ENGINEERING CLIMATE RESILIENCE FOR PEACE: TECHNOLOGICAL RESPONSES TO ENVIRONMENTAL CONFLICTS IN NIGERIA

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Abstract

Research Problem: *Environmental conflict in Nigeria has outlasted successive policy responses. In the Middle Belt and the Niger Delta, the parties to a dispute lack a shared, verifiable account of the land, water or pasture they contest.*
Methods/Theory: *This conceptual study draws on published scholarship and documentary sources. Using the Ecological Mediation Layer Framework (EMLF), it reads the January 2018 Benue State attacks and the contested Niger Delta spill investigations, and applies assumed conflict reductions to the Mercy Corps cost estimate.*
Results: *The weakness lies in how ecological change is observed, interpreted and acted upon, which scarcity explanations and existing policies leave unexamined. The EMLF identifies three functions (information amplification, behavioural structuring, institutional reinforcement) linked to predictive, adaptive, restorative and integrative technologies. Both cases show these functions were absent.*
Conclusion: *Institutions need legal authority for community data rights, platforms linking community, state and federal levels, and exposed communities as co-producers of the systems protecting them.*
Key Contribution to Knowledge: *The EMLF treats technology as a mediating actor whose effects depend on governance. It integrates scarcity literature, environmental peacebuilding and critical technology studies, and identifies data justice as a design condition.*
Recommendation: *A three-phase legal, pilot and scaling sequence: enact a conflict prevention Act; commission a national geographic information system platform; pilot early warning in Benue and Rivers States; establish a data governance code; negotiate regional data-sharing protocols.*

1. Introduction

Nigeria combines Africa's largest population with ecological zones that run from the Sahelian margins of the far north to the mangrove belt of the Niger Delta, and in both settings competition over land, water and pasture has turned violent with some regularity. In the Middle Belt, clashes between crop farmers and pastoralists have followed the southward movement of herds, and Amnesty International (2018) recorded at least 3,641 deaths in such clashes between January 2016 and October 2018. In the Niger Delta, the damage that oil extraction does to fishing and farming grounds has fed grievances that escalated, as Obi (2009) shows, from minority protest into insurgency. The two conflicts differ in actors, history and scale. They share a dispute over what has happened to a common resource and over who answers for it.

The explanation most often applied to these conflicts is the environmental scarcity thesis, which Homer-Dixon (1994) advanced to link resource depletion, population pressure and unequal access to violence. In Nigeria the thesis has directed attention to desertification and to shrinking grazing land in the north, yet the evidence it has produced is divided. Ofierohor et al. (2021) set desertification, measured by tree loss, against an index of internal conflict and found no significant relationship, whereas Lebari et al. (2022), working from secondary sources, concluded that climate change plays a major part in farmer–herder violence. Benjaminsen et al. (2012) had already taken a sceptical position for the Malian Sahel, where court records on land-use conflict showed little connection with climatic conditions and pointed instead to agricultural encroachment on herders' routes, a political vacuum and corruption among officials. When studies that use different indicators reach opposed conclusions about the same country, the disagreement points to something that none of them measures.

The argument of this paper is that the unmeasured element is the process by which ecological change is observed, interpreted and acted on, both by the disputing parties and by the state. That process rests on arrangements that settle who holds information about resource conditions, how the information is verified and who may act on it, and the paper calls these arrangements the mediating layer. Where they are absent or controlled by one party, ecological stress is read through suspicion and each side takes the other's conduct as aggression. Where the information is shared and can be verified, negotiation has a factual footing. Technology matters to the argument because satellite imagery, sensors, mobile reporting and shared digital records are now the main means of producing such information. Duffy (2014) documented the rise of militarised approaches to conservation and asked whether the coercive policies that accompany them are counterproductive, and the same risk attends any monitoring system introduced in Nigeria. The paper therefore treats technology as a mediating actor whose effect depends on how it is governed, and it builds the Ecological Mediation Layer Framework (EMLF) on that premise.

In light of this gap, the study pursues five objectives:

i. To examine how the observation, interpretation and use of information on ecological change shape environmental conflict in the Middle Belt and the Niger Delta.

ii. To explain why existing responses, namely security deployments, state legislation and compensation and spill-investigation processes, have not altered these patterns.

iii. To develop the EMLF, specifying its functions, architectures, propositions and conditions of failure.

iv. To apply the EMLF to the Benue attacks of January 2018 and the Niger Delta spill investigations, and to indicate the scale of the economic stakes through a sensitivity calculation.

v. To derive a sequenced set of policy measures and recommendations for Nigeria.

The argument proceeds as follows. Section 2 reviews the scholarship on environmental conflict, environmental peacebuilding and technology, and identifies the gap that the framework addresses. Section 3 sets out the materials and methods, including the selection of sources and the limitations of the study. Section 4 presents the EMLF, its three functions, its propositions and its conditions of failure. Section 5 reports the results: the two theatres of conflict, the reasons existing responses have not altered them, the application of the EMLF to the Benue attacks of January 2018 and the disputes over spill investigations in the Niger Delta, and a sensitivity calculation applied to the Mercy Corps estimate of the cost of conflict. Section 6 discusses the findings in relation to the framework and the literature. Section 7 presents the conclusion, the recommendations and directions for future research.

2. Literature Review

The disagreement described in Section 1 has a history in three bodies of scholarship, and each supplies part of the explanation that this paper requires.

2.1 Scarcity and Its Limits

Homer-Dixon (1994) identified reduced agricultural production, economic decline, population displacement and the disruption of institutions as the social effects through which environmental scarcity leads to violence. The Nigerian studies reviewed in Section 1 test the first link in that chain, from environmental change to conflict, and leave the intervening social effects unexamined. Benjaminsen et al. (2012) are an exception, since they attend to the conditions that intervene, and their finding that governance explained the Malian conflicts better than rainfall moves the question from the resource to the arrangements around it. None of the works discussed here examines how information about ecological change reaches the parties to a dispute, and that omission is where the argument of this paper begins.

2.2 Environmental Peacebuilding and Peace Engineering

Environmental peacebuilding asks the opposite question, namely whether shared environmental challenges can become occasions for cooperation between parties to a conflict. Dresse et al. (2019) assembled the conditions, mechanisms and outcomes of the field into a theoretical framework and pointed to the gaps that remain. Vivekananda et al. (2019) applied a joint analysis of climate and conflict risks to the Lake Chad region, identified four climate-fragility risks there, and argued that responses must be both climate-resilient and conflict-sensitive. These works show that resource governance can serve peace. They do not specify the information systems through which disputants arrive at a common factual basis for cooperation, and it is at that point that design becomes necessary.

Queiroz et al. (2023) offer a design orientation in a framework that links peace engineering with compassionate operations in pursuit of social good, supported by emerging technologies. This paper takes over the orientation towards design and adds the attention to power and distribution that the next strand of literature supplies.

2.3 Technology, Coercion and Data Justice

The turn to technology raises the question of whom a technology serves. Duffy (2014)

documented the rise of militarised approaches to conservation and questioned whether the coercive policies that accompany them are counterproductive. Obi (2009) traced the Niger Delta conflict to the struggle of minority groups for control of their natural resources against the alliance of the federal state and oil multinationals, and that history frames how any monitoring programme introduced in the region will be received. Taylor (2017) offers the corrective most relevant to design. Her data justice framework rests on three pillars, namely visibility, engagement with technology and non-discrimination, and it defines data justice as fairness in the way people are made visible, represented and treated through the data they produce. The EMLF adopts this framework as a condition of design. It also requires that satellite and sensor records be checked against observations made by the communities themselves, since a record that only outsiders can produce is hard for a disputing party to accept.

2.4 Blockchain and Distributed Ledgers

Within the technology literature, blockchain has attracted attention as a means of recording agreements in a form that no single party can alter. Smajgl and Schweik (2022), in a perspective article, argue that blockchain could give resource users new incentives, establish monitoring capacity and limit corrupt official behaviour, and they illustrate the argument with deforestation and groundwater management. Their examples concern sustainability and do not involve conflict between resource users, so the use of a distributed ledger for resource-sharing agreements in the EMLF extends their argument and does not rest on a finding of theirs. It is the least supported element of the framework, and it is retained in the integrative architecture as a proposition that field evidence must test.

2.5 Gap and Theoretical Grounding

Three observations follow from the review. The scarcity literature explains the conditions under which conflict becomes likely but leaves the process of interpretation unexamined. The peacebuilding literature establishes the value of cooperative governance without specifying the information systems on which cooperation rests. The critical technology literature shows how information systems can entrench exclusion and prescribes data justice as a corrective, yet it does not link that insight to a model of conflict prevention. The EMLF is built at the junction of the three.

Two further works supply the institutional logic. Ostrom (1990) listed monitoring of resource conditions, graduated sanctions and arrangements for resolving conflict among the design principles of enduring common-pool resource institutions, and the EMLF adds that the monitoring information must be open to the people who are monitored. Cash et al. (2006) hypothesised that cross-scale interactions are shaped by the interplay of institutions at different levels and suggested that boundary management, including knowledge co-production and mediation, may ease problems that decision makers have not solved. The framework takes from this the requirement that community, state and federal actors work from the same records.

3. Materials and Methods

3.1 Research Design and Analytical Procedure

Jaakkola (2020) describes four templates for conceptual articles, namely theory synthesis, theory adaptation, typology and model, and requires that the research design and the role of each theory be made explicit. The paper follows the theory synthesis template, combining three bodies of work into a model of mediating functions, and the choice suits a problem in which, as Section 1 showed,

the available studies disagree because they omit the same variable. The model was developed in four steps. A critical reading of the literature on environmental conflict, environmental peacebuilding and critical technology studies first identified the process linking ecological change to institutional response as the point at which the three bodies of work leave a gap. Three functions of that process were then derived from the shortcomings of Nigerian policy responses discussed in Section 5.2. The framework was next applied to two cases, and the conditions under which it would fail to predict cooperative outcomes were finally specified, so that later evidence can contradict it.

The two cases were chosen because an independent organisation has documented each (Amnesty International, 2013, 2018; UNEP, 2011) and because they differ in ecological base and in the form of the dispute, which concerns land and pasture in one case and responsibility for harm in the other. They serve as illustrations in the sense used in theory-building studies. They show where the framework locates absences in the documentary record, and they do not test it. The economic analysis in Section 5.4 is arithmetic applied to a published estimate from Mercy Corps (2015), introduces no new data and is presented as a sensitivity calculation and not as a forecast. The paper generates no primary data, and its claims about events and costs rest on the documents cited.

3.2 Selection Criteria and Data Sources

Sources were selected against four criteria, which are listed below, and Table 1 summarises the documentary sources that resulted and their contribution to the analysis.

- Publication date: sources published between 1990 and 2026.
- Geographic focus: Nigeria, with comparative references to the Sahel and the Lake Chad region.
- Thematic relevance: environmental conflict, environmental peacebuilding, and the role of technology and data in governance.
- Source type: peer-reviewed scholarship, reports by independent institutions and organisations, and news and policy material needed to document the cases.

Table 1. Documentary Sources and Their Contribution to the Analysis

Source type	Examples	Number of sources	Contribution to analysis
Published scholarship	Homer-Dixon (1994); Benjaminsen et al. (2012); Dresse et al. (2019); Taylor (2017); Ostrom (1990)	13	Provided theoretical and empirical context for environmental conflict, peacebuilding and technology
Institutional reports	Amnesty International (2013, 2018); UNEP (2011); Mercy Corps (2015); Vivekananda et al. (2019)	5	Provided documentary evidence on the Benue attacks, the Niger Delta spill investigations, the Ogoniland baseline, the economic costs of conflict and climate-fragility risks in the Lake Chad region

Source type	Examples	Number of sources	Contribution to analysis
News and policy material	Vanguard (2018); Nigerian legislation (Land Use Act; National Environmental Standards and Regulations Enforcement Agency [NESREA] Act; Climate Change Act)	4 (1 news report; 3 statutes named in the text)	Provided context on the Benue grazing law and on the policy frameworks relevant to the recommendations

Note. Counts refer to the sources cited in this paper and listed in the References, except for the three statutes, which are named in the text.

3.3 Limitations of the Study

Four limitations qualify the study. As a conceptual and analytical study, it generates no primary data, and the propositions of the EMLF await quantitative and field-based validation. The two cases rest on documentary sources, they were chosen for the availability of independent documentation, and they supply no instance in which an information system was in place and conflict persisted, which is the observation that would test the framework most severely. The framework also leaves aside much that Amnesty International (2018) and others identify as bearing on the Middle Belt conflicts, including impunity, ethnic and religious polarisation and the politics of land, and it claims only that the mediating layer is one condition of settlement among several.

The sensitivity calculation in Section 5.4 rests on assumed reductions and on a single published estimate for four states. The focus on two theatres also leaves other ecologically stressed zones, such as coastal erosion areas, south-eastern flood zones and the Lake Chad basin, outside the analysis.

4. Theoretical Framework

This section addresses Objective 3. The study does not adopt an existing theory unchanged, and the EMLF departs from each of the three bodies of work reviewed in Section 2 in a specific way. From the scarcity literature (Homer-Dixon, 1994) it keeps the concern with the conditions under which resource stress turns violent, but it moves the point of analysis from the resource to the process by which stress is observed and interpreted. From environmental peacebuilding (Dresse et al., 2019) and peace engineering (Queiroz et al., 2023) it keeps the premise that shared environmental problems can support cooperation and that cooperation can be designed, but it specifies the information systems on which cooperation depends. From critical technology studies (Duffy, 2014; Taylor, 2017) it takes the warning that monitoring can serve coercion, and it makes data justice a condition of design and not an afterthought.

The EMLF treats technology as an actor that mediates between ecological conditions, the behaviour of resource users and the response of institutions, and it assigns the mediating layer three functions. Information amplification acts on what the parties know, behavioural structuring acts on how they use land and pasture and settle damage, and institutional reinforcement acts on the bodies that must enforce agreements. Each function is paired with a class of technological architecture, as Table 2 shows, and each yields one proposition that later evidence can support or contradict.

Table 2. The Ecological Mediation Layer Framework: Functions, Architectures and Applications

EMLF function	Architecture type	Middle Belt application	Niger Delta application	Intended peace outcome
Information amplification	Predictive	Satellite pasture mapping; mobile rainfall alerts; shared herder–farmer resource dashboards	Spill detection through Earth observation (EO) satellites; pipeline pressure sensors; methane-detection unmanned aerial vehicles (UAVs)	Reduced misperception; shared ecological awareness; fewer information-driven escalations
Behavioural structuring	Adaptive	GPS livestock collars; digitally demarcated Farm-Protection Zones (FPZs); drought-triggered grazing restrictions	Community-based spill reporting platforms; verified compensation triggers; land-use compliance monitoring	Modified incentives; disputes replaced by negotiated corridor agreements
Institutional reinforcement	Restorative and integrative	Blockchain resource-sharing agreements (proposition); cross-state geographic information system (GIS) governance platforms; land rehabilitation monitoring	Transparent accountability chains; drone-supported compliance checks; joint state–community monitoring	Trusted and legitimate institutions; fewer grievances; long-term ecological restoration

Note. Authors' construct. EO = Earth observation; FPZ = Farm-Protection Zone; GIS = geographic information system; UAV = unmanned aerial vehicle.

4.1 Function I: Information Amplification through Predictive Architectures

The first function acts on perception. Resource users in conflict-prone areas often have no shared and reliable information on when pasture will fail, how far a spill has travelled or whether the rains will support a second crop, and in that condition each party reads the other's presence on the land through its own assumptions. Predictive architectures supply the missing information through satellite monitoring of pasture, mobile rainfall alerts, soil sensors, GIS mapping of grazing corridors and the detection of spills by EO. What matters most in their design is that the information reaches every party, including those outside the regulatory agencies, because a record held by one side cannot settle a dispute with the other. The first proposition (P1) follows: where the parties to a dispute share a verifiable record of resource conditions, the dispute is more likely to be settled by negotiation than by force.

4.2 Function II: Behavioural Structuring through Adaptive Architectures

The second function acts on how resource users relate to one another. Farm-Protection Zones (FPZs), which are digitally demarcated and legally recognised agricultural areas with GPS-guided pastoral corridors, are the principal adaptive instrument proposed for the Middle Belt. They differ from fixed designations because corridor use can be adjusted to current conditions and recorded. Livestock collars and movement beacons

produce time-stamped records, which allow a claim of crop damage to be checked against the movement of herds. In the Niger Delta, the counterpart is a community-based spill reporting platform tied to verified compensation triggers, which answers the weakness that Amnesty International (2013) found in spill investigation. The second proposition (P2) is that where the use of land and pasture is governed by recorded and adjustable arrangements, disputes over damage can be settled on evidence and are less likely to escalate.

4.3 Function III: Institutional Reinforcement through Restorative and Integrative Architectures

The third function acts on institutions. Restorative architectures, which include land rehabilitation, reforestation and soil stabilisation monitored by drone, rebuild the material basis of livelihoods and so reduce competition for degraded land. Integrative architectures link jurisdictions and parties through cross-state GIS platforms for joint governance, joint community–state monitoring and, as a proposition requiring testing (Section 2.4), blockchain-recorded resource-sharing agreements. Their value lies in the accountability created when records are held jointly, and it draws on the point made by Ostrom (1990) and Cash et al. (2006) that monitoring and cross-scale linkage support enforcement. The third proposition (P3) is that where records are held jointly across jurisdictions and are open to the people they describe, institutions gain the legitimacy needed to enforce agreements.

4.4 Neighbouring Approaches, Conditions of Failure and Data Justice

Two neighbouring approaches clarify what the EMLF adds. Environmental peacebuilding (Dresse et al., 2019) presents shared environmental challenges as occasions for building cooperation, and the EMLF specifies the information functions through which the cooperation would be built. Peace engineering (Queiroz et al., 2023) supplies a design orientation, and the EMLF adds the attention that political ecology gives to power and distribution, so that systems designed without regard to who benefits do not reproduce existing asymmetries.

The framework predicts cooperative outcomes only under certain conditions, and it states three in which it would fail. The first is where information asymmetry is produced for political ends and does not result from technical limitation, since better data cannot remove an interest in withholding them. The second is where distrust is so deep that communities read any state-sponsored system as surveillance irrespective of its design. The third is where scarcity is absolute, so that no shared account of resource conditions can create enough to share. A study that finds cooperation absent in conditions matching none of the three, despite functioning information systems, participation and legal protection, would count against the framework.

Data justice (Taylor, 2017) enters the framework as a condition that can be checked. A deployment meets it when the records produced on community land belong to the community, the platform is open to community users, participatory mapping precedes any demarcation, benefits from the data are shared, and a route exists for correcting a record that is wrong. A system that lacks any of these has failed the framework's own requirements, whatever its technical performance.

4.5 Theoretical Contribution

This study contributes to theory by developing the Ecological Mediation Layer Framework, which integrates scarcity literature, environmental peacebuilding, and critical technology studies into a single analytical framework. It also contributes by identifying data justice as a condition of

design and by specifying the conditions under which the framework would fail. The three propositions (P1 to P3) and the three failure conditions allow later evidence to support or contradict the framework, so that it is offered as a model open to test and not as a settled account.

5. Results and Presentation of Data

This section presents the findings and links each part to the research objectives stated in Section 1. Section 5.1 addresses Objective 1, Section 5.2 addresses Objective 2, and Sections 5.3 and 5.4 address Objective 4 by applying the framework developed in Section 4 (Objective 3) to the two cases and to the cost estimate.

5.1 Two Theatres of Environmental Conflict

This subsection addresses Objective 1. The two conflict theatres share a governance problem but arise from different ecological and economic conditions, and the contrast shapes the technological responses discussed later.

In the Middle Belt, the conflicts concern access to farmland and pasture. Amnesty International (2018) notes that raids and counter-raids between farmers and herders had gone on seasonally across the north for decades before they escalated from 1999, and the report documents attacks across Adamawa, Benue, Taraba, Kaduna and Plateau. Whatever weight is given to climate change in the debate summarised in Section 1, the conflicts arise where herds and farms meet, and the arrangements that regulate that meeting have failed to prevent violence. The same report identifies a second feature that any account must carry: the failure of the authorities to investigate attacks and prosecute those responsible has fuelled further attacks and reprisals.

In the Niger Delta, the conflict concerns damage to the resource base that sustains fishing and farming. Obi (2009) located the roots of the conflict in the struggle of minority groups for local autonomy and control of their resources, and the assessment of Ogoniland in Rivers State by UNEP (2011) documented the environmental damage with which the region lives. UNEP estimated that countering and cleaning up the pollution and catalysing a sustainable recovery could take twenty-five to thirty years. The dispute in this theatre is therefore less about competition between communities than about responsibility for harm, and it depends on how harm is measured and recorded.

Two features run through both theatres. Herd movements, planting and harvest follow annual cycles, and spills, although unscheduled, are followed by periods in which evidence deteriorates and claims have to be made, so that the timing of intervention matters in both. Scale is the second feature. Herds cross state boundaries, spills move through water, and the bodies responsible for response operate at community, state and federal levels, which means that a response effective at one level leaves the conflict unaddressed where it crosses the boundary. This is the difficulty that Cash et al. (2006) examined in their analysis of governance and information across scales. These features lead to the proposition on which the framework rests: where the parties to a dispute hold a shared and verifiable account of resource conditions, negotiation has a factual basis, and where the account is contested or held by one party, each side interprets the other's conduct as hostile and the dispute is likely to escalate.

5.2 Why Existing Responses Have Not Altered These Patterns

This subsection addresses Objective 2. Nigeria's responses to environmental conflict have taken the form of security deployments,

legislation at state level and compensation processes for affected communities. Each addresses a visible part of the problem, and the discussion below shows that each leaves the mediating layer untouched.

5.2.1 Fixed Boundaries in State Legislation

State legislation illustrates the first difficulty, which is that formal instruments fix boundaries for resources whose condition varies. Benue's law prohibiting open grazing, which took full effect on 1 November 2017 after a six-month period of sensitisation (Vanguard, 2018), required livestock owners to move to ranches. The instrument assumes that land is available and suitable where the law designates it, and it provides no means by which farmers and herders can verify the condition of designated areas or the movement of herds across them. Verification of this kind is the very thing on which compliance and complaint depend, and its absence leaves both sides to rely on their own accounts.

5.2.2 Contested Evidence in Spill Investigation

The Niger Delta shows the same difficulty from the side of harm. Amnesty International (2013) examined the system for investigating oil spills and concluded that it has systemic flaws, so that the outcome of the investigations lacks credibility, and it found that the lack of transparency contributes to tension in the region. Compensation and remediation turn on the cause, date and extent of a spill, which are the facts that an investigation is supposed to establish. Where the community cannot inspect the evidence independently, the investigation becomes one more contested claim.

5.2.3 The Absent Mediating Layer

The two examples point to a common absence. Across the documents reviewed in this paper, no arrangement appears that supplies the parties to an environmental dispute with a shared, timely and verifiable record of resource conditions and of the events affecting them. Decisions on grazing, farmland protection and spill response are consequently taken on information that the affected parties can contest, and a contested record is a ready source of escalation. The absence is one of design, and the framework presented in Section 4 is proposed as a response to it.

The proposal invites an objection from the critical literature reviewed in Section 2.3. If monitoring technologies have served coercion elsewhere (Duffy, 2014), a national information system could extend state surveillance over the communities it is meant to serve. The framework answers by making data justice a condition of operation, which Section 4.4 specifies as requirements that can be checked. What separates peace infrastructure from surveillance is control of the system, and the equipment itself does not settle that question.

5.3 The Ecological Mediation Layer Framework

This subsection addresses Objective 4 by reading two cases through the framework set out in Section 4. The cases serve as illustrations and do not test the framework (Section 3.1).

The attacks that began in the early hours of 1 January 2018 in Guma and Logo local government areas of Benue State show how the framework reads a case. Amnesty International (2018) reports that villages in the two areas began the year under attack by armed gangs, and Vanguard (2018) records that the attacks were the first since Benue's law prohibiting open grazing took full effect in November 2017. The documents consulted for this study discuss the dispute over that law and its enforcement, and they describe no arrangement through which farmers, herders

and the authorities of Benue and neighbouring states exchanged information on pasture conditions or herd movements before the attacks. Read through the EMLF, the case shows an information function that was absent, a behavioural function that the law met by prohibition alone, since it restricted open grazing without providing corridors that herders could use and farmers could verify, and an institutional function that stopped at the state boundary.

Competing explanations for the Benue attacks, including impunity, are weighed in Section 6.3.

The Niger Delta supplies a second illustration. Amnesty International (2013) concluded that the outcomes of oil spill investigations lack credibility, and the contest over that information bears directly on remediation and compensation for the communities concerned. Under the EMLF the missing elements correspond to the first two functions, namely detection that the affected community can inspect independently and a reporting and verification procedure that fixes the origin and extent of a spill before the evidence deteriorates. The Ogoniland assessment (UNEP, 2011) supplies a documented baseline against which a pilot in Rivers State, proposed in Section 7.2, could be measured.

5.4 The Economic Case: A Sensitivity Calculation

This subsection also addresses Objective 4, by indicating the scale of the economic stakes for the Middle Belt.

Environmental conflict also carries a cost that bears on the case for investing in prevention. Mercy Corps (2015) estimated that Nigeria stands to gain up to US$13.7 billion annually in macroeconomic progress under a scenario of peace between farmers and pastoralists in Benue, Kaduna, Nasarawa and Plateau states, and it found that states affected by the conflicts lost an average of 47 per cent of their internally generated revenue. The finding on revenue indicates that recovered output would also reach state finances. The figure of US$13.7 billion is a ceiling that assumes the absence of conflict, and the calculation below applies assumed fractions of it. For the Niger Delta, no comparable estimate is used, and UNEP (2011) is relied on only for the period of twenty-five to thirty years over which restoration of Ogoniland could extend.

Table 3 sets out the recovery implied by assumed reductions of 5 to 50 per cent in conflict-related losses, on the assumption that gains rise in proportion to the reduction. Each percentage point corresponds to US$137 million a year. The pairing of reductions with levels of deployment is the authors' assumption, and the reductions themselves carry no empirical support in this paper. A reduction of 15 to 20 per cent is paired with early warning deployed in part of the four-state area, a reduction of 30 per cent with early warning in the hotspot states, a national GIS platform and FPZs in five pilot areas, and a reduction of 40 to 50 per cent with all three functions deployed and coordinated at the level of the Economic Community of West African States (ECOWAS).

Table 3. Annual Recovery Implied by Assumed Reductions in Conflict-Related Losses

Assumed reduction in conflict-related losses (%)	Implied annual recovery (US$ billion)	Illustrative level of deployment
5	0.69	Pilot sites only
10	1.37	Pilot sites only
15	2.06	Early warning in part of the four-state area
20	2.74	Early warning in part of the four-state area
30	4.11	Hotspot states, national GIS platform, FPZs in five pilot areas
40	5.48	All three functions, with ECOWAS coordination
50	6.85	All three functions, with ECOWAS coordination

Note. Computed by the authors as the stated percentage of the US$13.7 billion annual ceiling estimated by Mercy Corps (2015) for Benue, Kaduna, Nasarawa and Plateau states.

Three limits attach to these results. The calculation covers only the four states in the Mercy Corps estimate, so it excludes the Niger Delta and the other Middle Belt states. It treats the link between deployment and conflict reduction as an assumption, since no study cited here measures the effect of early warning on conflict in Nigeria. It also scales linearly from the upper bound of a published estimate. The table therefore indicates the order of magnitude at stake if a given reduction were achieved, and it cannot show that any reduction will occur. This order of magnitude supports the case for piloting the measures in Section 7.2. A benefit–cost assessment would require cost estimates for the platforms and legal reforms, and none is offered here.

6. Discussion of Findings

6.1 Interpreting the Findings through the EMLF

The findings are interpreted here through the three functions of the EMLF (Section 4). The Benue attacks of January 2018 show an information function that was absent, a behavioural function that the law met by prohibition alone, and an institutional function that stopped at the state boundary. These absences correspond to the three propositions. No shared record of pasture conditions or herd movements is described in the documents consulted, so the parties had no common factual basis for negotiation (P1). The grazing law restricted open grazing without providing recorded and adjustable arrangements, such as corridors that herders could use and farmers could verify (P2). No records were held jointly across the jurisdictions through which herds move (P3).

The Niger Delta shows the same pattern from the side of harm. The conclusion of Amnesty International (2013) that spill investigations lack credibility points to a missing information function, since the affected community cannot inspect the evidence independently, and to a missing behavioural function, since no verified reporting procedure fixes the origin and extent of a spill before the evidence deteriorates. Because both cases rest on documentary sources, the correspondence shows where the

framework locates absences. It does not show that their presence would have prevented the violence or the dispute (Section 3.3).

6.2 Synthesis across the Research Objectives

Taken together, the results answer the five objectives as a single argument. The two theatres (Objective 1) differ in ecology and in the form of the dispute, yet in both the parties contest the factual account of what has happened to a shared resource. The responses reviewed (Objective 2), namely a grazing law that fixes boundaries and a spill-investigation system whose findings the affected communities cannot verify, each address a visible part of the problem. The overall pattern is that existing responses have not altered the conflict because they leave the mediating layer untouched. The EMLF (Objective 3) names what is missing in functional terms, its application to the two cases (Objective 4) locates the absences in the documentary record, and the recommendations (Objective 5) follow from that account.

The sensitivity calculation indicates the order of magnitude at stake in the four Middle Belt states without establishing that any reduction can be achieved. For policy and practice, the pattern implies that instruments directed at boundaries, security deployment or compensation should be judged by whether they give the disputing parties a shared and verifiable record, and not by their formal coverage alone.

6.3 Accountability, Shared Records and the Competing Explanation of Impunity

A competing explanation has to be weighed. The central finding of Amnesty International (2018) is that official failure to investigate attacks and prosecute those responsible fuels further violence. Impunity of this kind explains why attacks recur once begun, and it does not contradict the argument made here, since a shared record of events is also one of the means by which investigation and prosecution can be grounded.

This point deserves further development. Investigation and prosecution depend on establishing what happened, where and when, and the documents reviewed here describe the absence of an agreed record of events as a recurring difficulty: the Niger Delta material describes an investigation system whose outcomes lack credibility (Amnesty International, 2013), and the Middle Belt material describes a failure to investigate and prosecute (Amnesty International, 2018). A time-stamped record held jointly, of herd movements, crop damage or spill events (Sections 4.2 and 4.3), could serve as one input to such processes. The mediating layer would then have a second role beside the settlement of disputes, which is to support accountability.

Two cautions apply. First, a record does not create the will to prosecute. Where impunity reflects the unwillingness of officials, better data cannot remove an interest in inaction, which is the first condition of failure stated in Section 4.4. Second, records that can support prosecution can also support surveillance, so the data justice requirements of Section 4.4, namely community ownership, open access and a route for correcting a record, must govern who may use records for enforcement. The framework therefore treats the mediating layer as one condition of durable settlement alongside accountability, and it makes no claim that the absences it identifies caused the attacks.

6.4 Comparison with the Literature

The findings are consistent with the literature reviewed in Section 2 and extend it at specific points. The divided evidence of Ofierohor et al. (2021) and Lebari et al. (2022) on climate and farmer–herder violence is what the framework would lead one to expect if the

decisive variable is the mediating layer, since studies that measure environmental change alone cannot register it. Benjaminsen et al. (2012) found that governance explained the Malian conflicts better than rainfall. The present study agrees that the explanation lies in the arrangements around the resource, and it adds a specification of the information, behavioural and institutional functions that those arrangements would have to perform.

Amnesty International (2018) attributes the recurrence of violence in the Middle Belt to official failure to investigate and prosecute. The framework does not dispute that finding and places the mediating layer beside it (Section 6.3). Dresse et al. (2019) assembled the conditions and mechanisms of environmental peacebuilding and pointed to the gaps that remain, and the EMLF addresses one of them, the information systems on which cooperation rests (Section 2.2). Taylor (2017) defines data justice through visibility, engagement with technology and non-discrimination. The framework translates that concern into requirements that can be checked in a deployment (Section 4.4), and the account of militarised conservation given by Duffy (2014) explains why such requirements are binding and not optional.

7. Conclusion and Recommendations

7.1 Conclusion

This paper began from a disagreement in the literature. Studies of the link between climate change and farmer–herder conflict in Nigeria reach opposed conclusions, which indicates that a decisive variable lies outside what they measure. In relation to Objectives 1 and 2, the paper identified that variable as the mediating layer through which ecological change is observed, interpreted and acted upon. It showed that state legislation and spill-investigation processes fix boundaries or establish facts without giving the disputing parties a shared means of verification.

In relation to Objectives 3 and 4, the EMLF assigns technology three functions, which are to amplify information, to structure behaviour and to reinforce institutions, and it makes data justice a condition of its operation. The Benue attacks of January 2018 and the disputes over spill investigations in the Niger Delta show where these functions were absent in the documentary record, and the three failure conditions state what evidence would count against the framework. The sensitivity calculation indicates the scale of the sums at stake without establishing that any reduction can be achieved. Accountability for violence remains a separate requirement, which the mediating layer is meant to support and not to replace. The limitations set out in Section 3.3 qualify these conclusions.

In relation to Objective 5, the argument requires of Nigeria's institutions legal authority for community data rights, platforms that link community, state and federal levels, and the participation of exposed communities as co-producers of the systems intended to protect them.

7.2 Recommendations

7.2.1 Policy Sequencing and Three-Phase Roadmap

The analysis supports a sequence of measures and not a single intervention. Three principles guide the sequence. Legal authority has to precede technical deployment, because platforms that operate without statutory protection for community data rights would reproduce the surveillance problem described in Section 5.2.3. Participatory mapping has to precede formal demarcation, because corridors drawn without the agreement of their users cannot be enforced. Piloting has to precede national rollout, given the ecological variety of the country.

In Phase 1 (0–2 years), the Federal Ministry of Environment (FME), in

collaboration with the Federal Ministry of Justice, should lead the enactment of a Technology-Mediated Environmental Conflict Prevention Act. During the same period, NESREA should commission a national GIS platform for grazing corridors and FPZs, designed for open access by community users, and the National Emergency Management Agency (NEMA) should develop federal early-warning protocols for environmental conflict within its existing emergency architecture.

Phase 2 (2–5 years) concerns deployment and institutional integration. Benue State is recommended as the Middle Belt pilot because its conflict has been documented in detail (Amnesty International, 2018) and because it already has legislation on grazing. Rivers State is recommended as the Niger Delta pilot because the Ogoniland assessment (UNEP, 2011) provides a documented environmental baseline within it. Community capacity building runs in parallel with technical deployment. The pilots should be evaluated against four indicators: the number and severity of reported incidents per season, the time taken to verify a reported spill or crop-damage claim, the share of compensation claims settled without dispute, and the proportion of community members who report using and trusting the platform.

In Phase 3 (5–10 years), pilot architectures that have worked should be scaled nationally, with feedback loops built into institutional design. The National Drought Management Authority of Kenya and the Conflict Early Warning and Response Mechanism (CEWARN) of the Intergovernmental Authority on Development are existing regional institutions whose designs merit study as precedents. Nigeria should also negotiate ECOWAS-level protocols on environmental early warning to address the trans-boundary dimension of pastoral movement.

7.2.2 Recommendations and Their Linkage to the Findings

The sequence is translated into five recommendations, and each is linked to a finding of the study.

1. Enact a Technology-Mediated Environmental Conflict Prevention Act that establishes the legal framework for FPZs, early-warning systems and data governance standards. The Federal Ministry of Justice should lead, in collaboration with the FME, within 18 months. This addresses the finding that legal authority has to precede technical deployment.

2. Commission a National GIS Environmental Governance Platform under NESREA, with data-sharing protocols between state agencies and open access for community users, funded through the Ecological Fund, within 24 months. This addresses the finding that a record held by one side cannot settle a dispute with the other.

3. Launch integrated early-warning pilots in Benue State and Rivers State, calibrated to seasonal conflict cycles and combining community monitors with satellite data. State Environmental Protection Agencies should lead, with federal technical support from NESREA and the National Oil Spill Detection and Response Agency (NOSDRA), within 36 months. This addresses the finding that piloting has to precede national rollout.

4. Establish a National Environmental Data Governance Code that makes community ownership, transparent use and benefit-sharing requirements for every deployment aligned with the EMLF, developed through consultation that includes farmer and pastoral community representatives. This addresses the

finding that data justice is a condition of design.

5. Negotiate ECOWAS-level data-sharing and early-warning coordination protocols through the ECOWAS Commission, to address the trans-boundary dimension of environmental conflict, within the first five years. This addresses the finding that herds cross state lines and spills cross jurisdictions.

7.2.3 Conditions for Implementation

Four conditions determine whether the recommendations can be carried out. The first is legal. The Land Use Act, the NESREA Act and the Climate Change Act would govern these systems and require review for their provisions on data ownership, corridor recognition and access to information. The second is that data justice be written into statute and not left to the discretion of implementing agencies, because the critical literature reviewed in Section 2.3 shows that monitoring can be used to extract data from communities and to deliver the benefits elsewhere. The third concerns scale: herds cross state lines and spills cross jurisdictions, so policy confined to single states will be outpaced by the movement of the phenomena it addresses, and cross-state and ECOWAS protocols are structural requirements.

The fourth is capacity and connectivity. An early-warning system that communities neither understand nor trust will not produce the behavioural response that prevents conflict, so training for farmers, pastoralists and local youth is as necessary as hardware and software, and pilot sites should be chosen with the coverage of mobile networks in view. These conditions bear most heavily on Phase 1, which is why the legal and participatory steps come before deployment.

7.3 Future Research

The propositions of the EMLF await quantitative and field-based validation. The rural digital divide poses a further difficulty, since it can exclude the most conflict-exposed communities from the systems designed to protect them. Further research should measure the extent of this exclusion, test the three failure conditions of Section 4.4 against field evidence, and examine whether the blockchain element of the integrative architecture can be sustained where connectivity is low. Studies of the ecologically stressed zones that fall outside this analysis would show whether the framework travels. Vivekananda et al. (2019) describe interacting climate and fragility pressures in the Lake Chad basin, and the region offers a setting in which the framework can be examined.

Declarations

Conflict of interest. The authors declare no conflict of interest, financial or otherwise, that could have influenced the design, conduct or reporting of this research.

Data availability. This is a conceptual and analytical study and generates no primary datasets. All sources and documents cited are listed in the references, and links are given where they exist.

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