



A pluralistic mixed-methods research design for complex socio-ecological systems in Western Ethiopia

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Abstract

This study explores the potential and process of grounding the MMR (Mixed Methods Research) design in a pluralistic philosophical framework for complex socio-ecological analyses based on the empirical study conducted on global environmental change (GEC) processes and impacts in western Ethiopia. The conceptual-interrogatory framework was used to analyze the artifacts of the doctoral dissertation archived in 2018-2021. The convergence of mixed methods and the philosophical framework of the study was operationalized to mutually strengthen relationships in proposing the pluralistic MMR of this study. The pluralistic MMR design demonstrated three iterative stages of the integration process. The first-stage pluralistic MMR design shows the process of ontological synergy to capture and integrate multiple environmental changes. Second, validation and integration of various environmental change knowledge systems, where epistemological complementarities become essential. The third stage, pluralistic MMR, represents the integration of research approaches and methods that were substantially shaped by the two prior integration stages. The study underscores that grounding a study in pluralistic philosophy is not an abstract exercise, but an operational logic to enhance the application of MMR design. It shows proven potential for future studies in complex socio-ecological systems and other multidisciplinary MMR aimed at informing policy and development planning.

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INTRODUCTION

The multidisciplinary nature of environmental change research often conveys divergent philosophical-methodological assumptions about MMR (Onwuegbuzie & Abrams, 2025). These differences frequently remain unexamined, leading to studies that either privilege one approach over others or combine without adequately addressing underlying philosophical tensions. This limits the potential of MMR to generate truly integrative insights (Fetters & Freshwater, 2015). The study was intended to explore the interconnections between the design of MMR and the pluralistic

philosophical framework of our studies on localized GEC processes and impacts in western Ethiopia.

This study focuses on demonstrating how implicit engagement with philosophical pluralism transformed these challenges into opportunities for a more nuanced and contextually grounded understanding of the extensive studies the author has been conducting on localized GEC processes and impacts in rural settings in western Ethiopia. The specific objective is to build and propose a pluralistic MMR framework based on the retrospective analysis of the dissertation datasets

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archived in 2018-2021. It was intended to explore the methodology and empirical evidence that demonstrate how pluralism was operationalized in the MMR and improve the design. This was against popular arguments that pragmatism and pluralistic philosophy are strong but distinct advantages in designing MMR, because the study intended to ensure both practical relevance attributed to pragmatism and rigorousness, contextualism, epistemic justice, ethical engagement, and inclusiveness to pluralism. The specific propositions guiding this study include: First, the philosophical framework of the dissertation was characterized by pluralistic principles. Second, the pluralistic domains of meta-theoretical plurality, contextualism of environmental realities, and reflexivity of the researcher and political awareness have interactive relationships with mixed-method design in leveraging the contextual relevance and rigor of environmental change studies. Third, the pluralistic MMR is an analytical process resulting from the initial grounding of the study in contextually situated environmental change realities and knowledge systems (Olsson & Jerneck, 2018), while these local realities are framed within established theoretical traditions (Önkäl, 2024), with due consideration for reflexive environmental changes enquiry (Susur & Karakaya, 2021).

Statement of the problem

Although most of the MMR designs for GEC studies claim pragmatism, in my engagements in the discipline, I have witnessed this serving as an escape hatch from philosophical exercise. True pragmatism, which is rooted in judging knowledge by practical consequences and a careful bridging between global scientific and local contextual knowledge (Schoonenboom, 2023), is likely distorted. Most MMR design for localized GEC applies universal frameworks (e.g., climate models, resilience metrics) while overlooking context-specific environmental change realities, while others prioritize local narratives without linking them to established frameworks; mostly, the core principles of pragmatism are absent in both

Sci. Technol. Arts Res. J., July –Sep, 2026, 15(3), 169-187 frameworks (Johnson & Onwuegbuzie, 2007; Kelly & Cordeiro, 2020). These conditions have been affecting the utility of MMR, which is neither grounded in a consistent philosophical tradition nor genuinely pragmatic (since pragmatism should connect problem, method, and consequence). Although misleading, the philosophical orientation of pragmatism is a crucial issue; a parallel argument here is 'why put MMR in the single school of pragmatism?'

This study argued for the necessity of approaching MMR in philosophical pluralism as a crucial precondition for designing the approach (Johnson & Onwuegbuzie, 2007), and claimed the following associated advancements in the study. First, grounding the study in philosophical pluralism was critical in challenging the integration, which reduces MMR to a technical tool (Tzagkarakis & Kritas, 2023). Specifically, most MMR in GEC research use a qualitative approach for contextual illustrations, quantitative for modeling the process and impacts using rigid global frameworks, and apply the mixing only for substantiation. However, within the pluralistic framework, the study was the foundational instrument for treating these multiple environmental changes as parallel and equally valid realities, along with associated sources of knowledge and epistemic positions. Second, the design process avoided hierarchies between perspectives, allowing parallel tracking of qualitative and quantitative approaches. Third, the process validated the distinct roles each knowledge source and epistemology play. Fourth, it allowed complementarity across paradigmatically exclusive perspectives and renovated the design on the scope of "objectively knowable" environmental change phenomena. Finally, it was used for integrative synergy of multiple environmental change realities and knowledge systems, which were introduced as a pluralistic MMR design in this paper.

This study has substantial significance in advancing both the philosophy and practice of mixed-method research, particularly in the field of GEC, complex and context-sensitive settings such as rural western Ethiopia. This paper will have

substantial significance in advancing both the philosophy and practice of mixed-method research, particularly for the field of GEC in complex socio-ecological settings similar to rural western Ethiopia. It offers an alternative to the current GEC research characterized by MMR loosely connected to the principles of pragmatism, while skipping the theoretical traditions. The study will essentially add to the methodological direction towards pluralistic MMR for a methodologically robust and locally grounded research.

Research questions

1. Why is a pluralistic philosophical framework necessary to design mixed methods in the context of complex socio-ecological studies in rural western Ethiopia?
2. What relationships exist between the MMR design and the pluralistic philosophical framework applied in the study, and how can the pluralistic MMR design be developed through the integration of the MM principles and pluralistic philosophical assumptions?
3. How does pluralistic MMR design enhance the integrative capacity beyond the conventional approaches in the analysis of complex socio-ecological landscapes in rural western Ethiopia?

MATERIALS AND METHODS

Context of the study

The study was carried out in the rural setting of Anger watershed in Western Ethiopia, a region characterized by diverse agro-climates (*dega*, *woinedega* and *kola*), complex socio-ecological history and a livelihood background. Although climate change was a crucial environmental issue, the region is characterized by complex socio-ecological systems, unlike other parts of Ethiopia. Specifically, the lowlands *kola* ecology of the Anger River valley, primarily inhabited by indigenous Oromo and Neolithic communities, boasted rich biodiversity, and socioeconomic systems, mainly until the 1970s. However, the unique non-climatic environmental change resulted from competition over fertile lands and rich natural resources and became a complex process that has

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been shaping ecological and livelihood systems (Ofgeha & Abshare, 2020).

The doctoral dissertation developed a hierarchical philosophical structure consisting of the ontology of 'being', connected to the dual epistemologies of objectivism and constructivism. The positivism and interpretivism perspectives were used and aligned with different research approaches and methods and with the ontology through their respective epistemological underpinnings. Furthermore, the initial observation of the researcher of localized environmental change situations in the study area was framed within the conceptual and theoretical frameworks of established GEC research, such as agroecological theory, sustainable livelihood frameworks, political ecology and vulnerability frameworks, to provide analytical structure and connect to broader scientific discourse. Moreover, the study maintained critical awareness of power dynamics, equity issues, and the political economy shaping environmental change and local responses.

Research design

In this study, a retrospective research design was used to systematically examine the artifacts of the dissertation activities, focusing on what these documents reflect on the design and conducting of mixed methods within the entire doctoral research process (Stalhandske et al., 2025). It has the capacity to examine process rather than only outcome by making the dissertation artifacts an object of analysis to reconstruct a new analytical configuration of MMR design. The design was intended to explore the arrangement through which the original research evolved toward designing and employing the MMR rather than a single cross-sectional data set. The design facilitated the tracing of the research process from preliminary field observations and initial conceptualization to research design, data collection, manuscript drafts, and dissertation development to characterize the MMR design.

The convergence mixed-methods design and philosophical pluralism were operationalized as mutually reinforcing processes in this study (Garcia

et al., 2025; Kinnebrew et al., 2021). Therefore, the research design was an iterative process grounded in critical analysis and reflection on deep engagement and convergence of multiple environmental change realities, epistemologies, archived data, and methodologies used in the study. The process began with the reflexivity of the researcher about the study's context. The scoping and mapping of the realities and knowledge systems of environmental change was the first task. Identification of context-specific environmental change processes and systematic mapping of relevant knowledge sources (paradigmatic and local, institutional, indigenous, elders, smallholder farmers). This was followed by a critical interrogation of the conceptual frameworks of climate change, LULC dynamics, and land tenure used, and how the study identified the points of synergy and tension (Calero-López et al., 2025). All sources and types of knowledge systems were validated as parallel (White & Lidskog, 2023).

The explanatory purpose of the study was not limited to the use of different data sets to illuminate and interrogate each other, but to seek ontological and epistemological diversity for better integration and a more nuanced explanation. To these ends, the dissertation artifacts, theoretical and empirical findings, and methodological structures were critically examined for their effects in establishing relationships from preliminary observations of the study area, early conceptualization, data collection, and design and execution of MMR design.

Sources and types of data

The data previously compiled by the author, which were originally collected from numerous sources, were used. The datasets consist of the research designs and frameworks of all sections of the study, the proposal drafts, and textual transcriptions from data collection protocols (that is, questionnaires, interviews, and focus group discussions), the dissertation drafts, and the manuscripts of research articles stored in docx format. Field notes and analytical and reflective memos taken by the researcher during the original data collection period were used. Furthermore, the preliminary field

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observations, transect walks, and community meetings were an important source of data in this study.

The decision to utilize these data for the current paper was based on the fact that these databases provide a firm, consistent, and rich empirical foundation for the present study's critical reexamination of the methodologies that is logistically and financially not feasible to recollect. This approach aligns with principles of research efficiency, maximizing the value of previously collected data, and avoiding the burden of reengaging communities for the same primary information.

Methods of analysis

In this study, the conceptual inquiry framework analysis was used. It is an analysis technique that links the design of mixed methods in the study, the pluralistic philosophical framework, the established research frameworks on environmental change, the reflexivity, and observed local realities and knowledge systems by using specific questions to guide the analysis. This involves defining these components, developing questions that bridge the relationships, and then applying these interrogations to understand the processes and roles (Calero-López et al., 2025; Hakkarainen et al., 2020). The researcher's field observation processes and notes and other archived data were analyzed to explore the observational perspective and preconceptions on the socio-ecological conditions of the study area. This was not just a description, but a critical exercise in exploring how the researcher's position influences problem formulation, data management, and engagement with the issues.

The artifacts of the dissertation were critically examined to explore how the philosophical framework and MMR design mutually strengthen each other on climate change, nonclimate environmental change processes, LULC drivers, and land tenure systems to create a holistic understanding that goes beyond single generalized frameworks. This analysis scrutinized their underlying assumptions, ontological perspectives

(e.g., realism for climate as a statistical trend vs. relativism for LULC and tenure systems as a social construct), and points of theoretical tension or synergy on the established relationships between the philosophical framework of the study and MMR design. Similarly, archived data and secondary sources were systematically analyzed and integrated for the analysis of the pluralistic MMR to illustrate the full spectrum of their interrelationships, mutually reinforcing feedback loops (Johnson & Onwuegbuzie, 2007; Tryggvason et al., 2023). Finally, integration, synthesizing, and reflecting on the implications of the processes and outputs of the previous stages on the pluralistic MMR design were employed. However, these techniques were not applied in a linear sequence but formed an iterative cycle.

RESULTS AND DISCUSSION

Results

Evidence generated from dissertation artifacts archived from 2018-2021 was used to examine the interactive process and the effects of the empirical, methodological, and philosophical structures of the initial in shaping the MMR design. Accordingly, the critical analyses of this evidence in this study have been organized into three mutually strengthening analytical levels of constructing the pluralistic MMR design. Exploring the problem identification and formulation process and implicit pluralistic philosophical principles that guided the dissertation was the first analytical level of this study. This was followed by operationalizing the pluralistic philosophical framework in mixed-method design. The third analytical level demonstrates the practical process of pluralistic MMR integration.

Exploring and Operationalizing the Pluralistic Philosophical to MMR Design

The evidence items from preliminary observations of the study areas and initial reviews of the literature show how the insights of practical fields shaped the central thesis of the study by influencing the author's conceptual and empirical knowledge about environmental changes and climate change

Sci. Technol. Arts Res. J., July –Sep, 2026, 15(3), 169-187 (Table 1). Consequently, the observed differences in environmental realities and the claims of local communities at the beginning of the dissertation in 2018 were the sources of two important developments: First, 'climate change is not the only, but one of the environmental change denominators, external to local communities.' This revealed that the conceptual transformation from single to multiple environmental change realities was established at this stage as an essential requirement to understand these complex phenomena, mainly the change processes and impacts. Second, comparative analysis of evidence from preliminary field observations and initial literature engagement revealed the fragmentation of knowledge systems in addressing both scientific generalizability and contextual relevance of environmental change research in the study area.

Recognizing plural problems or issues in the problem identification stage automatically required pluralistic thinking in the study (Table 1). The synthesis of this evidence identified three key pluralistic pillars implicit in the dissertation: reflexivity, contextualism, and meta-theoretical pluralism. Critical analysis of evidence items identified from all stages of the dissertation artifacts revealed mutually strengthening relationships between early-stage research components, pluralistic philosophical pillars, and their operations in the process of designing mixed methods. The process consists of the reinforcing interactions of the pluralistic pillars in shaping the MMR design, while execution of the design challenges and deepens the philosophical framework (especially the ontology).

Moreover, the initial research components of the study and emergent pluralistic pillars show potential to be translated into methodological functions and operational effects on the MMR design (Table 1). Researcher reflexivity to study contexts, such as scoping and mapping of environmental change realities and knowledge systems, was the first pillar. Reflectivity as a crucial philosophical pillar was evident in most of the dissertation artifacts. The evidence items of preliminary field observations artifacts show the

critical awareness of the author regarding the context-sensitivity of environmental realities and socio-ecological complexity as a crucial aspect of reflexivity. The evidence elements collected from the protocols of data collection instruments and drafts of specific articles show how this pillar was established in the study and increased the utility of embedding ethical responsibility to address multiple environmental change denominators, and how national policies and global agendas shape local processes and impacts of changes. Problem identification and formulation were naturally substituted with pluralistic principles of multiple environmental changes. This component and associated pluralistic principles become operational in MMR design to avoid hierarchical relationships with realities of environmental change. As a result, multiple environmental realities were not treated as objective reality and subjective or confounding/secondary issues. Thus, environmental change denominators of climate and non-climate were treated as parallel, coexisting, and integrative changes in the design.

Although the process was not mutually exclusive, the author's reflexive observations and the claim for the multiplicity of environmental realities automatically resulted in the formation of the second philosophical domain of the study, operationalized as contextualism in this study. The identification of context-specific environmental change processes and systematic mapping of relevant knowledge sources (paradigmatic and local, institutional, indigenous, elders, smallholder farmers). Contextualism in this study conveys that situated environmental change realities emerge from context-specific situations, and usable knowledge depends on the micro-level change processes and impacts. Thus, it guided the grassroots-informed framing of research issues as the initial philosophical stance of the studies (Abma et al., 2019). The position on contextualism emphasized the ontological primacy of situated reality and local experiences of knowledge in defining environmental change. This refers to an orientation in which the study begins by identifying inherently existing issues and real-life

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environmental change problems. This was followed by a critical interrogation of the conceptual frameworks of climate change, LULC dynamics, and land tenure used, and how the study identified the points of synergy and tension.

Similarly, the second research component was the identification of valid environmental knowledge systems. It was reflexively identified during preliminary field observations and initial literature reviews, and was gradually tested and recognized as multiple sources and forms of valid knowledge. This becomes operational in MMR design, where no knowledge system is blindly labeled as a standard, global, local, or experiential. Accordingly, the design does not subordinate the knowledge systems to one another. This was hidden behind the complementarity of different forms of knowledge in the development of environmental change processes, factors, stressors, and vulnerability variables.

The third pillar substantially evident in the artifacts of the execution stage, such as data collection instrument protocols, dissertation drafts, and two specific research articles on the impact of environmental change, was meta-theoretical pluralism. Preliminary field observations and initial literature engagement substantially shaped the adoption and orientation of this pillar toward bridging contextualism or local relevance and scientific rigor, mainly in the vulnerability analysis (Eriksen & Kelly, 2007; Olmos-Vega et al., 2023). Although rigid adherence to a single paradigmatic tradition was rejected due to the effects of the first two pluralistic pillars, coherence was equally recognized by this pillar to bring localized realities of the study area into global narratives. This naturally led the study toward both local relevance and adhering to meta-theoretical orientation to advance adaptability, epistemic plurality, and practically responsive, a hallmark of paradigmatic pluralism (Reis & Câmara, 2023). The reasoning about environmental change as the third early stage research component of the study shows strong alignment with this philosophical pillar in the adoption of conventional reasoning approaches.

Table 1*The initial research components of the study for adoption of pluralistic principles*

Initial research components	Pluralistic principles	Emergent philosophical pillars	Operations in MMR design
Problem identifications	Multiple environmental changes	Reflexivity; Contextualism; Meta-theoretical pluralism	Avoid hierarchy between environmental realities; Multiple, coexisting realities
Identification of knowledge sources	Diverse, valid sources	Contextualism; Meta-theoretical pluralism	Knowledge systems were not subordinated to one another;
Environmental reasoning	Plural logic	Meta-theoretical pluralism; Reflexivity	Adopt conventional approaches for their distinct and integrative roles, matching pluralistic logic.

It elevated both inductive and deductive logic to match the parallelism of environmental realities. The MMR design of the study was guided by the pluralistic synergy of inductive and deductive logic. The reasoning approach was operational in the MMR design of this study as a pluralistic blending of inductive and deductive approaches.

Pluralistic Mixed-Method Process of Integration

The identified Nature of the relationships within the philosophical framework, together with the MMR design, was the initial milestone in demonstrating the pluralistic MMR design of this study. The characteristics of the mixed methods design in all dissertation sections were neither mechanical mixing of qualitative and quantitative approaches nor a pragmatic process of simplistic integration. Although it was not explicitly identified in the dissertation, the evidence obtained from the dissertation artifacts shows numerous contexts used to characterize the process of a pluralistic MMR in this study.

The proposed pluralistic MMR design consists of three iterative stages of the integration process that are substantially different from the conventional mixed-method approach. The first stage of pluralistic integration of MMR was ontological synergy. In most cases, this initial synergy automatically validated diverse knowledge

systems, epistemic complementarity, and integration as the second stage of pluralistic mixed methods. The third stage of pluralistic MMR design was the integration of research approaches and methods shaped by the two prior integration stages (Figure 1).

First stage pluralistic MMR integration

The pluralistic MMR design in the first stage shows the process of ontological synergy to capture and integrate multiple environmental changes (Table 2). The critical analysis of the artifacts revealed three gradual development processes of the pluralistic MMR design for this specific stage in capturing and integrating multiple environmental changes. The evidence shows a sort of procedural pattern throughout the research life cycle in treating environmental change denominators of climate and nonclimate as parallel, coexisting, and integrative change components. The evidence of preliminary field observations and initial literature engagements in 2018 revealed that the process started with (a) acknowledging that environmental change is not a singular, universally defined phenomenon, but is also contextually situated and constitutes multiple valid realities. Evidence from drafts of the proposal and artifacts from the execution stage, such as data collection instrument protocols, shows that this process was followed by (b) validating multiple

environmental changes as parallel and equally important realities. Finally, the drafts of the dissertation and associated research articles revealed how these gradual developments were reflected in the dissertation sections or specific articles (c) the integration of multiple environmental changes through pluralistic MMR design and associated framework of vulnerability to multiple stressors (Figure 1). These evidence elements reflect the frame of mixed methods as an ontological synergy, intended to address multiple realities of environmental change.

Although it was substantially reflected in the preliminary-stage artifacts, most of the evidence items show the immediate stimulus the pluralistic philosophy posed on the MMR design, acknowledging that environmental change is not a singular, universally defined phenomenon but is also contextually situated and constitutes multiple valid realities. Similarly, encountering the limitations of standard positivist vulnerability frameworks when faced with diverse environmental stresses (change in environmental resource access, uses/functions) provided concrete evidence against a singular reality. This validated and deepened the commitment to ontological plurality within the research team. Designing the separate examination of environmental change processes as non-climate and climate change analysis was the initial process intended to capture multiple environmental changes. This was followed by the practical process of designing structural land use dynamics and local implications as the first article in the dissertation, and the spatiotemporal variations of climate change as the second article. This practical endeavor plays a transformational role in valuing multiple environmental change realities as parallel and equally important regardless of their differences at multiscale and micro-level spatiotemporal variations.

Moreover, the evidence items from the protocols of data collection instruments on environmental changes, particularly items of impact analysis, and drafts of manuscripts show how the mixed methods design defined these multiple changes as coexisting realities and

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integrative. In the mixed methods design of vulnerability analysis, the first phase was the mixing of validated environmental change realities in problem definition. Conceptual, theoretical, and philosophical integration was the initial aspect of mixed methods design in this particular part of the dissertation to address climate change, non-climate biophysical changes, changes in environmental uses, and functions as environmental issues of parallel realities. Therefore, the pluralistic MMR recognized the spatio-temporal variations in the types and Nature of changes, but also the equally real and pressing environmental change realities shaping vulnerability dynamics in the study area. Rather than assuming a singular reality of climate change and squashing non-climate environmental changes to locality, the pluralist stance of the study embraced that environmental changes are complex, intersecting, and simultaneously real, though differently experienced and understood (Figure 1). Therefore, pluralistic MMR design was essential to comprehend complex change situations and reveal a complete picture of vulnerability to environmental changes.

Furthermore, the findings revealed how the pluralistic MMR design implicit in the vulnerability analysis addressed the premise of the initial study of environmental changes. The design was systematically interconnected and integrated these change realities unfolding on different spatial, temporal, and social scales (Figure 1). The integration was an act of cross-scale synthesis and did not simply merge datasets but created a dialogue between these scaled realities to explain how they influence and constitute one another. For example, it deals with how nonclimate change at the microscale LULC change and local tenure insecurity emerge from the macroscale interaction of the global food security agenda and large-scale agricultural investments that are enabled by mesoscale national development policy in shaping the vulnerability of the local community. Therefore, pluralistic MMR treats these scale-specific realities as parallel and equally necessary for explanation, while realizing the integration to prevent the fallacy of reductionism. Integration provided a mechanistic

understanding of the chains of causality and experience that link global processes to local outcomes, and local actions to systemic changes.

In general, pluralistic MMR design allowed the study to move significantly beyond the limitations of both single-paradigm research and sensibly driven MMR, anchored in a redefined understanding of the reality of environmental change itself. The mixed-methods design of vulnerability analysis, which was one of the sections of the study, clearly illustrates this by avoiding the approach that packs environmental change realities into a single pocket of climate

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change and operationalizes vulnerability into standardized climate indicators. The pluralistic MMR for the integration of multiple realities of environmental change was deeply rooted in ontological fidelity. Therefore, it was a shift from instrumental mixing of data and methods to the embedding of multiple realities in the study. This demonstrates that philosophical pluralism acts not merely as a methodological guide but as a profound ontological reorientation, wherein the existence of multiple, co-constitutive realities becomes the conceptual starting point for the MMR design.

Table 2

Pluralistic MMR process and comparisons with conventional MMR design

The study components	Dominant process in conventional MM design	The study's pluralistic MM process
Ontological dimension	Pragmatism	Ontological fidelity for synergistic integration of paradigmatically exclusive orientations and local ontologies
Epistemology	Pragmatism	Complementarity and synergistic integration of empirical, reflexive, local knowledge systems
Meta-theoretical	Procedural, positivism + interpretivism	Pluralistic integration of positivism and interpretivism
Reasoning approaches	Procedural, deductive + inductive inquiry, or vice versa.	Pluralistic reasoning: eg elevating inductive inquiry to explore context-specific realities, to make parallel with deductively established inquiry, and pluralistically blending
Dominant frameworks	Procedural: climate, spatial sciences, political ecology	Pluralistic integration of climate sciences, spatial technologies, political ecology
Research approaches	Quantitative + Qualitative; or vise-versa	Pluralistic synergy of quantitative and qualitative approaches. Pluralistic principles for parallel structuring of climate and non-climate environmental data
Sampling	Multistage: Pragmatic; Probability + Non-probability	Multistage: integrating probability+ non-probability guided by multiple realities and diverse knowledge sources
Typical methods and data	Procedural, Numerical/structured climate data + Narrative and observational for non-climate; or vice versa.	Pluralistic synergy: methods and datasets were not intended to be categorized as qualitative or quantitative (eg., the primary aims of preliminary field observation, walking interview, climate datasets, and remote sensing LULC were to capture multiple environmental realities)

Second stage pluralistic MMR integration

In most cases, this initial synergy automatically validated diverse knowledge systems, epistemic complementarity, and integration as the second stage of pluralistic mixed methods. The critical synthesis of evidence elements shows the substantive complementarity of meta-theoretical pluralism, reflexivity, local knowledge systems, and experiential knowledge in the study (Table 2). Most of the evidence items revealed that the process of identifying and validating multiple environmental realities and the participation of various knowledge systems were developed simultaneously. The evidence of this specific case study shows how the application of mixed methods design in vulnerability analysis was deeply rooted in different knowledge systems and epistemic stances, unlike most previous vulnerability studies.

The analysis of the artifacts shows how the integration of diverse knowledge systems and epistemologies becomes possible in pluralistic MMR design. Specifically, the analysis developed the following process to illustrate how the design advanced the mixing or integration of various knowledge systems: (a) reflexive engagements with diverse knowledge systems, (b) clarifying the distinct roles each knowledge system and epistemology plays in the vulnerability study, (c) complementarity of different sources of knowledge in developing environmental change processes, factors, stressors, and vulnerability variables, (d) synergistic integration of quantitative and qualitative methods across different knowledge systems. Quantitative techniques and models were not fixed to standardized variables and deductively operated change factors, but were complemented by inductively constructed variables in line with parallel nonclimate changes.

Although the processes were not mutually exclusive, first, the researcher's role was reoriented from an objective observer to a facilitator of knowledge integration. The reflexive and critical socio-ecological knowledge and positionality of the researcher offered different roles in surfacing observable environmental change issues and

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concerns, multiscalar relationships and power dynamics among actors, institutional dynamics, and historical marginalization in environmental change processes and impacts of environmental change. This form of knowledge plays a pivotal role in the identification, framing, validating, and integrating knowledge systems in the vulnerability study. As far as recognizing the multiplicity of environmental realities is concerned, the participation of MMR in diverse epistemologies was not optional. It became a core strategy to capture these multiple and context-specific realities. The preliminary deep observations, the context-specific narration of the local communities, the reflexivity of the researcher, and the associated development of multiple environmental changes were indicators of the engagement with various knowledge systems. This was followed by refining the roles of different epistemologies in the design of the vulnerability analysis. For example, the emergence of locally defined nonclimate environmental changes was enforced by a critical reevaluation of the role of the existing climate change framework in the vulnerability study. It did not negate climate data, but clarified that its role was one part of a larger picture defined by the lived experience of the community.

The second process of integration at this stage of the pluralistic design of MMR was clarifying the distinct roles each knowledge system plays in the study. For example, evidence from data collection instrument protocols and dissertation drafts shows how paradigmatically designed climate change epistemologies grounded in positivist traditions provide a systematic framework that serves as a baseline for environmental change models and is used to guarantee the generalizability of the study. Contextual knowledge (indigenous/experiential epistemology) was used to realize the relevance of the study. It was crucial to place the real and pressing environmental changes, capturing non-climatic (e.g., changes in environmental use, functions) that were parallel and sometimes more pressing than climate change. These are context-specific realities that require localized experiential epistemology, often invisible to conventional

climate models, and the initial role of the grassroots epistemologies was defining the full scope of relevant environmental changes.

Therefore, local epistemologies and context-specific sources have distinct roles in providing context-relevant environmental change knowledge (e.g., land use changes, resource access, tenure insecurity, loss of communal grazing lands). Therefore, the design has demonstrated that the MMR in a pluralistic framework is not about combining diverse knowledge, but leveraging the unique strengths of each way of knowing and epistemic stance, and ensuring mutual reinforcement of the whole process to optimize the environmental change knowledge. Practically, the pluralistic MMR design of the study goes beyond the typical reliance on a rigid framework of vulnerability models used in purely climate-centric models. In general, the pluralistic MMR design advanced the study by broadening the scope of objectively measured environmental changes. This enabled the MMR design to value empirical, experiential, local, and theoretical knowledge simultaneously. Thus, the pluralistic MMR design creates a space where scientific, indigenous knowledge, historical data, reflexive positionality of the researcher, and institutional experiences are complemented, converged, and integrated, contributing to a more nuanced and multidimensional understanding of environmental changes.

The third process in this stage represents how pluralistic MMR design allows the complementarity of paradigmatically exclusive perspectives. Complementarity in this study is the pluralistic process of addressing issues or variables missed by certain perspectives/approaches through another domain of pluralism. The reinforcements between the meta-theoretical framework and contextualism observed in the initial-stage artifacts or early-stage framing of the dissertation facilitated the complementarity of the positivist climate change models and relational ontologies/interpretivism perspectives. Therefore, interpretivism was used to bridge different nonclimate environmental changes to be treated in

parallel with climate change, in addition to conventional use in qualitative research and the substantiations of the MMR commonly observed in GEC research. For example, this reinforcement transformed the scope of "objectively knowable" environmental change impact phenomena by reframing vulnerability analysis (i.e., one of the dissertation's sections). Therefore, the paradigms traditionally viewed as incompatible, such as standardized climate change variables versus interpretivism and contextually situated nonclimate changes, were not treated as mutually exclusive or hierarchically ordered forms of knowing in this pluralist MMR design. Place-based exposure, sensitivity conditions, and contextually valid measurable environmental change and impact indicators were identified and used to anchor environmental data in lived experience.

Furthermore, the evidence items collected from the artifacts show that the conventional reasoning approaches were adopted and pluralistically integrated in most of the dissertation sections. Accordingly, the inductive-deductive relationships were guided by the pluralistic principle of anchoring multiple inquiries without subordinating one to another. For instance, the distinct role of inductive logic to explore context-specific environmental realities was used to support the deductive approach to address multiple factors in modeling environmental changes. Thus, the pluralistic framework practically elevated the inductive approach commonly used for qualitative inquiry into the capacity to identify nonclimate change realities parallel with deductively defined climate change. The need to integrate inductively or qualitatively identified 'non-climate' environmental changes with quantitative climate change factors demanded a refinement of the quantitative framework to accommodate this expanded view, demonstrating how mixed methods design is directly shaped by pluralistic philosophy. On the other hand, the successful integration, where distinct epistemological contributions (like defining the problem scope qualitatively and measuring specific drivers quantitatively) combined to form a coherent, richer narrative,

served as powerful validation for the advanced roles assigned within the pluralistic framework. This reinforced the value of allowing different ways of knowing to play their specific, nonredundant parts.

In general, the pluralistic MMR design of the study was characterized by the synergistic integration of epistemologies, knowledge systems, and paradigmatically exclusive perspectives on vulnerability analysis, as illustrated in [Figure 1](#). This design process has transformed the MMR from an epistemologically limited model into a pluralistically convergent design, one that integrates diverse perspectives and engages multiple sources of knowledge in vulnerability analyses. These have significant implications and offer insights for the advancement of quantitative climate science-based epistemology in the design of vulnerability studies. It shows the potential that a study can move beyond simplistic sources of evidence into comprehensive knowledge systems that are contextually relevant, methodologically valid, and scientifically replicable. These enhance the design potential for future studies aimed at greater functionality, rigor, depth, and epistemological justice on vulnerability to multiple environmental changes.

Third stage pluralistic MMR integration

The third stage pluralistic MMR represents the integration of research approaches, methods, and data which were substantially shaped by the two prior integration stages. The quantitative-qualitative relationship was the first demonstrative process of pluralistic MMR design in this stage. Unlike the conventional approach, the pluralistic MMR represents multiple dimensions of environmental change in the study area, which require different forms of inquiry and integration. Typically, the primary aims of preliminary field observation, walking interviews, climate datasets, and remote sensing LULC were not to isolate them as quantitative and qualitative methods and data, but to utilize their unique contribution in capturing environmental realities and framing the vulnerability and dynamics of adaptation strategies

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in line with these multiple changes in the study area. Therefore, the MMR design synergistically integrated these methods and data to set hypotheses, identify variables, and qualitative content ([Table 2](#)). Consequently, the design does not privilege climate change as the primary measurable reality while treating nonclimate changes as secondary explanatory factors. Instead, each relevant change domain was explicitly conceptualized, operationalized, hypothesized, measured, or investigated using suitable approaches, and subsequently brought into integration. The analytical logic of the study expressed the plural change issues and knowledge systems through parallel conceptualization, operationalization, data generation, integration, and meta-inference. Importantly, the integration of quantitative and qualitative approaches did not impose an a priori hierarchy in which some variables are designated as measurable while others are explanatory or supportive. Thus, MMR was born from a commitment to a pluralistic framework, became the mechanism through which the ontologies were enacted to test, refine, validate, and synergistically integrate knowledge systems, research approaches, and data.

For example, in most vulnerability studies that apply the conventional MMR design, the quantitative analysis primarily establishes patterns of climate change and then uses a qualitative approach for other context-specific realities to explain the findings. However, the pluralistic MMR design for vulnerability analysis, as one of the dissertation sections, begins from the plurality and complexity of environmental change realities themselves. The distinction was therefore not simply between the Nature of data as quantitative and qualitative, but between change realities that require appropriate forms of knowing and investigation. Therefore, each quantitative and qualitative method performs constitutive, explanatory, contextual, or corroborative roles, depending on the environmental reality and the objectives to be addressed. In turn, integration occurs through complementarity, convergence, and interaction among environmental evidence, rather

than through subordinating one approach to another. This was the core analytical distinction of the pluralistic MMR design: the methods were selected and related according to the plurality of environmental change, and no methods were reduced or subordinated according to preexisting analytical procedures.

Specifically, the evidence from the protocols of the data collection instruments artifact shows how this complementarity was practically implemented in developing the survey questionnaires for vulnerability to multiple environmental changes. Consequently, the categories of change stressors and associated vulnerability factors and variables were designed to represent each environmental change reality. The design was able to align the survey tools with local realities (e.g., household vulnerability surveys incorporated community-identified stressors). In particular, indicators of vulnerability to denied access to land and natural resources, local community exposure to large-scale agricultural extraction investments, deforestation, land degradation, and sensitivity to traditional land use systems were designed in parallel with inferred indicators of climate change. Thus, each variable of both components was identified, validated, and integrated. This transformed the scope of "objectively knowable" environmental impact phenomena by avoiding the framing of climate change as an objectively quantified change impact, and nonclimate changes as qualitative and secondary change issues. This enhanced the connection between globally inferred climate and contextually defined knowledge of nonclimatic environmental change in this vulnerability analysis (Figure 1).

The second typical demonstration of pluralistic MMR in this stage was the characteristics of the multistage sampling framework employed (Table 2). The evidence obtained from the dissertation drafts and manuscripts of specific research articles articulated the pluralistically grounded sampling logic of the study. Probability and purposive sampling serve different but complementary epistemological purposes rather than being treated simply as alternative sampling techniques.

Probability sampling was used to represent the multiplicity and distribution of the realities of environmental change within and along the geographic scales of the study. It provides a systematic basis for representing this within-scale variation and between-scale variation, reducing the risk that particular environmental realities are selected only because they are visible, accessible, or theoretically expected. Its epistemological role is consequently associated with establishing a defensible representation of the distribution of multiple realities within the defined study populations. Purposive sampling complemented this representational logic by explicitly pursuing epistemological inclusiveness. Rather than seeking statistical representativeness, purpose-based sampling deliberately included participants, knowledge holders, cases, and contexts that could provide different, marginalized, experiential, contextual, or otherwise distinctive understandings of environmental change. This inclusiveness operated within scales, capturing diverse perspectives within a particular household, community, or landscape, and along scales, connecting knowledge and interpretations across household, community, institutional, landscape, and broader environmental levels. Finally, the pluralistic logic is used for the integration of these multiplicities for greater meta-inference. This makes sampling itself part of the pluralistic MMR design rather than merely a technical procedure for participant selection.

In addition, the dominant approach of procedural integration of data in mixed methods of environmental change was not used in the study. For instance, in most of the previous studies, climate is considered as the structured reality measured through quantitative climate datasets, and nonclimate change reality is prematurely defined as an unstructured reality used to substantiate the established climate reality. However, the explanatory purpose of the study was not limited to the use of distinct datasets to illuminate, but to seek ontological and epistemological diversity for better integration and a more nuanced explanation. Therefore, climate and nonclimate data were

critically evaluated, particularly in impact assessments such as vulnerability analysis. Thus, vulnerability factors were structured in line with the values assigned to both climate and nonclimate environmental denominators through deep engagement with ontologies, epistemic stances, and reasoning approaches. In general, these dynamic and mutually constitutive relationships were the engine driving the MMR design beyond the sum of its parts. This process elevates the discussion from methodology to the fundamental level of ontology, demonstrating that the true power of pluralistic philosophy in MMR lies in its capacity to redefine what we understand reality itself to be in complex environmental contexts. The strength of the

knowledge produced lies not just in its methodological robustness but fundamentally in its faithfulness to the Nature of the phenomenon studied. By starting from and actively engaging a pluralistic framework throughout the research process, the resulting outputs, integrated narratives, typologies, and models better reflect the inherent complexity, dynamism, diverse knowledge systems, and multireality Nature of environmental change. This MMR design ensures that the study delivers insights that are not only empirically sound, but also ontologically resonant and epistemologically just, offering a more authentic representation of the complex socio-ecological realities under investigation.

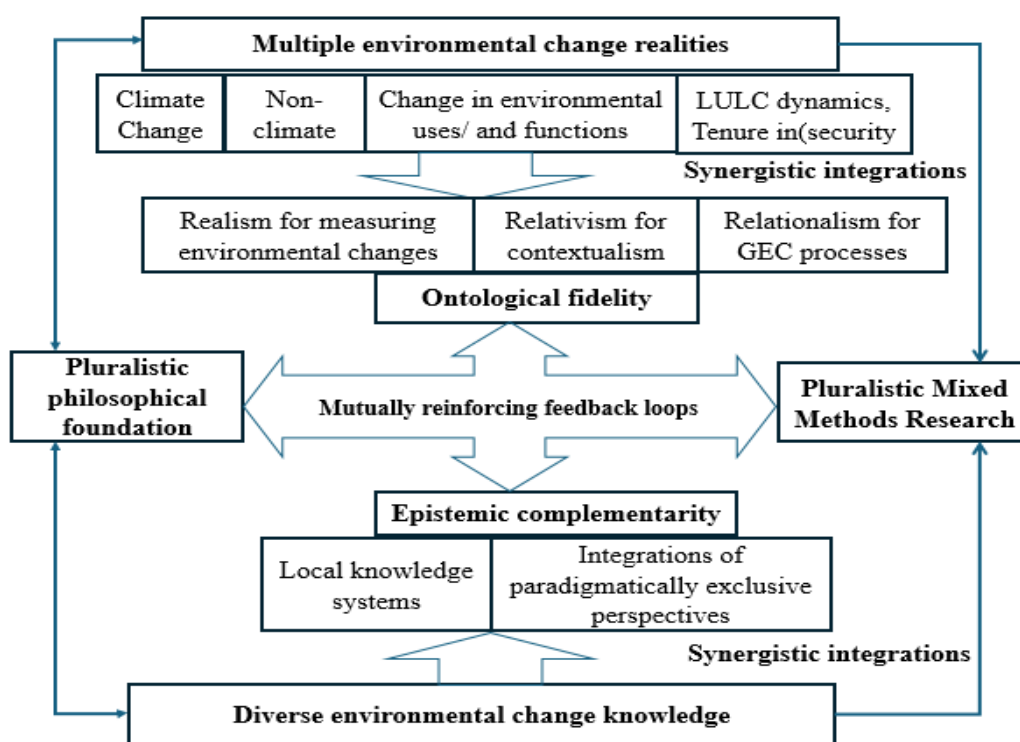


Figure 1. *Pluralistic MMR design framework*

Limitations of Pluralistic MMR Design

Despite its potential, the pluralistic MMR design has several limitations. Engagement with multiple epistemological perspectives and knowledge systems increases analytical complexity and requires substantial methodological competence. Therefore, pluralistic MMR should not be

understood as eliminating epistemological tensions, but rather as providing a deliberate framework for making those tensions visible, critically negotiating them, and using complementarities among perspectives to generate more comprehensive explanations. Although parallel evidence can be systematically integrated, the interpretation of such

evidence also inevitably involves researcher judgment, even when reflexive procedures are employed to make positionality explicit.

Discussions

Similar to previous studies that identified the same challenges, encountering the limitations of paradigmatic loyalty, a single philosophical framework, and pragmatic integration of data when faced with multiple environmental realities on the ground provided evidence against these orientations in the MMR design for the context of the study (Deulofeu & Suárez, 2023; Glock & Schmidt, 2021; Tryggvason et al., 2023). A proposed pluralistic MMR design of this study intended to enhance the integrative potential of the approach, not for methodological convenience, but to faithfully represent complex, multi-layered realities and diverse knowledge systems. Empirical investigations of artifacts from the doctoral dissertation archived from 2018-2021 demonstrated how the pluralistic philosophical foundation of the study logically guided the choice and structure of an MMR design (Abbas et al., 2021; Hesse-Biber, 2019; Onwuegbuzie & Abrams, 2025). Definitely, because the pluralistic philosophy already recognized multiple realities, diverse ways of knowing, and contextual interdependence, the methodological design of MMR had to reflect these same pluralistic principles. Automatic facilitation does not mean that it happened without rationale; rather, it indicates that the logic of the philosophical framework inherently required an MMR design capable of accommodating and integrating multiple forms of reality and knowledge systems.

Furthermore, the collection of various data streams (quantitative trends of environmental change for both climate and non-climate land use, qualitative lived experiences, policy documents) actively surfaced the co-existence and interplay of the multiple environmental realities (Geniusas, 2020). The pluralistic MMR process shows fidelity to the integration (e.g., showing how climate change is integrated with nonclimate changes in the assessments of environmental impact in multiple-

Sci. Technol. Arts Res. J., July –Sep, 2026, 15(3), 169-187 change scenarios). The act of integrating methods and data representing different realities became a practical enactment of pluralistic MMR design. This has a fundamental role in refining understanding of realities and revealing nuances within and between realities (eg, how 'universal' climate trends manifested in specific local contexts, how non-climate structural LULC changes were perceived relative to climate change and their spatial-temporal dimensions). Thus, the pluralistic MMR design provides numerous advancements, differing from the conventional design.

This study was structured around a central inquiry of methodologists and users in general, and the GEC researcher in particular, on contrasting philosophical-methodological assumptions about MMR. According to prominent MMR methodologists, it introduced the role of grounding a study in a pluralistic philosophical framework for enhanced MMR design (Onwuegbuzie & Abrams, 2025; White & Lidskog, 2023). Rather than following the conventional design path, mostly under the 'umbrella of pragmatism while escaping its true principles', which is common in mixed methods GEC research, this article familiarized pluralistic MMR as a better alternative in complex, politically charged, and dynamically evolving environmental settings (Schoonenboom, 2023). Although the culture in GEC research is shallow, anchoring MMR in philosophical pluralism was crucial and practical in addressing complex issues, including localized GEC challenges. The pluralistic MMR design is not just about technical combinations of multiple data and methods, but about integrating multiple realities and knowledge systems from diverse sources for significantly enhanced integration of data and methods.

The transformative processes of the pluralistic framework of advancing mixed methods research design recommended by MMR methodologists were systematically adopted in this study (Bliss, 2008). Although the process was mutually reinforcing (Onwuegbuzie & Abrams, 2025), it began with grounding in contextualism, recognizing that knowledge and realities about environmental change are situated within specific

socio-ecological, cultural, and political contexts (Olsson & Jerneck, 2018). Furthermore, reflexivity ensures that researcher positionality and value orientations play a substantial role throughout the research process (Susur & Karakaya, 2021). The third anchor is meta-theoretical pluralism, representing diverse traditions of environmental change sciences. The integration of these anchors generates dynamic ontological and epistemological engagements, allowing the addressing of complex, multilevel realities of environmental change. Thus, pluralistic MMR was demonstrated as a product of grounding a study in pluralistic research philosophy. With this base, it is not a mere technical choice, but an ontologically and epistemologically necessary strategy. Understanding localized change processes, vulnerabilities, and adaptation strategies requires integrating multiple environmental change denominators, diverse knowledge systems, perspectives, data, and methods (Gonda et al., 2021; Grineski et al., 2015).

This pluralistic MMR design has a number of implications for multidisciplinary research in general and GEC studies in complex socio-ecological systems in particular. First, it has transformed the approach in its contribution to epistemic justice. By legitimizing diverse sources of knowledge, especially local epistemologies, the pluralistic MMR model advances knowledge justice (White & Lidskog, 2023). Second, it allowed the approach to situate local voices not as supplementary but as central to the production of valid and actionable knowledge (Erwin et al., 2022). This resulted from strategic leveraging of the unique strengths of different ways of knowing, which has brought local knowledge as a critical epistemological pillar alongside scientific environmental change theories, rather than treating it as supplementary. This is particularly important in environmental change research, where lived experiences, contextually situated ecological shifts, and place-based sensitivity offer realistic signals of vulnerability, resilience, or systemic transformation (Gobena et al., 2024). Furthermore, the shift toward a pluralistic orientation improves the reflexivity of the approach in the research process. This reflexive

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posture in the approach improves ethical grounding and cultural sensitivity, especially in context-rich studies dealing with contested environmental meanings or socio-ecological conflicts (Gonda et al., 2021). It ensures that the research process is not simply a technical exercise in data integration, but a deeply contextualized and ethically responsible endeavor aimed at transformative understanding and equitable change.

CONCLUSIONS

Drawing from the study in rural settings in western Ethiopia, this study demonstrated the process of designing a pluralistic MMR framework. The pluralistic philosophical framework of the study, beginning with its ontological fidelity, was the foundation for the advanced MMR design. The process transformed MMR design from a toolbox into a co-constituted framework with the complex, multi-reality Nature of environmental changes in western Ethiopia, yielding insights that were not only robust and nuanced, but ontologically faithful and, therefore, fundamentally more integrative of knowledge systems.

Therefore, the pluralistic MMR design in this study was the result of the research process underpinned by ontological fidelity, epistemological complementarity, and methodological coherence. First, the approach advanced the integration of multiple and coexisting environmental change realities, ranging from global climate change to LULC transformations, non-climate biophysical changes, and evolving environmental functions, which was a critical step in capturing the full scope and complexity of environmental change. This multidimensional integration allowed the research to represent a more holistic and nuanced picture of environmental realities as experienced in rural western Ethiopia. Second, the approach advanced the integration of diverse knowledge systems, effectively bridging scientific analyses with experiential and community knowledge. This integration not only enriched the data but also enhanced the epistemic justice, relevance, and legitimacy of the research results for both academic and local audiences.

Third, the convergence of paradigmatically exclusive perspectives, numerous knowledge systems, and epistemologies was central to the advancement process. Moreover, this paper illustrated the established feedback loop, where pluralistically strengthened MMR, in turn, reinforces the coherence and utility of philosophical pluralism, providing an innovative model for GEC research. Continuous feedback between ontological fidelity, epistemological complementarity, methodological practice of MMR design, and empirical findings creates a virtuous cycle that enhances both the rigor and relevance of the study.

Recommendations

This study provides a recommendable framework on how a pluralistic MMR is designed and presents a replicable and adaptable framework for future GEC studies and other multidisciplinary research. It recommends this framework by showing how pluralism is not only a philosophical position, but also a practical strategy for designing MMR for inclusive, reflexive, and scientifically robust tools of knowledge production. Although considering the identified limitations is important, the findings signify the potential of the proposed pluralistic MMR for environmental change studied in complex socio-ecological settings, mainly for inclusive epistemology, methodological coherence, contextual responsiveness, and ethical engagement. In general, this study advocates the potential and calls for future researchers to adopt a pluralistic MMR for multidisciplinary studies in general and GEC studies operating in complex and contested environmental contexts.

CRedit authorship contribution statement

Gemechu Yigezu Ofgeha: Conceptualization, Methodology, Software, Validity tests, Data curation, Writing- Original draft preparation, Visualization, Investigation, Software, Validation, Writing- Reviewing and Editing.

Declaration of competing interests

The author declares that he has no competing interests.

Ethical approval

The initial studies received an ethical approval letter from Addis Ababa University. Consent of participants during data collection was obtained by verbally explaining the purpose of the study, the duties and responsibilities of researchers and participants. Ethical issues related to this study, including anonymity, confidentiality, and voluntary and informed consent, were addressed. The permissions of the concerned bodies to access the study site and the participants were obtained before the start of data collection. The survey data, field notes, and other documents of the participants' responses were kept confidential. Furthermore, all methods were performed in accordance with the relevant guidelines and regulations of the University Research Ethics Protocols.

Data availability statement

Data supporting the findings of this study are available from the corresponding author, upon reasonable request.

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