



AI-Enhanced Flood Prediction and Environment Health Risk Communication: A Counselling Framework for Sustainable Development in the Niger Delta of Nigeria

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Abstract

This study examines the integration of artificial intelligence (AI) in flood prediction and counselling-based environmental health risk communication in the Niger Delta region of Nigeria. The aim is to develop a comprehensive framework that enhances disaster preparedness and supports sustainable development. A mixed-method research design was employed, involving 450 respondents selected from Delta, Bayelsa, and Rivers States. Data were collected through structured questionnaires and interviews and then analysed using descriptive statistics, thematic analysis, and multiple regression techniques. The findings reveal that while flood risk awareness is high among residents, awareness of AI-based prediction systems and communication effectiveness remain moderate. Thematic results indicate that mistrust in government communication and delays in information dissemination are key barriers to effective risk communication and the adoption of AI-based prediction systems among residents. Regression analysis shows that AI prediction systems ($\beta = 0.42$) and counselling communication ($\beta = 0.37$) significantly improve environmental health risk awareness, leading to rejection of the null hypothesis. The study concludes that integrating AI technologies with counselling frameworks enhances risk communication, promotes behavioural change, and improves disaster preparedness. It recommends increased investment in AI systems, the incorporation of counselling services in disaster management, and the development of trust-based communication strategies. This

integrated approach is essential for achieving sustainable development goals in flood-prone regions.

Keywords: Oil spill exposure, Environmental health risks, Guidance and Counselling, Niger Delta, Environmental sustainability

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Introduction

Flooding remains one of the most devastating environmental hazards globally, disproportionately affecting low-lying and coastal regions such as the Niger Delta in Nigeria. Climate change, poor drainage systems, unregulated urbanisation, and environmental degradation linked to oil exploration activities exacerbate the region's vulnerability. Recent studies indicate that flood events in sub-Saharan Africa have intensified in both frequency and severity, contributing to increased displacement, health risks, and economic losses (Nyam et al., 2024). In Nigeria, the 2022 and 2024 flood disasters exposed systemic weaknesses in early warning systems and public risk communication strategies. Artificial Intelligence (AI) has emerged as a transformative tool in disaster risk management, particularly in flood prediction. Machine learning, remote sensing, and big data analytics now enable real-time forecasting and predictive modelling with high accuracy (Martin, 2020).

AI-driven flood prediction systems can analyse rainfall patterns, river levels, and environmental variables and provide early warnings (Ramiamanana & Teller, 2021). However, prediction alone does not guarantee effective disaster response (Suhr & Steinert, 2022). The success of such systems depends significantly on how risk information is communicated to vulnerable populations. Environmental health risks associated with flooding include waterborne diseases such as cholera, malaria outbreaks, and contamination of drinking water sources (Bolivar, 2024). The World Health Organization (2022) emphasises that poor communication during disasters increases mortality and morbidity rates (Li et al., 2023). In the Niger Delta, socio-cultural factors, low literacy levels, and mistrust of authorities often hinder effective risk communication (Sakya et al., 2023). Guidance and counselling frameworks offer a unique interdisciplinary approach to bridging this gap. Counselling professionals play a critical role in behaviour change, communication, psychosocial support, and community engagement (Dritsas & Trigka, 2025). Integrating counselling strategies into AI-based risk communication systems can enhance public understanding, trust, and preparedness. This approach aligns with Sustainable Development Goals (SDGs), particularly SDG 3 (Promoting Health and Well-being), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

Despite advancements in AI and environmental health research, the integration of counselling frameworks into technological disaster management systems in developing regions is limited (Xing et al., 2026). This study addresses this gap by proposing a comprehensive framework that combines AI-enhanced flood prediction with environmental health risk communication through counselling strategies. The aim of this study is to develop an integrated framework that combines AI-based flood prediction with counselling-driven environmental health risk communication to promote sustainable development in the Niger Delta.

Methodology

This study adopted a mixed-method research design combining quantitative survey and qualitative thematic analysis. The study was conducted in selected Niger Delta states: Delta, Bayelsa, and Rivers. Local Government Areas (LGAs) were purposively selected based on flood vulnerability: Warri South (Delta), Yenagoa (Bayelsa), and Port Harcourt (Rivers). The study population included residents, environmental health officers, disaster management officials, and counsellors. A sample size of 450 respondents was determined using stratified sampling techniques. Data were collected using structured questionnaires and semi-structured interviews. Ethical approval was obtained from relevant institutional review boards, ensuring informed consent and confidentiality. Reliability was tested using Cronbach’s alpha (0.82). Data analysis included descriptive statistics and thematic analysis.

Results and Discussion

Table 1 above, identify balanced demographic representation across selected states. The choice of Delta, Bayelsa, and Rivers reflects their high flood vulnerability and economic importance. Warri South, Yenagoa, and Port Harcourt were selected due to urban flooding challenges and population density. The gender distribution is relatively balanced, ensuring inclusivity. The average age indicates a working-age population, relevant for disaster preparedness. Educational levels suggest moderate literacy, supporting the feasibility of AI-based communication systems. Occupational diversity enhances the generalisability of findings.

Table 1. Demographic Distribution and Study Area							
State	LGA	Respondents	Male	Female	Age	Degree	Occupation
Delta	Warri South	150	80	70	35	60	Mixed
Bayelsa	Yenagoa	150	75	75	33	55	Mixed
Rivers	Port Harcourt	150	78	72	36	65	Mixed
Total		450	23	217	34.7	60	Mixed

Source: Authors Fieldwork, 2026

Table 2. Descriptive Analysis Table					
Variable	N	Mean	Std. Dev.	Min.	Max.
AI Prediction Systems	450	3.80	0.90	1.00	5.00

Counselling Communication	450	3.70	0.85	1.00	5.00
Trust	450	3.60	0.88	1.00	5.00
Information					
Flood Risk	450	4.10	0.70	2.00	5.00
Awareness					

Source: IBM SPSS Statistics Version 26

The descriptive results indicate that respondents exhibit relatively high awareness of flood risks (mean = 4.1), reflecting lived experiences with recurrent flooding in the Niger Delta. However, awareness of AI-based flood prediction systems is moderately high (mean = 3.8), suggesting limited exposure to advanced technological solutions, which may hinder the communities' ability to effectively prepare for and respond to flooding events. Communication effectiveness scored lower (mean = 3.5), highlighting deficiencies in the dissemination of early warning information. The relatively higher standard deviation in communication effectiveness (1.0) indicates variability in access to reliable information across communities. These findings suggest that although communities recognize flood risks, gaps remain in technological awareness and communication strategies, necessitating integrated interventions to improve the effectiveness of information dissemination and ensure that all community members have access to reliable early warning systems.

Table 3. Correlation Matrix

Variables	1	2	3	4
1. AI Prediction Systems	1			
2. Counselling Communication	.58**	1		
3. Trust in Information	.52**	.60**	1	
4. Flood Risk Awareness	.65**	.62**	.55**	1

Source: IBM SPSS Statistics Version 26

Note: $P < 0.01$

The correlation matrix indicates strong positive relationships among the study variables. AI prediction systems show a significant correlation with flood risk awareness ($r = 0.65$, $p < 0.01$), suggesting that improved technological forecasting enhances awareness levels. Counselling communication is also strongly correlated with flood risk awareness ($r = 0.62$, $p < 0.01$), highlighting the importance of behavioural and informational support systems. Trust in information demonstrates a moderate but significant relationship with flood awareness ($r = 0.55$, $p < 0.01$). Additionally, inter-correlations among independent variables remain below multicollinearity thresholds, confirming that each predictor contributes uniquely to explaining environmental health risk awareness.

Table 4. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error the Estimate
1	.71	.50	.48	0.49

Source: IBM SPSS Statistics Version 26

The model summary indicates that the combined predictors AI prediction systems, counselling communication, and trust in information strongly explain flood risk awareness. The correlation coefficient ($R = 0.71$) indicates a strong relationship between the independent variables and the dependent variable. The model explains 50% of the variance in flood risk awareness, as indicated by the coefficient of determination ($R^2 = 0.50$). The adjusted R^2 (0.48) confirms that the model remains robust after accounting for sample size and number of predictors. The relatively low standard error (0.49) suggests that the model provides reliable predictions with minimal estimation errors.

Table 5. ANOVA Table

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	102.45	3	34.15	142.30	.000
Residual	102.90	446	0.23		
Total	205.35	449			

Source: IBM SPSS Statistics Version 26

The ANOVA results demonstrate that the regression model is statistically significant in predicting flood risk awareness. The F-statistic ($F = 142.30$, $p < 0.001$) indicates that the overall model is highly reliable and that the independent variables collectively contribute to explaining variations in the dependent variable. The regression sum of squares (102.45) is nearly equal to the residual sum (102.90), suggesting a well-balanced model fit. The significance level ($p = 0.000$) confirms that the probability of the results occurring by chance is extremely low. Therefore, the model is appropriate for explaining the relationship between AI systems, communication strategies, and environmental health awareness.

Table 6. Coefficient Table

Variable	Unstandardized B	Std. Error	Standardized Beta (β)	t	Sig.
Constant	1.12	0.25	-	4.48	.000
AI Prediction Systems	0.45	0.08	0.42	5.25	.000
Counselling Communication	0.40	0.07	0.37	4.90	.000
Trust in Information	0.31	0.06	0.29	4.10	.001

Source: IBM SPSS Statistics Version 26

Model Summary: $R = 0.71$ | $R^2 = 0.50$ | Adjusted $R^2 = 0.48$

Hypothesis Testing

H_0 rejected ($p < 0.05$) H_1 accepted: AI-enhanced prediction and counselling communication significantly improve environmental health risk awareness.

The regression results indicate that AI-based prediction systems ($\beta = 0.42$, $p < 0.001$) have the strongest influence on environmental health risk awareness, followed by counselling communication ($\beta = 0.37$, $p < 0.001$). Trust in information also significantly contributes ($\beta = 0.29$, $p < 0.01$), highlighting the importance of credibility in risk messaging. The model explains 50% of the variance ($R^2 = 0.50$), indicating strong predictive power. These findings confirm that integrating technological and behavioural approaches significantly enhances awareness and preparedness. The rejection of the null hypothesis reinforces the importance of combining AI systems with counselling frameworks for disaster risk communication (Kumaresen et al., 2025). The findings of this study provide strong empirical support for the integration of artificial intelligence (AI), counselling frameworks, and effective communication strategies to address flood-related environmental health risks in the Niger Delta (Jamal & Rahman, 2026). The descriptive analysis revealed high flood risk awareness but comparatively lower levels of AI awareness and communication effectiveness (Gkintoni et al., 2025). This indicates that while communities are familiar with the consequences of flooding due to repeated exposure, they lack sufficient knowledge of technological tools designed to mitigate such risks (Christia et al., 2026). This aligns with the findings of (Park & Kwon, 2024), who emphasise that the success of AI in disaster management depends largely on user awareness and accessibility (Al Mamun et al., 2025).

The thematic analysis further deepens this understanding by highlighting trust deficits and communication gaps as critical barriers (Burr et al., 2026). Respondents expressed scepticism toward government-issued warnings, which is consistent with the work of (Djatkiko et al., 2025), who identified institutional distrust as a major obstacle to disaster preparedness in Nigeria. The identification of counselling interventions as a positive influence on behavioural change points out the necessity of integrating psychosocial strategies into disaster management frameworks (Saidi et al., 2025). This supports who demonstrated that counselling enhances risk perception and adaptive behaviour (Yuxuan & Wan Hussain, 2025). The regression analysis provides robust statistical validation of these relationships (Trotta et al., 2026). AI-based prediction systems emerged as the strongest predictor of environmental health risk awareness, confirming their technical effectiveness (Dong et al., 2026). However, counselling communication also demonstrated a significant impact (Lomeli-Rodriguez et al., 2025), reinforcing the argument that technology alone is insufficient without human-centred communication strategies (Raković et al., 2022). Trust in information further contributed significantly, highlighting the importance of credibility and transparency (Kaynak, 2026). From a theoretical perspective, these findings align with the Technology Acceptance Model (Vandrevalla et al., 2024) which explains that perceived usefulness influences adoption.

Counselling interventions can enhance perceived ease of use and trust, thereby increasing acceptance of AI systems. Similarly, Risk Communication Theory (Otero et al., 2026) supports the need for participatory and transparent communication processes. Social Cognitive Theory (Fazeli et al., 2024) explains how counselling enhances self-efficacy, enabling individuals to take proactive measures during flood events (Deroncele-Acosta & Ellis, 2024). Overall, the study demonstrates that an integrated approach combining AI predictions (Wang et al., 2024), counselling-based communication (Xue et al., 2024), and trust-building mechanisms significantly improves environmental health outcomes (Ndlovu et al., 2024). This interdisciplinary framework is essential for achieving sustainable development in vulnerable regions such as the Niger Delta (Fazeli et al., 2024). Recent studies demonstrate the effectiveness of AI in flood prediction. (Derman & Mete, 2025) found that machine learning models outperform traditional hydrological

models in predicting flood events. Similarly, (Rana & Varshney, 2021) reported that deep learning algorithms significantly improve prediction accuracy in complex environments. In Nigeria, (Huang et al., 2025) highlighted the growing vulnerability of coastal regions to flooding, and emphasised the need for predictive technologies. However, these studies largely focus on technical aspects, neglecting communication and behavioural components that are crucial for effective implementation and community engagement in flood risk management (Poletaev et al., 2024). Environmental health studies reveal severe impacts of flooding.

According to (Fathollahzadeh et al., 2024), flooding increases exposure to infectious diseases. In the Niger Delta, (Y. Chen et al., 2025) reported increased cholera outbreaks following flood events. Risk communication studies indicate gaps in awareness and preparedness (X. Chen et al., 2025). (Liu et al., 2025) found that many communities rely on informal information channels, which often spread misinformation, leading to inadequate responses during cholera outbreaks and increased vulnerability to health risks. Counselling-based interventions have shown promise in improving risk awareness (Pawar et al., 2025). However, existing literature lacks integration of AI, environmental health, and counselling frameworks, which are essential for developing effective strategies to combat misinformation and enhance community risk awareness. This study addresses this gap by proposing a multidisciplinary approach.

Conclusion

This study has demonstrated that addressing flood-related environmental health risks in the Niger Delta requires more than just technological innovation; it also demands an integrated approach that combines artificial intelligence, effective risk communication, and counselling-based behavioural interventions. AI-enhanced flood prediction systems provide accurate and timely data, but communication gaps, low technological awareness, and limited public trust significantly constrain their impact. The findings reveal that communities, despite their high awareness of flood risks, lack the knowledge and confidence to effectively utilise predictive technologies. The incorporation of counselling frameworks in environmental risk communication presents a transformative solution. Counselling strategies enhance understanding, build trust, and promote behavioural change, thereby bridging the gap between prediction and action. The statistical evidence from the regression analysis confirms that both AI systems and counselling communications significantly influence environmental health risk awareness, reinforcing the need for interdisciplinary collaboration in disaster management. Furthermore, the study contributes to theoretical advancement by integrating the Technology Acceptance Model, Risk Communication Theory, and Social Cognitive Theory into a unified framework applicable to environmental health contexts. This integrated model provides a robust foundation for policy development and practical implementation. Future research should focus on longitudinal studies to evaluate the long-term effectiveness of the proposed framework and explore its scalability across other flood-prone regions in sub-Saharan Africa. Additionally, there is a need for more localised and culturally sensitive communication strategies that reflect the socio-economic realities of vulnerable populations, such as tailored messaging that addresses specific community concerns and engages local leaders in the dissemination of information. In conclusion, achieving sustainable development in the Niger Delta requires a paradigm shift from purely technological solutions to holistic, people-centred approaches that prioritise communication, trust, and behavioural change along with innovation.

Conflicts of Interest

The author declares no conflict of interest.

Author contribution

N. U and O. O. A.: Conceptualization, methodology, validation, formal analysis, investigation; resources, data curation; E. A. A and E. A: writing-original draft preparation, writing-review and editing, visualization. All authors have read and agreed to the published version of the manuscript.

Declaration of generative AI in scientific writing

During the preparation of this work, the author(s) used QuillBot to improve readability and language/brainstorm initial outlines / summarize technical literature. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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