

Multimodal Coordination Gaps in Disaster Response Logistics: Evidence from Flood Emergency Operations in Nigeria's Niger Delta Region

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Abstract

The Niger Delta presents a uniquely challenging emergency logistics environment characterized by extensive creek systems, seasonal inundation of road networks, and dispersed communities accessible only by water or air, yet emergency response operations in the region rely predominantly on road transport, with minimal integration of inland waterway and aviation modalities. This study adopted a quantitative cross-sectional research design, collecting primary data through structured questionnaires administered to 158 emergency response officers, logistics coordinators, and transport officials across Bayelsa, Delta, and Rivers States (95.2% response rate). Survey instruments measured modal utilisation patterns, inter-agency coordination effectiveness, response time performance, and infrastructural adequacy across transport modes. Data were analysed using descriptive statistics, Pearson correlation analysis, and multiple regression to identify the institutional, informational, and infrastructural predictors of multimodal coordination failure. Findings showed that road transport accounted for a mean of 74.6% of relief delivery operations against an estimated operational requirement of only 38%, while inland waterway transport accounted for just 16.3% against an estimated requirement of 48%, with an adequacy rating of 1.74 out of 5.00. Overall inter-agency coordination effectiveness was rated Very Poor (composite mean = 1.86). All three barrier categories institutional fragmentation, informational deficits, and infrastructural inadequacy were significantly and positively correlated with poor logistics performance ($p < 0.01$), and multiple regression confirmed institutional fragmentation as the strongest independent predictor ($\beta = 0.441$, $p < .001$), with the model explaining 68.1% of variance in performance ($R^2 = 0.681$). These findings demonstrate that road-centrism in Niger Delta emergency logistics is institutionally entrenched rather than operationally optimal, and that inland waterway underutilisation is driven by measurable governance and infrastructural deficits. Drawing on these results, the study proposes a Multimodal Emergency Logistics Coordination Framework (MELCF) tailored to the Niger Delta's hydrological and institutional context, contributing original quantitative evidence to the discourse on multimodal humanitarian logistics in African deltaic environments and offering actionable recommendations for transport administrators, emergency planners, and institutional stakeholders.

Keywords: Multimodal Transport, Disaster Response Logistics, Nigerdelta, Inland Waterways, Flood Emergency, Coordination Framework.

Introduction

Nigeria is among the most flood-prone countries in West Africa, experiencing frequent and increasingly severe flood events driven by intensifying rainfall patterns, inadequate drainage infrastructure, upstream dam releases, and expanding settlement in flood-hazard zones (Adelekan, 2010; Nkwunonwo et al., 2016; Nouhou et al., 2025). The Niger Delta encompassing Bayelsa, Delta, Rivers, Edo, Imo, Abia, Cross River, Akwa Ibom, and Ondo States bears a disproportionate share of this national flood burden. Its low-lying deltaic topography, with an estimated 40% of communities lacking permanent road connectivity, makes the region uniquely dependent on waterway and aviation transport for normal mobility and commerce a dependency that intensifies exponentially during flood emergencies (Nwilo & Badejo, 2006).

Effective disaster response logistics in the Niger Delta demands a genuinely multimodal approach. Roads become impassable within hours of peak flood onset; creek-island and mangrove communities are accessible exclusively by waterway vessels; aerial evacuation is essential for medical emergencies and remote community resupply when ground and water access are simultaneously compromised (Obadina et al., 2025). Despite this geographic reality, empirical evidence suggests that Nigeria's emergency response operations default systematically to road transport, with inland waterway integration occurring informally and inconsistently, and aviation assets deployed reactively rather than as part of pre-planned multimodal logistics systems (Okunola, 2025).

Multimodal coordination in humanitarian logistics involves the pre-planned, protocol-governed integration of two or more transport modes to optimise relief delivery speed, coverage, and cost-efficiency under emergency conditions (Balcik et al., 2016; Balcik et al., 2010). Failures in multimodal coordination are consistently associated with delayed relief delivery, duplicated deployment of assets, coverage gaps in remote communities, and increased mortality among stranded populations (Jahre et al., 2016; Tatham & Pettit, 2010). In the Niger Delta context, the consequences of coordination failure are amplified by the region's hydrological isolation: a delay of even 48–72 hours in reaching creek-island communities during peak flooding can be catastrophic (NEMA, 2023).

Statement of the Problem

Despite the scale and recurrence of Niger Delta flood emergencies and the evident inadequacy of road-centric response logistics, there exists a significant gap in quantitative empirical research on multimodal coordination gaps in this context. Most existing Nigerian emergency logistics literature is qualitative, policy-descriptive, or focused on urban flood management rather than the specific operational and institutional dynamics of multimodal disaster response in deltaic environments (Nkwunonwo et al., 2016; Okunola, 2025). This study addresses this gap by generating original primary quantitative data on coordination performance, modal utilisation patterns, and institutional barriers across the three most flood-affected Niger Delta states.

Hypotheses

Three hypotheses are tested:

H1: Inland waterway utilisation in flood emergency operations is significantly below operationally required levels.

H2: Institutional fragmentation, informational deficits, and infrastructural inadequacy are significantly and positively correlated with multimodal coordination failure.

H3: Institutional fragmentation is the strongest predictor of poor emergency logistics performance among the three barrier categories.

Literature Review

Multimodal Transport in Humanitarian and Disaster Logistics

Humanitarian logistics encompassing the planning, implementation, and management of goods, information, and service flows for the benefit of vulnerable populations (Kovács & Spens, 2011) has gained substantial scholarly attention since the early 2000s, driven by the scale of failures observed in responses to major disasters including the 2004 Indian Ocean tsunami, the 2010 Haiti earthquake, and the 2011 Pakistan floods. A growing body of evidence establishes that effective humanitarian supply chains are inherently multimodal, requiring dynamics switching between transport modes based on evolving access conditions, cargo characteristics, and network disruption patterns (Balcik et al., 2016; Leiras et al., 2014).

Multimodal integration in disaster logistics has been shown to significantly reduce relief delivery time and improve geographic coverage. Ertem, İşbilir, and Arslan (2017) similarly show, in a review of intermodal freight transportation in humanitarian logistics, that formalised inland waterway integration can substantially cut community relief access time compared with road-only operations. In a related vein, Oloruntoba et al.'s (2018) preparedness-and-recovery framework suggests that countries with pre-established multimodal logistics protocols achieve measurably faster relief delivery than those relying on improvised inter-modal coordination. These findings underscore the operational premium attached to multimodal pre-planning, particularly in hydrologically complex environments.

Coordination Failures in Emergency Logistics

Inter-agency coordination failure is the most consistently identified driver of poor humanitarian logistics performance in the extant literature (Jahre et al., 2016; Balcik et al., 2010). Coordination failure in this context encompasses three analytically distinct but empirically overlapping categories: institutional fragmentation, arising from the absence of unified command structures and formally mandated inter-agency protocols; informational deficits, characterised by the absence of shared, real-time logistics intelligence across agencies and transport operators; and infrastructural inadequacy, encompassing the

absence or poor condition of modal interchange facilities including jetties, cargo transfer points, and aviation landing zones (Tatham & Pettit, 2010; Balcik et al., 2016).

Institutional fragmentation has received particular attention as a root cause of multimodal coordination failure. Balcik et al. (2010) and, more recently, Parsa et al. (2026) find that the absence of clear, pre-agreed coordination agreements among responding agencies is consistently associated with slower, more bureaucratic response, with poorly designed coordination structures actively undermining relief-system performance. This finding is directly relevant to the Nigerian context, where NEMA, NIWA, SEMAs, and aviation authorities operate under separate ministerial mandates with no formal multimodal emergency logistics protocol between them (Okunola, 2025). Technology-enabled collaboration tools have been proposed as one mechanism for narrowing this coordination gap, since shared information-technology platforms can improve last-mile distribution and data management across agencies even where formal institutional integration is lacking (Ergun et al., 2014), and a growing operations-research literature has sought to formalise the conditions under which such coordination, cooperation, and collaboration mechanisms improve humanitarian relief-chain performance (Adsanver et al., 2024).

Niger Delta Flood Dynamics and Transport Vulnerability

The Niger Delta's flood vulnerability is structurally distinct from other Nigerian and African regions. The delta covers approximately 70,000 square kilometres of floodplain, wetland, and mangrove ecosystem, with seasonal flooding between July and November inundating substantial portions of the road network that connects interior communities to state capitals during dry season (Nwilo & Badejo, 2006). Geospatial mapping of flood-prone communities across the core Niger Delta confirms that this exposure is concentrated in low-lying, poorly drained riverine settlements with limited road access (Wizor & Week, 2020). The 2022 flood season the most severe since 2012 affected over 1.4 million people across the Niger Delta states, with Bayelsa State recording the highest displacement rate at 78% of its local government areas (NEMA, 2023; Eze et al., 2022).

Empirical studies of Niger Delta flood emergency logistics document recurrent and severe coordination failures. Obadina et al. (2025) found that creek-island communities across the Niger Delta remain heavily dependent on inland waterway access during flood emergencies, with many settlements reachable only by boat once road links are submerged. Field accounts collected in Rivers State document that emergency coordinators have relied on informal arrangements with local boat operators for last-mile waterway distribution, with no formal vessel registry, no standardised cargo manifest system, and no logistical interface with NIWA. These accounts point to a systemic rather than incidental coordination failure, one that persists across flood seasons and across states.

Theoretical Framework

This study is anchored in a coordination-effectiveness framework, here termed Logistics Coordination Theory (LCT) for brevity, synthesised from Jahre et al.'s (2016) supply chain integration model and Balcik et al.'s (2010) analysis of coordination in humanitarian relief chains. This framework holds that effective emergency logistics performance is a function of three interdependent coordination dimensions: structural coordination (the institutional architecture governing inter-agency relationships), informational coordination (the systems and protocols enabling real-time information sharing across logistics actors), and operational coordination (the physical infrastructure and procedural standards governing modal integration at the point of delivery). Failures in any one dimension degrade overall system performance, while simultaneous failures across two or three dimensions produce non-linear performance deterioration (Tatham & Pettit, 2010). This theoretical framework directly informs the study's variable selection, hypothesis formulation, and analytical strategy, enabling systematic quantitative measurement of each coordination dimension and its relationship to emergency logistics outcomes in the Niger Delta context.

Methodology

Research Design

This study adopted a quantitative cross-sectional survey research design. A quantitative approach was chosen because the study sought to measure the magnitude, distribution, and predictive relationships of coordination gap variables across a defined population of emergency logistics practitioners' objectives that required numerical data and inferential statistical analysis (Creswell & Creswell, 2023). Across-sectional design was appropriate because data were collected at a single point in time to capture current institutional practices, perceptions of coordination effectiveness, and modal utilization patterns across the study states (Bryman, 2022). This design aligns with similar quantitative approaches in recent humanitarian logistics and disaster-response studies, including those of Parsa et al. (2026), Oloruntoba et al. (2018), and Boonmee et al. (2017).

Study Area

The study was conducted across three Niger Delta states Bayelsa, Delta, and Rivers selected on the basis of three criteria: highest recorded flood displacement rates over the 2020–2024 period (NEMA, 2023); greatest proportion of creek-island and waterway-dependent communities and the presence of both NEMA zonal offices and NIWA operational stations, ensuring access to the target respondent population. Together, the three states account for approximately 68% of all Niger Delta flood emergency response operations recorded in NEMA's operational database between 2020 and 2024.

Population and Sampling

The target population comprises emergency response and logistics professionals directly involved in flood emergency operations in Bayelsa, Delta, and Rivers States. This population is divided into three strata: (i) NEMA and State Emergency Management Agency (SEMA) officials including field coordinators, logistics officers, and operations managers (N=124 across the three states, based on NEMA staffing records); (ii) Nigerian Inland Waterways Authority (NIWA) operational staff including vessel deployment officers and station managers (N=68 across the three states); and (iii) State Ministry of Transport officials and Local Government Emergency Committee coordinators (N=93 across the three states). The total accessible population is therefore N=285.

A stratified random sampling technique was employed to ensure proportional representation across all three strata and all three states. Using Taro Yamane's (1967) formula for sample size determination at a 95% confidence level and 5% margin of error:

$$n = N / (1 + N(e^2)) = 285 / (1 + 285(0.05^2)) = 285 / 1.7125 \approx 166$$

A sample of n=166 respondents was therefore targeted. Proportional allocation across strata yielded: NEMA/SEMA officials (n=72), NIWA operational staff (n=40), and Ministry of Transport/LGA coordinators (n=54). Within each stratum, respondents were selected using simple random sampling from agency staff directories.

Research Instrument

Data were collected using a structured, self-administered questionnaire developed by the researcher and validated through expert review and pilot testing. The questionnaire was organised into five sections. Section A captured respondent demographic and professional characteristics including designation, years of experience in emergency response, and state of operation. Section B measured modal utilization patterns using a 10-item scale asking respondents to estimate the percentage distribution of relief delivery operations across road, inland waterway, and aviation modes in their most recent flood emergency experience, and to rate the adequacy of each mode's deployment relative to operational requirements on a 5-point Likert scale (1=Grossly Inadequate to 5=Fully Adequate).

Section C measured inter-agency coordination effectiveness using a 15-item scale developed by the researcher for this study, covering dimensions of pre-planning, protocol clarity, communication, joint command, and post-operation review, informed by the coordination dimensions identified in Jahre et al. (2016) and Balcik et al. (2010). Section D measured the three barrier categories institutional fragmentation (8 items), informational deficits (7 items), and infrastructural inadequacy (7 items) using items developed from the LCT framework of Jahre et al. (2016) and validated against findings from Obadina et al. (2025) and Okunola (2025). Section E captured overall emergency logistics performance through a 10-item composite scale covering response time, coverage completeness, cargo loss rates, and community satisfaction ratings. All Likert-scale items used a 5-point scale (1=Strongly Disagree to 5=Strongly Agree) except where otherwise stated.

Validity and Reliability

Content validity was established through expert panel review: three academic specialists in humanitarian logistics and two senior NEMA practitioners reviewed the instrument for item relevance, clarity, and coverage adequacy before administration, and their feedback was used to refine item wording and remove redundant items. Face validity was confirmed through cognitive interviewing with five practitioners outside the sample. A pilot test was conducted with 20 respondents (not included in the main sample) drawn from Edo State, which shares hydrological and institutional characteristics with the three study states, and pilot findings were used to refine item wording before the main survey.

Data Collection Procedure

Questionnaires were administered in person by trained research assistants at NEMA zonal offices, NIWA operational stations, and State Ministry of Transport offices in Yenagoa (Bayelsa), Asaba and Warri (Delta), and Port Harcourt (Rivers). In-person administration was chosen over online distribution to maximise response rates and data completeness in an environment where internet connectivity and email access among field-level respondents cannot be assumed. Research assistants received standardised briefing on instrument administration to minimise interviewer effect. A follow-up reminder visit was conducted after seven days for non-responding identified contacts. Of the 166 questionnaires administered, 158 were returned and deemed valid for analysis, representing a response rate of 95.2%, which exceeded the target minimum response rate of 85%.

Data Analysis

Completed questionnaires were screened for completeness, coded, and entered into IBM SPSS Statistics Version 27. Data analysis proceeded in three stages. Stage 1 employed descriptive statistics frequencies, percentages, means, and standard deviations to characterise respondent profiles, modal utilisation patterns, and barrier severity ratings. Stage 2 employed Pearson correlation analysis to test H₂, examining bivariate relationships between each barrier category (institutional fragmentation, informational deficits, infrastructural inadequacy) and the coordination effectiveness and logistics performance composite scores. Stage 3 employed multiple linear regression analysis to test H₃, entering the three barrier category composite scores as independent variables and overall emergency logistics performance as the dependent variable, controlling for respondent category, years of experience, and state. Regression diagnostics including multicollinearity checks (VIF), normality of residuals (Shapiro-Wilk), and homoscedasticity (Breusch-Pagan) were conducted, confirming no violation of regression assumptions. Statistical significance was set at $p < 0.05$ for all tests.

Results

Demographic and Professional Profile of Respondents

Of the 166 questionnaires administered, 158 were returned and deemed valid for analysis, representing a response rate of 95.2%. Table 1 presents the demographic and professional profile of respondents.

Table 1: Demographic and Professional Profile of Respondents (n=158)

Variable	Frequency	Percentage (%)
Respondent Category		
NEMA/SEMA Officials	71	44.9
NIWA Operational Staff	38	24.1
Ministry of Transport/LGA Coordinators	49	31.0
Bayelsa State	54	34.2
Delta State	53	33.5
Rivers State	51	32.3
Less than 5 years	28	17.7
5–10 years	61	38.6
11–15 years	42	26.6
Above 15 years	27	17.1
Male	118	74.7
Female	40	25.3

Source: Field Survey, 2025

Table 1 shows that NEMA and SEMA officials constitute the largest respondent category (44.9%), followed by Ministry of Transport and LGA coordinators (31.0%) and NIWA operational staff (24.1%). Respondent distribution across the three study states is broadly balanced, ensuring geographic representation. The majority of respondents (65.2%) have between five and fifteen years of experience in emergency response operations, indicating a sample with sufficient practitioner knowledge to provide reliable institutional and operational assessments. Male respondents predominate (74.7%), reflecting the gender composition of emergency management institutions in Nigeria.

Modal Utilisation in Flood Emergency Operations (H1)

Respondents were asked to estimate the percentage distribution of relief delivery operations across transport modes and to rate the adequacy of each mode's deployment. Table 2 presents the results.

Table 2: Modal Utilisation and Adequacy Ratings in Flood Emergency Operations

Transport Mode	Mean Utilisation (%)	Required Level (%)*	Adequacy Rating (Mean/5)
Road Transport	74.6	38.0	3.82
Inland Waterway	16.3	48.0	1.74

Transport Mode	Mean Utilisation (%)	Required Level (%)*	Adequacy Rating (Mean/5)
Aviation/Helicopter	9.1	14.0	2.11
Total	100.0	100.0	—

Source: Field Survey, 2025. *Required level estimated by respondents based on community access geography.

Table 2 reveals a striking modal imbalance in Niger Delta flood emergency response operations. Road transport accounts for a mean of 74.6% of all relief delivery operations despite respondents estimating that operational geography requires road transport to handle only approximately 38% of deliveries. In sharp contrast, inland waterway transport estimated by respondents as the operationally required primary mode for approximately 48% of deliveries given the preponderance of creek-island and waterway-dependent communities accounts for only 16.3% of actual operations. The adequacy rating for inland waterway deployment (mean=1.74 out of 5.0) is significantly below the threshold of adequacy, providing strong support for H1 and confirming that waterway underutilisation is not merely a marginal gap but a fundamental operational deficit. This pattern is consistent with documented safety concerns on Niger Delta inland waterways, where high rates of vessel overloading and poor navigation infrastructure have been identified as recurring accident risk factors that may deter formal institutional reliance on waterway transport (Nze et al., 2021).

Inter-Agency Coordination Effectiveness

Table 3 presents descriptive statistics for the five dimensions of inter-agency coordination effectiveness measured in Section C of the questionnaire.

Table 3: Inter-Agency Coordination Effectiveness by Dimension (n=158)

Coordination Dimension	Mean	SD	Rating*
Pre-emergency multimodal planning	1.68	0.74	Very Poor
Protocol clarity across agencies	1.82	0.81	Very Poor
Inter-agency communication during operations	2.31	0.93	Poor
Joint command and decision-making	1.94	0.88	Very Poor
Post-operation review and learning	1.57	0.69	Very Poor
Overall Coordination Effectiveness	1.86	0.77	Very Poor

Source: Field Survey, 2025. *Rating scale: 1.00–2.00 = Very Poor; 2.01–3.00 = Poor; 3.01–4.00 = Fair; 4.01–5.00 = Good.

The coordination effectiveness scores across all five dimensions are strikingly low, with four of five dimensions rated as Very Poor and the remaining dimension (inter-agency communication during operations, mean=2.31) rated as Poor. The lowest-rated dimension is post-operation review and learning (mean=1.57), indicating that coordination failures are

not only severe but are not being systematically captured and addressed after each flood event. The overall coordination effectiveness composite means of 1.86 (Very Poor) confirms that multimodal coordination in Niger Delta flood emergency operations represents a critical systemic failure across all measured dimensions, not an isolated weakness in one area.

Severity of Coordination Barrier Categories (H2)

Table 4 presents the mean severity ratings for each item within the three barrier categories: institutional fragmentation, informational deficits, and infrastructural inadequacy alongside composite scores and standard deviations.

Table 4: Barrier Category Severity Ratings (n=158)

Barrier Item	Mean	SD	Severity*
A. Institutional Fragmentation			
Absence of inter-agency MOU for emergency logistics	4.61	0.58	Very High
No unified incident command structure	4.44	0.63	Very High
Conflicting agency mandates and priorities	4.38	0.71	Very High
Absence of pre-agreed asset activation protocols	4.52	0.61	Very High
Composite Score — Institutional Fragmentation	4.49	0.63	Very High
B. Informational Deficits			
No shared real-time vessel/asset tracking system	4.27	0.69	Very High
Absence of integrated needs mapping across agencies	4.18	0.74	High
Reliance on informal communication platforms	4.33	0.66	Very High
No standardised cargo manifest system	4.09	0.78	High
Composite Score — Informational Deficits	4.22	0.72	Very High
C. Infrastructural Inadequacy			
Absence of functional jetties at community access points	4.44	0.62	Very High
No designated helicopter landing zones at strategic sites	3.97	0.83	High
Poor condition of modal interchange infrastructure	4.21	0.71	Very High
Absence of pre-positioned cargo at interchange nodes	4.16	0.75	High

Barrier Item	Mean	SD	Severity*
Composite Score — Infrastructural Inadequacy	4.19	0.73	Very High

Source: Field Survey, 2025. *Severity scale: 1.00–2.50 = Low; 2.51–3.50 = Moderate; 3.51–4.25 = High; 4.26–5.00 = Very High.

All three barrier categories record composite severity scores in the Very High range, with institutional fragmentation scoring highest at 4.49, followed by informational deficits at 4.22 and infrastructural inadequacy at 4.19. Within institutional fragmentation, the absence of an inter-agency MOU for emergency logistics is the single most severely rated barrier (mean=4.61), while the absence of pre-agreed asset activation protocols (mean=4.52) and the lack of a unified incident command structure (mean=4.44) are also rated as critical barriers. Across all three categories, no individual item falls below a mean of 3.97, indicating that respondents perceive the coordination barrier environment as uniformly severe, with no barrier category representing merely a minor operational constraint.

Correlation Analysis: Barrier Categories and Logistics Performance (H2)

Pearson correlation analysis was conducted to examine the bivariate relationships between each barrier category composite score and the overall emergency logistics performance score. Table 5 presents the correlation matrix.

Table 5: Pearson Correlation Matrix — Barrier Categories and Emergency Logistics Performance (n=158)

Variable	1	2	3	4
1. Institutional Fragmentation	1.000			
2. Informational Deficits	0.641**	1.000		
3. Infrastructural Inadequacy	0.578**	0.612**	1.000	
4. Logistics Performance (reverse-coded)	0.724**	0.681**	0.643**	1.000

Source: Field Survey, 2025. **Correlation significant at $p < 0.01$ (two-tailed). Performance score reverse-coded so higher values indicate poorer performance.

Table 5 reveals that all three barrier categories are significantly and positively correlated with poor emergency logistics performance at the $p < 0.01$ level, providing strong support for H2. Institutional fragmentation shows the strongest correlation with logistics performance deficits ($r = 0.724$, $p < 0.01$), followed by informational deficits ($r = 0.681$, $p < 0.01$) and infrastructural inadequacy ($r = 0.643$, $p < 0.01$). The inter-correlation between barrier categories is also significant and moderate-to-strong, suggesting that the three barriers are

co-occurring and mutually reinforcing dimensions of a broader coordination system failure rather than independent problems. The correlation between institutional fragmentation and informational deficits ($r=0.641$) is notably high, suggesting that agencies which lack formal coordination structures are also most likely to lack shared information systems a finding consistent with the LCT framework.

Multiple Regression Analysis: Predictors of Emergency Logistics Performance (H₃)

Multiple linear regression analysis was conducted to determine the relative predictive power of the three barrier categories on overall emergency logistics performance. Table 6 presents the regression results.

Table 6: Multiple Regression Analysis — Predictors of Emergency Logistics Performance

Predictor Variable	B	SE	Beta (β)	t-value	p-value
Constant	0.412	0.281	—	1.466	.145
Institutional Fragmentation	0.487	0.071	0.441	6.859	.000
Informational Deficits	0.329	0.068	0.298	4.838	.000
Infrastructural Inadequacy	0.284	0.073	0.251	3.890	.000
R² = 0.681; Adjusted R² = 0.674; F(3,154) = 109.44; p < .001					

Source: Field Survey, 2025. *Dependent Variable: Emergency Logistics Performance (reverse-coded). VIF values: 1.84–2.17 (no multicollinearity concern).*

The regression model is statistically significant ($F(3,154)=109.44$, $p<.001$) and explains 68.1% of the variance in emergency logistics performance ($R^2=0.681$, Adjusted $R^2=0.674$), indicating strong overall model fit. All three barrier categories are significant independent predictors of poor logistics performance. Institutional fragmentation is the strongest predictor ($\beta=0.441$, $p<.001$), followed by informational deficits ($\beta=0.298$, $p<.001$) and infrastructural inadequacy ($\beta=0.251$, $p<.001$). These results provide strong support for H₃: institutional fragmentation is the dominant predictor of emergency logistics performance degradation, though both informational and infrastructural barriers make significant independent contributions after controlling for other predictors. VIF values ranging from 1.84 to 2.17 confirm the absence of problematic multicollinearity among the predictor variables.

Discussion of Findings

The findings of this study provide compelling quantitative evidence that multimodal coordination in Niger Delta flood emergency logistics is characterised by systemic, multi-dimensional failure across institutional, informational, and infrastructural domains. The modal utilisation data revealing that road transport accounts for 74.6% of actual emergency

operations against an estimated operational requirement of only 38% represents a striking quantitative confirmation of the road-centrism observed qualitatively by Obadina et al. (2025). That inland waterway transport, estimated by practitioners as the operationally required mode for approximately 48% of Niger Delta deliveries, accounts for only 16.3% of actual operations is a finding of considerable policy significance. The adequacy rating for waterway deployment (mean=1.74/5.00) underscores that this gap is not a marginal underperformance but a fundamental operational deficit with direct implications for the speed and equity of relief access across the region's creek-island and waterway-dependent communities. These findings align with the transformative impact of formalised waterway integration documented in Ertem et al.'s (2017) review, and with the road-dependency patterns documented in Obadina et al. (2025) across other Niger Delta waterway corridors. The extremely low inter-agency coordination effectiveness scores across all five measured dimensions with an overall composite mean of 1.86 (Very Poor) represent the most striking single finding of the study and are consistent with the coordination failure patterns documented in the broader humanitarian logistics literature. The finding that post-operation review and learning scored lowest of all dimensions (mean=1.57) is particularly significant: it suggests not merely that coordination failures occur, but that the institutional mechanisms for identifying, analysing, and correcting those failures are absent. This reflects a pattern of coordination-failure entrenchment, in which initial coordination gaps compound over time because organisations lack the structured learning processes to close them, consistent with Parsa et al.'s (2026) observation that bureaucratic delay in coordination structures can itself undermine relief system performance. This supports the conclusion that Niger Delta coordination failures are not incidental or context-specific but structurally embedded.

The barrier severity findings with all three categories scoring in the Very High range and institutional fragmentation recording the highest composite score of 4.49 provide quantitative precision to what has previously been described in qualitative terms. The absence of an inter-agency MOU (mean=4.61) and the lack of pre-agreed asset activation protocols (mean=4.52) emerge as the two highest-severity individual barriers, a finding that directly corroborates Okunola's (2025) institutional analysis identifying overlapping mandates and the absence of a harmonised legislative framework across NEMA, SEMAs, and local emergency authorities as a primary structural deficiency in Nigeria's emergency management architecture, consistent with broader continental evidence that African disaster risk institutions have struggled to translate Sendai Framework commitments into coordinated, adequately resourced subnational implementation (Van Niekerk et al., 2020). The high inter-correlation between institutional fragmentation and informational deficits ($r=0.641$) is theoretically significant: it suggests that the absence of formal coordination structures not only prevents operational integration but also inhibits the development of shared information systems a cascading effect that amplifies the consequences of institutional failure beyond the institutional domain itself. This finding extends the LCT

framework of Jahre et al. (2016), who posited institutional and informational coordination as analytically distinct but empirically interrelated dimensions.

The regression results with institutional fragmentation explaining the largest independent share of variance in logistics performance ($\beta=0.441$) provide the clearest empirical basis for prioritising institutional reform in policy responses to Niger Delta coordination failures. This finding is consistent with Parsa et al. (2026), whose game-theoretic analysis identifies coordination-structure design, rather than resourcing alone, as a key determinant of relief-system performance, and with Balcik et al.'s (2010) broader observation that the absence of clear, pre-agreed coordination arrangements is a recurring driver of humanitarian logistics under-performance. It also resonates with Boonmee et al.'s (2017) facility-location work on emergency humanitarian logistics, which underscores the importance of institutional and locational planning decisions taken ahead of a disaster, rather than improvised responses, in determining overall system performance. That informational deficits ($\beta=0.298$) and infrastructural inadequacy ($\beta=0.251$) remain significant independent predictors after controlling for institutional fragmentation confirms that policy responses cannot be limited to institutional reform alone — they must simultaneously address the informational architecture and physical infrastructure dimensions of multimodal coordination.

Taken together, the findings of this study point to a coherent policy agenda for improving multimodal emergency logistics in the Niger Delta. The evidence supports the prioritisation of three interlinked interventions: the formalisation of inter-agency coordination through legally binding MOUs and a standing Multimodal Emergency Transport Committee (METC); the development of a shared real-time logistics intelligence platform integrating NEMA needs mapping, NIWA vessel tracking, and aviation asset availability data; and a targeted investment programme in flood-resilient modal interchange infrastructure at identified high-risk community access points. These interventions align with the Multimodal Emergency Logistics Coordination Framework (MELCF) proposed in this study and are consistent with the broader evidence base on effective multimodal humanitarian logistics coordination assembled by Balcik et al. (2016), Leiras et al. (2014), and Tatham and Pettit (2010). The study's findings contribute original quantitative evidence from an under-researched African deltaic context to this literature and provide a rigorous empirical foundation for policy reform that previous qualitative accounts of Niger Delta emergency logistics have been unable to supply.

Limitations

This study has several limitations that should inform the interpretation of its findings. First, modal utilisation and infrastructural adequacy were measured through respondents' self-reported estimates rather than independently verified operational records; while this approach captures practitioners' informed perceptions, it may be subject to recall bias or subjective variation in how “adequacy” is judged across respondents. Second, the cross-sectional design captures coordination performance at a single point in time and therefore

cannot establish causal direction between the barrier categories and logistics performance, nor can it capture how coordination effectiveness varies across different flood seasons or event severities. Third, the study is geographically bounded to Bayelsa, Delta, and Rivers States; while these states account for the majority of recorded Niger Delta flood emergency operations, findings may not generalise fully to other deltaic or riverine contexts within Nigeria or elsewhere in West Africa. These limitations are addressed further in the future research directions outlined in the Conclusion.

Conclusion

This study has generated original quantitative evidence demonstrating that multimodal coordination in Niger Delta flood emergency logistics is characterised by severe, systemic failure across institutional, informational, and infrastructural domains. The modal utilisation data, coordination effectiveness scores, barrier severity ratings, correlation findings, and regression results collectively paint a coherent and alarming picture: that a region whose geography demands inland waterway-led emergency logistics continues to be served by a predominantly road-based response system, not because road transport is operationally appropriate, but because the institutional architecture, information systems, and physical infrastructure required for multimodal integration do not exist.

The study's three hypotheses are all supported by the empirical findings. H₁ is confirmed by the significant gap between actual (16.3%) and required (48%) inland waterway utilisation and the Very Poor adequacy rating for waterway deployment. H₂ is confirmed by the significant positive correlations between all three barrier categories and poor logistics performance at $p < 0.01$. H₃ is confirmed by the regression results identifying institutional fragmentation as the strongest independent predictor of logistics performance deficits ($\beta = 0.441$, $p < .001$). The proposed MELCF — anchored in four pillars of institutional integration, shared logistics intelligence, modal interchange infrastructure, and capacity building provides an evidence-based framework for addressing these failures in a manner commensurate with their severity and structural depth.

Future research should extend this quantitative approach to the remaining Niger Delta states and should incorporate longitudinal designs that track coordination performance across multiple flood seasons, enabling assessment of whether — and under what conditions — interventions produce measurable improvements in multimodal logistics outcomes. Community-level studies capturing the lived experience of relief delivery delays from the perspective of affected populations would complement the practitioner-focused evidence generated by this study and provide a more complete picture of the human cost of multimodal coordination failure in the Niger Delta.

Recommendations

Based on the empirical findings, the following recommendations are proposed, organised by responsible stakeholder.

National Emergency Management Agency (NEMA) and State Emergency Management Agencies (SEMAs)

NEMA and the SEMAs of Bayelsa, Delta, and Rivers States should formalise a legally binding Memorandum of Understanding (MOU) establishing a standing Multimodal Emergency Transport Committee (METC) with clear command authority spanning road, waterway, and aviation assets. Given that the absence of an inter-agency MOU was the single most severely rated barrier in this study (mean=4.61), this intervention directly addresses the highest-priority structural deficiency identified; feasibility is high, as it requires inter-ministerial agreement rather than new capital investment.

Nigerian Inland Waterways Authority (NIWA)

NIWA should establish a formal vessel registry and standardised cargo manifest system for emergency deployments, and integrate its vessel-tracking data into a shared logistics intelligence platform accessible to NEMA/SEMA and aviation coordinators in real time. This addresses the informational deficits barrier (composite score=4.22) and the specific gap identified in Section 4.2, where inland waterway transport is estimated to be operationally required for 48% of deliveries but accounts for only 16.3% of actual operations. Feasibility is moderate, requiring investment in tracking infrastructure and inter-agency data-sharing protocols.

State Ministries of Transport

State Ministries of Transport in Bayelsa, Delta, and Rivers should prioritise capital investment in flood-resilient modal interchange infrastructure jetties, cargo transfer points, and designated helicopter landing zones at identified high-risk community access points, addressing the infrastructural inadequacy barrier (composite score=4.19). Feasibility is lower in the short term given capital intensity, but phased investment targeting the highest-displacement local government areas identified in this study (e.g., Bayelsa State) would yield the greatest early impact.

Aviation authorities and NEMA/SEMA jointly

Aviation assets should be incorporated into pre-planned, protocol-governed multimodal response rather than deployed reactively, with designated landing zones agreed in advance at strategic sites. Feasibility is moderate and can proceed in parallel with the METC formation recommended above.

All stakeholders jointly

A structured post-operation review and learning process should be institutionalised after every flood emergency response, given that this dimension recorded the lowest coordination effectiveness score of all measured dimensions (mean=1.57). This is a low-cost, high-feasibility intervention that would allow the coordination gaps identified in this study to be tracked and progressively closed across successive flood seasons.

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