully, ravine	Sheet erosion and rill-gully erosion	Sheet erosion and rill erosion
Farming system	Single crop	Two crops	Multiple crops
Cropping intensity (%)	105	147	180
Two major crops' grown	Paddy; oil sheet	Paddy; Vegetable	Paddy; floriculture
Fertility status	Very low	Low- Medium	Medium- high
Food Security condition	Insecure	Secure	Secure
Average land size per households (ha)	0.86	1.06	0.75
Total no. of farmers	352712	439957	639201
Percentage of irrigated area to cultivated area	22.93	80.35	77.05

Purulia is a drought-prone district where only rain-fed agriculture is practiced due to lack of irrigation facilities (Government of West Bengal 2011). Consequently, cropping intensity in the district is only 105 % (West Bengal State Marketing Board 2012). 49.6% area is under the agricultural productivity. Bankura is an intermediate district in terms of topography with undulating uplands towards Purulia and lower alluvial plains towards Paschim Midnapore. In Paschim Medinipur district, 59.80% area is under agricultural land (Table 1). In the present research, an agro-economic survey was conducted to assess the knowledge of farmers' perceptions of soil erosion problems (Fig 2) and also to appraise knowledge of conservation measure of soil erosion made by local participants.

3. RESEARCH METHODS

The study was conducted in three districts namely, Purulia, Bankura and Paschim Medinipur located in the upper, middle and lower catchment of the Kangsaboti watershed respectively. Table 1 shows major physio-socioeconomics characteristics of the study districts. A total of 540 farm households were randomly selected from the 45 villages for personal interviews (Fig 3). Table 2 represents the detailed characteristics of the sample households of the study villages. The data was acquired during the period between January and March 2014 that corresponds to maximum agricultural activities. The questionnaire used in the present study is consisted of both the closed and open-ended questions. However, the most of the questionnaires were open-ended thus providing respondents with a prospect to convey their outlooks without being constrained by pre-coded reaction. The key issues incorporated in the questionnaire were farmers' perception of erosion occurrence, extent and impact, changes in soil fertility and yielding properties of land, and knowledge of soil preservation and fruitful upgrading procedures. The test survey period also permitted standardization of interview technique for all interviewers. Basic information on demography, farming practices and livestock constituted the closed type of question. Issues of perceived knowledge relating to soil degradation and soil conservation practices known or practiced by farmers were put in open question format. The respondents were encouraged to mention as many indicators, reasons and

practices as possible in order to allow farmers to express their perceptions, knowledge and ideas.

Total 540 households' characteristics were considered in this study in relation to soil erosion and soil water conservation (SWC). Household characteristics were grouped in three classes based on knowledge of soil erosion and soil water conservation (Table 3). The choice of household and SWC characteristics selected in this analysis are based on the literature and informal interview. Statistical packages for social sciences (SPSS) software were used to analyze the data. Descriptive statistics primarily cross tabulation was employed to summarize the data. Finally, to identify determining factors at household level Pearson correlation was used between farmers' perceptions of soil erosion and SWC in land management.

Figure 3. Households Survey; (a and b) Women Farmers', (c) Group discussion on soil erosion and conservation techniques.

Table 2. The study villages of Kangsaboti watershed

Watershed	Catchments	Districts (village)	Study villages	Samples size (households)	Sex (%) in households size samples	
					Male	Female
Kangsaboti	Upper	Purulia	14	178	71	29
	Middle	Bankura	18	194	76	24
	Lower	Paschim Medinipur	13	168	78	22

Table 3. Soil erosion and SWC management classes at household in Kangsabotiwatershed

Household factors	Classes		
	1	2	3
Age	<30 (Young)	30-50 (Middle)	>50 (Old)
Literacy	<Class-VIII	Class-VIII-XII	>BA/BSc
Farming experience	<10	10-15	>15
Economically active family members	<3	3-5	>5
No of Farm training	0	1	>1
Soil erosion	Minor	Moderate	Severe
SWC view	No	No responses	Yes

4. RESULTS AND DISCUSSION

4.1 Household and farm characteristics

The household characteristics for each study village are represented in Table 4. The age of the farmers ranged between 21 and 68 years (±34 years). In the study area 25% households were female headed and 62% were uneducated and 45% were literate as per Indian Census 2011. Literacy rates among the investigated villages varied according to distance from district headquarters.

It is remarkable that the land properties size of the respondent families varied between 0.15 hectares and 2.0 hectares, with an average holding size of about 1.8 hectares. 81% households were stated that the size of land holdings were progressively more insufficient to support their households. It is due to the growth of rural population, soil erosion, dilapidated efficiency and nonexistence of substitute sources of occupation. Additionally, the capability of the land to sustain ever upward populations had been conciliation by property crumbling.

4.2 Cause and effects of soil erosion perception

The farmers of the Kangsaboti watershed constrain crop production problems from several decades. More than 73% of the farmers countenance soil erosion (Table 5). Soil erosion marker listed by the farmers included loss of topsoil, development of rills, the carry away of seeds and seedlings by rain, water logging in low land fields etc. In our study, mainly observed forms of erosion were rills (26%), gullies (11%) and sheet wash (63%). Severe gully erosions were found during field work in Purulia district (15%). 26% respondents in the study area had observed the pervasiveness of wearing down of topsoil during pre-monsoon season. The trouncing of topsoil from the paddy fields condensed the depth of the topsoil and direct to an abridged potential production.

Table 4. Household characteristics in upper, middle and lower catchment in Kangsaboti watershed

Household characteristic	Description	Purulia (n=178) (Upper catchment)		Bankura (n=194) (Middle catchment)		Paschim Medinipur (n=168) (Lower catchment)	
		Mean	SD	Mean	SD	Mean	SD
Age	Age of household head (years)	38	14	32	10	33	11
Literacy	Percentage of literacy rate of household head	34	10	69	13	82	9
Family size	Number of children, husband and wife	4	1	5	1.2	5	1.7
Farming experience	Number of farming years by household head	11	4.2	10	4.1	8	2.9
Economically active family members	Number of Economically Active Family Members (EAFM)	3	0.8	4	1.5	4	1.8
Off farm income	Number of household estimated off-farm income in last 12 months	15	5.1	19	6.0	25	8.4
Land size	Average land size per household (ha)	1.8	0.5	0.9	0.4	0.8	0.3
Farm plots	Number of farm plots	5	2	5	3	5	2
Number of oxen	Number of oxen per household	1.6	0.8	1.5	0.8	1.3	0.9
Livestock size	Total livestock size per household (TLU)	5.4	1.2	3.5	0.9	2.4	0.5
Livestock per capita	Number of livestock per family member	4	0.5	3	0.7	3	0.6
Farm training	Farm trainings received in the past 5 years of total household	4	2	5	1.4	6	1.8

Regarding the intensity of the problem of soil erosion, 42% of total affirmed it as moderate, 40% considered as less potential, while the continuing 18% affirmed a very less potential. 26% of the respondents avowed the severe impact, and 25% respondents considered as moderate and 49% believed to have minor impact of soil erosion on crop yields. In the surveyed area, individual farmers revealed that when seeds sown, seeding and plants are washed away during heavy rains. Results of our study illustrated that more than 18% of respondents stated temporal changes of soil erosion had become more severe, while 40% argued that it had become less

severe. Answering to the question on the possible prospect trend of the event, >49% respondents whispered soil erosion will acquire enlarged given their practices over the precedent years.

Table 5. Farmers' views of soil erosion problems, types and its impact and change over time (Percentage of respondents)

Farmers' responses to:	Purulia (n=178)	Bankura (n=194)	Paschim Medinipur (n=168)	Total (n=540)
Erosion faced in own farm				
Yes	82	71	67	73
No	18	29	33	27
Prevailing form of erosion				
Sheet erosion	60	57	71	63
Rill erosion	25	33	20	26
Gully erosion	15	10	9	11
Severity of soil erosion				
Severe	28	16	11	18
Moderate	46	40	42	42
Minor	25	44	40	40
Impact of erosion on crop yield				
Severe	27	28	22	26
Moderate	30	25	21	25
Minor	43	47	57	49
The rate over time				
Increasing	70	48	28	49
Same	20	34	45	33
Decreasing	10	18	27	18

High rainfall and steep slopes as the chief factors of soil erosion revealed by 47% and 25% respondents' respectively. Local people also stated that poorly assembled preservation structures and runoff from roadside drainage and culverts were the additional causes of soil erosion in the study area. Turn down of productivity on land was evidenced by all of the interviewed farmers, and they accredited rainfall deficiency, declining productivity for unremitting cultivation (Table 6).

Farmers reported that they observed decline in land productivity, loss of fertile soil, shortage of farm and grazing land, loss of seeds, loss of chemical fertilizers and pesticide, ever increasing fertilizer requirements, formation of gullies that inhibit plowing and mobility of people and cattle, exposure of hard subsoil layers as the consequence of soil erosion. Our result on farmers' perception of the impacts of soil erosion is also corroborated with the previous study conducted by Lal 2001; Bewket, 2011. The analysis also stated that farmers actually paying attention on the loss of soil and spoil caused to agricultural lands by sediment deposits that have caused substantial dent to downstream grazing lands.

Table 6. Farmers' perception in own plots of the causes soil erosion and productivity decline and assessment of fertility status and change over time (Percentage of respondents)

Farmers' responses to:	Purulia	Bankura	Paschim	Total

	(n=178)	(n=194)	Medinipur (n=168)	(n=540)
Causes of soil erosion				
Erosive rains	45	42	54	47
Slope steepness	34	23	17	25
Damaged conservation structures	12	20	15	15
Tillage	9	15	14	13
Causes of productivity decline				
Heavy Rainfall	0	3	15	6
Rainfall shortage / drought	69	44	29	47
Fertility decline	11	19	26	19
Continuous cultivation	5	21	13	13
Soil erosion	15	11	16	14
Others	0	2	1	1
Soil fertility status in own plots				
High fertility	0	2	5	2
Medium fertility	52	71	81	68
poor fertility	48	27	14	30
Changes in fertility over time				
Improving	7	16	21	15
Declining	89	79	72	80
No change	4	5	7	5

4.3 Changes in Soil Fertility and Land Productivity

Agro-ecological factors perceive by farmers as reasons behind low crop yield. Six factors were identified by farmers in focus groups in the communities of Purulia, Bankura and Paschim Medinnipore respectively (Table 6). 68% farmers in the study site stated that their plots having a medium level of soil fertility while 30% respondents considered for poor soil fertility. Over 80% of the cultivators observed a waning trend in their farm plots' soil fertility in the past years that have been accredited to the factors with soil erosion by water (42%) and over cultivation (13%) (Table 6).

Table 7. Farmers' knowledge and use of SWC measure (Percentage of respondents)

Farmers' response to:	Purulia (n=178)	Bankura (n=194)	Paschim Medinipur (n=168)	Total (n=540)
Any soil conservation measure applied				
Yes	83	78	64	75
No	17	22	36	25
What SWC can influence				
Increased crop yield				
Yes	82	66	54	67
No	18	34	46	33
Improved soil fertility				
Yes	67	56	51	58
No	33	44	49	42
Improved soil-water retention				

Yes	87	61	57	68
No	13	39	33	32
Add market value of land				
Yes	46	51	56	51
No	54	49	44	49
Assured long-term productivity				
Yes	7	11	16	11
No	93	89	84	89
Prevent soil erosion				
Yes	89	64	59	71
No	11	26	31	29
Type of SWC measure				
Contour plowing				
Yes	88	64	17	56
No	12	36	83	44
Drainage ditches				
Yes	78	75	97	83
No	32	25	3	17
Stone terraces / bunds				
Yes	89	63	10	54
No	11	37	90	46
Waterways				
Yes	28	32	62	41
No	72	68	38	59
Tree planting				
Yes	13	27	54	31
No	87	73	46	69
Grass strips				
Yes	25	38	60	41
No	75	42	40	59
Soil bunds				
Yes	16	39	84	46
No	84	61	16	54

4.4 Knowledge and use of conservation techniques

Water erosion control measures are land management practices that control run-off or run-on. Soil and stone bunds are the introduced techniques which can be used alternatively based on the availability of stones and labor. The survey showed that, on an average 40% of households constructed either stone or soil bunds in at least one of their plots to counter water erosion. In Purulia and Bankura, 89% and 63% respectively of households constructed stone bunds for water erosion control (Table 7). Only 10 per cent of households in Paschim Medinipur district had constructed stone bunds as water control measures due to the flat topography of the area.

According to survey results, check-dams were initiated recently by the government's extension service, while the rest of the measures had a longer history of use in Purulia district (Fig 4). Some cultivators also practiced crop rotation and dung as soil conservation techniques in Bankura and Paschim Medinipur district (Table 7). Nevertheless, 25% respondents measured existing soil erosion control and management practices inadequate in our study site.

Several individuals recognize that they could not employ several soil management practices such as terraces, grass strips, grassed field boundaries, surrounding the land holding in Purulia

and Bankura districts due to the shortage of labour, too small landholdings, lack of money, and lack of secure land tenure.

Table 8. Pearson correlation of farmers' perception of Soil erosion and SWC management with household factors

Household factors	Purulia (n=178)		Bankura (n=194)		Paschim Medinipur (n=168)	
	Soil erosion	SWC	Soil erosion	SWC	Soil erosion	SWC
Age	0.25	0.30	0.26	0.23	0.31	0.37
Literacy	0.27	0.22	0.39	0.41	0.48	0.45
Farming experience	0.56*	0.54*	0.52*	0.58*	0.68**	0.62**
Economically active family members	0.39	0.51	0.36	0.45	0.44	0.53
Farm training/workshops	0.44*	0.43*	0.54*	0.48*	0.59**	0.64**

*Correlation is significant at 0.05 level (two-tailed), ** Correlation is significant at 0.01 level (two-tailed).

Finally, table 8 shows the Pearson correlations between farmers' perception of soil erosion and SWC in land management at household level. The results of our analysis showed farming experience have a strong and positive correlation with the soil erosion and SWC. Despite the fact that most farmers in the study area perceive education, farming experience and training as an increasing perception of SWC, this perception dose not significantly influence their decisions to SWC in land management.

Figure 4. Conservation techniques of soil erosion

(a) Field Visit on March, 2014 for assessment and identification causes of soil erosion and its impact on crops production. (b) Plaguing techniques of agriculture field, (c) Mud bending in agricultural plots to protect the water, (d) Check dam to protect the soil erosion, (e) Terrace cultivation for vegetable crops and (f) Terrace cultivation for rice crops.

5. CONCLUSION

Present study assess the farmers' perception and knowledge in relation to soil erosion process and its mitigation measures in three districts- Purulia, Bankura and Paschim Medinipur of West

Bengal within Kangsaboti river basin. The results of our study illustrated that farmers in the study area are well aware of the soil erosion problem and its positive and negative impacts. More than 73% of individuals reported that they have faced soil erosion in any case at one of their plots of land. Farmers are able to identify erosion and fertility loss indicators that are relevant and sufficiently express the degree and the nature of the problems in their area. This study also stated that farmers have a holistic observation of soil erosion and turning down of productiveness as the consequence. Cultivators had superior information on soil wearing away, management, and productiveness enhancement methods. Consequently, building on farmers' knowledge via participatory advances to tackle the barricades that hamper their full consumption of known soil erosion control and conservations would have a optimistic contact on soil water conservation (SWC) and sustainable land management.

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