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A Probit Regression Analysis of Sustainable Disaster Preparedness in Erosion-Prone Areas of Abia State, Nigeria

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Abstract*—The study assessed the determinants of disaster preparedness in erosion-prone communities of Abia State, Nigeria, by employing the probit regression analysis. A sample size of seventy-two (72) respondents was selected using the two-stage sampling technique. Using the probit regression analysis, the relationship between the farmers' perception of erosion causes and disaster preparedness was analyzed. A perception score was created and categorized into binary preparedness (1 = Prepared, 0 = Not Prepared) based on the mean (3). The independent variables included in the model were human activities, climate change, soil nature, and religion. The marginal effect was not included in this study. The results showed that farmers' perception of gully erosion causes, particularly climate change, soil nature and religion, were statistically significant at a 1% level of significance, while human activity was found significant at a 5% level of significance, and they are negatively associated with disaster preparedness. Therefore, policymakers and development professionals should bridge these knowledge gaps by promoting science-driven understanding through education, extension services and effective communication methods. Also, local beliefs through a participatory approach should be incorporated without perpetuating a culture of inaction.

Keywords*—Sustainability, Technology, Climate change, Disaster Preparedness, Rural Development

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I. Introduction

Climate change significantly impacts the global frequency and intensity of natural disasters, affecting various aspects, including human mobility, public perceptions, and vulnerability. The severity of natural disasters led the United Nations (UN) to develop the 2015 – 2030 Sendai Framework for disaster risk reduction to reduce the risks associated with ongoing disasters and prevent future ones [1]. Substantial efforts have been made to enhance the quality of climate information and hazard data, yet relatively little attention has been devoted to the evaluation of vulnerability and underlying social, economic, and historical factors that exacerbate the vulnerability of communities [2]. Climate change is projected to increase the intensity and frequency of storms, floods, erosion, and extreme temperatures, which are major drivers of global human displacement and disasters [3], [4]. Studies have found that climate change and natural disasters have a significant effect on a country's economic growth, development and loss of human and crops, thereby negatively affecting its Gross Domestic Product (GDP), particularly in developing nations [5], [6], [7]. The Sustainable Development Goal (SDG) 13, named "Climate Action", revealed the reality of climate change and its undeniable threat to the entire civilization. The first target (SDG-13.1) highlights the significance of strengthening resilience and adaptive capacity to climate-related hazards and natural disasters in all nations [1]. Global natural disasters pose a widespread issue, largely due to their escalating severity, with no country exempt, although the economic cost differs across developed, developing and underdeveloped countries. The Sustainable Development Goals Target 11.5, which aims at reducing the adverse effects of natural disasters, remains vital to achieving sustainable cities and communities [1].

Erosion is a major global soil degradation threat to the environment and socio-economic stability, particularly in developing countries [8]. Regions like Asia and Africa are particularly vulnerable due to high erosion rates resulting from land use alterations and climate change [9], [10]. Soil erosion could cause a global economic downturn of $625 billion by 2070, presenting a significant challenge to food security in Africa and other vulnerable regions [11].

In Nigeria, the South-East has been reported to be the hardest hit area in terms of floods, landslides, and erosion [12]. Gully erosion in South-East Nigeria is predicted to substantially increase by 2030, primarily due to a significant expansion of gully areas across the region, thereby exacerbating a pressing environmental concern [13]. Several factors, such as soil characteristics, hydrology, topography, and human activities, have been identified to influence gully erosion in the region [14], [15]. In Abia State, gully erosion has posed a life-threatening threat to the North Senatorial District and Isuikwuato, resulting in the closure of roads that connect villagers to the rest of the area [16].

Disaster preparedness refers to all the measures taken to prepare for and reduce the impact of disasters. It is defined as the knowledge and capacities developed by governments, response and recovery organizations, individuals and communities to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters [17]. Preparedness is a critical component in reducing the impacts of natural disasters, including gully erosion. Disaster preparedness are influenced by various demographic factors, including age, income and educational background as noted by [18], [19]. Community involvement is critical to disaster response, and a high level of preparedness among them is essential to strengthening resilience and reducing economic losses following a disaster [20]. Also, the integration of advanced technologies such as early warning systems, smartphones and digital tools can enhance the speed and efficiency of disaster response efforts [21].

An assumption exists that climate risks and actual losses caused by storms, floods, erosion or droughts are influenced not only by the climate hazard itself, but also by various social and economic factors that affect how communities are prepared to cope with such events [2], [22]. Despite the increasing threats from environmental disasters like gully erosion, particularly in vulnerable areas like Abia State, there is a considerable gap in empirical research that systematically examines how local perceptions, socio-institutional constraints, and access to technology come together to shape disaster preparedness. While existing literature has explored various aspects of disaster management, little consideration has been given to how these factors collectively influence preparedness at the community level.

Furthermore, few studies have adopted robust statistical models such as probit regression to analyze these dynamics. This analytical gap limits the capacity of policymakers and development professionals to design context-specific interventions that promote sustainable disaster preparedness. This study seeks to assess the determinants of disaster preparedness in erosion-prone communities of Abia State, Nigeria by employing the probit regression analysis.

A. *Hypothesis of the Study*

HO1: There is no significant relationship between farmers' perceived causes of gully erosion and their preparedness.

II. Methodology

The study was carried out in Bende and Isuikwuato, which are located in the North Senatorial District of Abia State, South-East, Nigeria. The North Senatorial District comprises Arochukwu, Bende, Isuikwuato, Ohafia, and Umu Nneochi Local Government Areas. Each of the Local Government Areas for the study has the following latitudes and longitudes: Bende (5.55700N, 7.63040E) and Isuikwuato (5.73520N, 7.50280E). The population of the study comprises crop farmers in the two local government areas. A two-stage sampling technique was employed to select the sample for the study. In the first stage, Bende and Isuikwuato were purposively chosen because of the prevalence of gully erosion in the areas. In the second stage, a snowball technique was used to select 40 and 32 contact farmers, respectively.

The data was analyzed using descriptive analysis (Frequency, Mean, and Percentage) and inferential statistics (probit regression). The perceived constraints were measured using a 5-point Likert scale and analyzed using mean ranking, offering a clear view of the major constraints that affect farmers' preparedness to gully erosion. The probit regression was fit to estimate the perception causes since the response dependent variable is a binary one. The dependent variable is preparedness. A perception score was created and categorized into binary preparedness (1 = Prepared, 0 = Not Prepared) based on the mean (3). The independent variables included in the model were human activities, climate change, soil nature, and religion. The perceived causes were captured using simple statements with Yes (1) and No (0) responses. The marginal effect was not included in this study. Interpretation was based on the sign and significance of the coefficients not the magnitude of the probability change.

The model specification using probit regression is thus:

$$P\ (Y=1) = \Phi\ (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4)$$

Where:

$P = (Y = 1)$ Probability that the farmers are prepared for the gully erosion disaster

Φ = Cumulative Distribution Function (CDF) of the normal distribution

β_0 = Intercept

β_1 = Coefficients of each of the independent variables

X_1 = Perceived human activity

X_2 = Perceived climate change

X_3 = Perceived soil nature

X_4 = Perceived religion.

III. Key Findings and Discussions

Socio-economic characteristics of farmers

The result in Table 2 showed the demographic profile of the farmers. The mean age of farmers was 50 years, indicating that the majority of the respondents are middle-aged to older adults. Despite possessing extensive local knowledge, this group is constrained in its adaptive capacity by age-related limitations. This is consistent with the findings of [23], who reported that older adults are perceived to be better prepared for a disaster but engage in fewer actual preparations when compared to younger adults. Furthermore, the respondents reported an average of 21 years in farming, which suggests a familiarity with the land and traditional practices. Their level of experience in farming can influence how they interpret the causes of erosion. Farmers perceive over-cultivation, deforestation and heavy rainfall as major causes of erosion [24]. Moreover, the mean years of residency is 33 years, and this indicates a deep and enduring connection to the area. Farmers who reside in erosion-prone areas for a long period are likely to have experienced numerous gully erosion events; this factor makes their perception and preparedness crucial, especially in understanding community resilience.

TABLE 1: INDEPENDENT VARIABLES OF THE PROBIT MODEL AND THEIR EXPECTED SIGNS

Variable	Description	Expected Signs	Rationale
Perceived human activity	Binary (Yes = 1, No = 0)	+	Scientific understanding promotes preparedness
Perceived climate change	Binary (Yes = 1, No = 0)	+	Awareness of real causes likely promotes preparedness
Perceived soil nature	Binary (Yes = 1, No = 0)	+/-	Could lead to realistic planning (+) or fatalism (-)
Perceived religion	Binary (Yes = 1, No = 0)	-	Could reduce preparedness and discourage scientific interventions

While other socio-economic characteristics (gender, educational level and social network participation) were presented as frequencies, the predominance of male farmers was observed, and the majority of the respondents had only secondary education. This suggests the implication of access to information, responsiveness to technological interventions and leadership roles in disaster planning. This aligns with the findings of [25] that lack of information can hamper the ability of farmers to respond to technology interventions.

TABLE 2: SOCIO-ECONOMIC CHARACTERISTICS OF FARMERS (N = 72)

Variables	Frequency	Percentage (%)	Mean
Gender			
Male	42	58.3	
Female	30	41.7	
Age			
<30	7	9.7	
30 – 39	13	18.1	
40 – 49	14	19.4	
50 – 59	12	16.7	50.8194
60 – 69	14	19.4	
≥70	12	16.7	
Educational level			
No formal education	8	11.1	
Primary School	11	15.3	
Secondary School	39	54.2	
Tertiary	14	19.4	
Years of farming			
<10	17	23.6	
10 - 19	17	23.6	
20 - 29	11	15.3	21.8056
≥30	27	37.5	
Years of residency			
<10	4	5.6	
10 – 20	12	16.7	
21 – 30	20	27.8	
31 – 40	14	19.4	33.3611
41 – 50	13	18.1	
>50	9	12.5	
Social network			
Member	33	45.8	
Not a member	39	54.2	

Perceived Constraints to Disaster Preparedness

The highest ranked constraint in Table 3 was Poor communication channels (4.7917), this reflects the challenge farmers face in receiving relevant information and timely disaster warnings. This is unique with rural communities or erosion-prone areas where mobile connectivity and public communication infrastructures are not in existence. Information availability enhances disaster preparedness [26]. Closely followed was lack of resources (4.7639), this highlights the economic limitations faced by farmers in implementing disaster preparedness measures like relocating farm plots, building drainage systems or adopting early warning technologies. Both low educational levels of farmers and poor vegetation cover ranked the same (4.7361), which underscores structural vulnerabilities. Finally, infrastructural-related constraints such as poor linkage with disaster management agencies and the absence of drainage routes and emergency helplines indicate a systemic governance gap in local disaster risk management. Taking early preventive measures and proactive steps is necessary to reduce the impact of extreme events on the community [27].

TABLE 3: PERCEIVED CONSTRAINTS TO DISASTER PREPAREDNESS

Variables	Mean	Rank
Lack of resources	4.7639	2nd
Poor vegetation cover	4.7361	3rd (tie)
Poor/loose soil types	4.6667	6th
Poor meteorological stations	4.0972	10th
Poor linkage with disaster management agencies	4.7222	5th
Low educational levels of farmers	4.7361	3rd (tie)
Lack of drainage routes	4.5972	7th
Unavailability of emergency helplines	4.3194	8th
Poor communication channels	4.7917	1st
Incessant grazing and stampeding of farmland	4.2917	9th

Probit Regression estimates of disaster preparedness

The result in Table 4 indicates that farmers' perception of gully erosion causes, particularly climate change, soil nature and religion, were found to be statistically significant at a 1% level of significance. In contrast, human activity was found significant at a 5% level of significance. This implies that the farmers are likely to be prepared for a gully erosion disaster because they attribute the causes of erosion to these factors. Farmers who believe erosion is caused by human activities often lack the motivation to prepare because they feel incapacitated to control community-wide actions like deforestation and construction. Furthermore, farmers who perceive climate change to be the cause of erosion tend to see it as an uncontrollable force, thus, they are unlikely to prepare or take local action. Again, farmers who believe erosion is caused by soil nature are less likely to prepare because they believe it is inevitable and does not warrant preparation. Finally, the farmers who believe erosion is caused by religious or spiritual reasons are significantly less likely to prepare. They have the belief that religious activities, rather than planning, are the only way to save the situation.

TABLE 4: PROBIT REGRESSION ESTIMATES OF DISASTER PREPAREDNESS

Independent Variables	Coefficient (B)	Std. Error	Wald	P-value	df	Interpretation
Perceived human activity	-0.795	0.3962	4.021	0.045*	1	Statistically significant
Perceived climate change	-2.099	0.4065	26.664	0.000**	1	Highly statistically significant
Perceived soil nature	-1.268	0.3671	11.928	0.001**	1	Highly statistically significant
Perceived Religion	-1.033	0.3508	8.673	0.003**	1	Highly statistically significant

** (p<0.01), * (p<0.05)

IV. CONCLUSION

The study concludes that contrary to expectations, the probit regression results revealed that perception of human, natural and spiritual causes of erosion were statistically significant and negatively associated with disaster preparedness. This finding suggests that beliefs on uncontrollable and external forces may reduce disaster preparedness. Therefore, the null hypothesis of no significant relationship is rejected. Going forward, policymakers and development professionals should bridge these knowledge gaps by promoting science-driven understanding through education, extension services and effective communication methods. Also, local beliefs through a participatory approach should be incorporated without perpetuating a culture of inaction.

Declaration of Conflicting Interests

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