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Original Research

Case Study Strategy for Global Environmental Change Research: Empirical-Methodological Lessons from Rural Western Ethiopia

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Abstract	Article Information
<i>This study is aimed to explore the potentials and process of integrating different case study methods used in our studies on the local processes and impacts of global environmental change (GEC) in western Ethiopia into comprehensive research strategy. The author's extensive fieldworks for the dissertation, methodological lessons, and archived raw data were applied, and analyzed by the conceptual framework method. The results revealed the pluralistic philosophical framework of the initial studies as a key element on both empirical and methodological inputs in this study. Though the entire analytical process and results were mutually reinforcing in this study, the role of the framework was crucial in the first stage of characterizing each case study method, followed by elevating their distinct roles in the process. In the third stage, the patterns of relationships were designed, and applied for enhancing the complementarities and integration of the methods. The aggregate of entire analytical process resulted to the synergistic integration of the methods into a framework, designated as a comprehensive case study research strategy in this study. The study underscores the rigor of the analytical process in designing this research strategy, legitimacy for studies in complex socio-ecological landscapes, and heightened potential to informing policy on context-sensitive development plans. This study recommends the strategy as a crucial tool for unpacking multiple global environmental changes, and their processes and impact evidence at micro-levels without sacrificing global nuance.</i>	Article History: Received: 29-05-2026 Revised : 09-06-2026 Accepted : 09-09-2026 Keywords: global environmental changes, case study, local change processes, differential impacts, pluralistic philosophy *Corresponding Author: Gemechu Yigezu E-mail: dandigemechu11@gmail.com

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INTRODUCTION

Although case study methods have shown immense potentials to multidisciplinary research, the utilization for the complex GEC issues in contexts like rural settings of western Ethiopia and other countries of global south remain untapped. The methods significantly underutilized in GEC research, mainly resulted from poor integration stemming from philosophical-methodological defects, and narrow disciplinary orientation of the studies.

They often treated as exclusively different research methods, rather than considering potentials of integrating and comprehending into a comprehensive research strategy [1–3]. Thus, this study intended to characterize case study methods, identify potentials and processes of enhancing their distinct roles and relational patterns used for complementarities and integration, and transforming into a comprehensive research strategy. These were

conducted based on numbers of case study methods applied in our studies on environmental change processes and impacts in rural settings of western Ethiopia.

The case study research in GEC studies exhaustively reviewed in this study were used to consider poles of philosophical-methodological paradigm. Case study as a research method are employed in both quantitative and qualitative traditions, though often in stretched and differentiated ways [8]. In both paradigms, the unique or intrinsic value of the unit of analysis remains central; however, the paradigmatic orientations guiding their applications are treated as exclusive. Both usage often falls short in one way or the others such as replication, capturing the deep contextualization of complex environmental change processes, overlooking the socio-cultural, political, and ecological interdependencies. In positivist-dominated GEC studies, case study used as units of measurement or as a bounded site, within experimental or quasi-experimental designs aimed at generalization. On the other hand, qualitative interpretivist approach use case study method to explore specific, context-based issues, focusing on depth and meaning rather than generalization. However, most of the studies stick to certain theories, poorly connect multidisciplinary environmental issues, and treat cases as isolated stories instead of parts of larger global and local processes. The mixed method GEC studies, which tries to combine quantitative and qualitative strengths, has not fully used the potentials of integrating different case study methods. Often, they tended to either of the approaches, apply on data integration without philosophical-methodological blending, poor commitment to combining different perspectives or knowledge systems.

The central argument of this study was that the limitations observed in most of the GEC studies were significantly addressed in all case study methods used in our initial studies, enabled the aim of designing a comprehensive case study strategy in this study. The pluralistic philosophical framework of the author's dissertation and associated studies was serve as a backdrop to this study. The design of this study was embodied by pluralistic philosophical framework of these initial studies which facilitated the process of synergistic integration of different types of case study methods, farther integration of multiple research tools and techniques relevant for case-based distinct realities, and paradigmatically informed alternatives [9–11]. The framework lies at the heart of the embraced paradigmatic transformation, actively guided the ontological and epistemological positioning of the studies [4,5]. Specifically, the initial studies' adoption of the ontology of being emerged from this framework, offering a philosophical bridge between long-divided among case study methods, enabling a nuanced integration of case study method [6,7]. Rather than confining itself to a fixed or paradigm-bound ontology, the framework of the initial studies embraced ontology of being as a dynamic orientations on their methodological utilizations. Therefore, this study focused on critical analyses of different case study methods, unique characteristics of each method and distinct roles in the initial studies by adhering to broader theoretical frameworks, and maintaining a reflexive approach throughout this study.

The objective of this study was to characterizing and integrating different case study methods used in our studies on the local processes and impacts of GEC in rural settings of western Ethiopia. It demonstrate how our study transformed the applications of case

study methods into a comprehensive research strategy. The purpose was enhancing the methodological advancements of case study research in understanding the complex processes and impacts of GEC at micro-levels. While case study approaches have often been used as mutually exclusive, this study demonstrates how integrating multiple forms of case study methods within a pluralistic framework can generate a more comprehensive and coherent research strategy. By doing so, the paper highlights a methodological pathway that is both context-sensitive and capable of capturing the complexity of socio-ecological systems. This transformation not only enriches empirical research but also provides a replicable framework for other scholars working in similar contexts, ultimately strengthening the capacity of case study methods to inform policy, practice, and sustainable development pathways.

METHODS

Research Design

This study adopts different case study methods used in our studies on localized GEC processes and impacts in Anger watershed as an empirical and methodological reference point. It drawn on extensive fieldwork and multi-year investigations conducted in the climate-sensitive and complex socio-ecological settings of Western Ethiopia. The purpose of the initial studies were to provide a comprehensive knowledge on the local processes of global environmental changes through exploring courses, magnitudes and spatial dimensions of these changes, primarily guided by case-based assessments of the processes and impacts to address multi-layered and context-sensitive environmental changes, and their simultaneous impacts on the livelihoods of small-scale farmers. Numbers of case study methods were used for systematic examinations of the change processes, households' differential vulnerability, and spatial variations of adaptation strategies in these studies. Rather than conducting new fieldwork, this paper employs critical reflection and secondary analysis of the

author's archived datasets as a empirical-methodological exercise. The procedures illustrate how case study methods can be re-conceptualized not as a descriptive tools or singularly a method but as a comprehensive research strategy when integrates multiple case study methods framed in different disciplinary orientations, utility perspectives, sources and types of data, and scales of analysis. Unlike conventional case study applications that are often fragmented, this work re-examines the methodological pathways of a completed doctoral study to generate philosophical-methodological insights relevant for transforming case study methods into comprehensive strategy for GEC research.

Types and sources of data

This study based on datasets originally compiled by the author including the land use land covers (LULC) data, gridded meteorological data, survey questionnaires, interviews, and FGD data sets accessed for this specific work since 12 October 2024. The case study, as a comprehensive research strategy for global environmental change research, as well as the data set for this study, is identical to those of our previous studies. The approach integrates multiple data types and analytical procedures within a single research framework, thereby demonstrating the synergetic integration potential and process of case study methods.

Analytical procedures

The empirical-methodological the initial studies from the dissertation were critically revisited, restructured, and synthesized in three layers of analysis were employed in this paper. First, revisiting the philosophical-methodological structures of the initial studies, their potential to bridge local contexts and global environmental change debates, and roles in the case study methods. Second, restructuring all case study methods using the pluralistic philosophical framework of the initial studies. This includes demonstrating the potentials of the framework in avoiding the fragmentations, enhancing distinct roles of

each methods, relationships, and complementarities of the methods in the process. Finally, synthesize the mutually reinforcing process of the synergistic integrations of case study methods, transformation into a comprehensive case study research strategy framework.

RESULTS AND DISCUSSIONS

Revisiting the philosophical framework of the initial studies

The results revealed that the initial studies identified multiple dimensions of GEC at local level—atmospheric climate trends, biophysical non-climate, land-use change dynamics, livelihood adaptations, and governance processes case-specific realities on requiring different but integrative approaches. Therefore, recognizing the multiple environmental change realities in the study was the entry point of designing this specific study. They acknowledge that rural socio-ecological systems are shaped by overlapping and interacting drivers of climate and non-climate environmental change. This realized the establishment of the initial studies on three philosophical pillars of contextualism in environmental change realities, adherence to paradigmatic framework of the fields, and reflexivity and politically aware orientation in the study. Each pillar has its own role in bringing a specific reality to the stage, appropriate case study method for investigation, and for bridging a specific case study methods in the pluralistic framework, while their mutual reinforcement was used for the synergistic integration. Climate change refers to temperature and rainfall change and variability and associated droughts and extreme events that directly affect ecosystems and livelihoods [14]. Non-climate are the changes in environmental uses and functions including shifts in how land, water, and forest resources are accessed and used by the local community resulting from a process external to

a community such as state driven resettlement programs, investment projects, or other socio-political factors [15]. These realities have remarkable spatio-temporal dimensions and represent the starting conditions that shape the vulnerability and adaptation responses of the local communities (Figure 1). Rather than forcing a single case study approach to do all the work, we elevated each for what it does best and designed our case study research strategy to weave these strengths into a coherent whole.

The choice to adopt a pluralistic philosophical framework was central to reimagining the roles of each type of case study approaches in the studies. Though methodological debates in GEC research often fall into paradigm wars and framed case study approaches as mutually exclusive [12,13], the pluralistic framework was achieved moving beyond rivalries in this study. Pluralism was not simply a matter of combining methods; it was about integrating the philosophical commitments underpinning various paradigms characterizing applications of case study methods.

In practical terms, this meant that when investigating vulnerabilities and adaptation responses, each case study approaches was elevated for its best roles and integrated with others rather than competing or hierarchical treatment. For instance, in examining climate and non-climate changes, the agroclimatic gradient (*dega*, *woinadega*, and *kola*) and socio-ecological (Highlands versus lowlands valley) cases as units of analysis were employed. However, case studies were used as a quantitative and qualitative approach. The first case component of agro-climatic cases were used positivist climate change impact analysis (quasi-experimental logic), while the second was grounded in qualitative, political ecology perspective in facilitating concurrent mixed method approach. Therefore, the historical climate records, remote sensing data for LULC, survey data on households'

perception, FGD based thematic content analyses, and institutional documents were used to generate variables and test hypotheses about vulnerability and adaptation responses.

This study revealed the roles of pluralistic philosophical commitments of the study for introduced application of case study methods as a comprehensive research strategy (Figure 1). The pluralistic processes for synergistic integrations of multiple approaches in this study were one of the philosophical and methodological advancements over the decades [16,17]. However, the integration wasn't simplistic, but grounded in pluralistic philosophical commitments of the study. Thus, the study design transformed case study from being treated as a tool, single method, or a simple choice of unit analysis to a comprehensive research strategy. Specifically, it synergistically integrates case selection, research methods/design, data collection, and analysis into a systematic framework in this study. This transformation has been particularly valuable for environmental change research, mainly in contexts like Ethiopia, where complex socio-ecological systems and localized manifestations of global environmental changes demand a nuanced and comprehensive research strategy.

From an epistemological perspective, the shift in case study research is rooted in a move from positivist traditions. Though this was a crucial paradigm that emphasizes understanding the subjective meanings and contextual realities, the lessons from our study revealed that this paradigm is characterized by numerous limitations and the potential of case studies. The intended process of solving these epistemic limitations was established on polarized perspectives, and produced competitions only. However, grounding a study on a pluralistic framework transformed the position of case study research from competing research approaches to a comprehensive research strategy. Thus, the

crucial roles of this framework was transforming the potential of case study research through elevating the distinct roles of each approach, enhancing their complementarities and synergistic integration.

This study builds on these traditions but extends them in three key ways. First, the study transformed all types of case approaches from paradigm loyalty to pluralism. This was the initial method design for methodological and epistemological integration, which elevated both qualitative and quantitative forms without subsuming one into the other. Second, this initial orientation transformed the case study from a method to a strategy – rather than treating the case study as a discrete approach, the study was used as an integrative framework for research design, case selection, and analysis. Similarly, this condition transformed from single to multi-component cases – by combining agro-climatic and political ecology cases, the study creates a multi-layered case architecture that allows analysis of both climatic and non-climatic drivers. Ultimately, this transformative research strategy synergistically integrated these exclusive approaches in this study.

Distinct roles and complementarities of case study methods

The traditional case study research, primarily applied as qualitative or quantitative methods, were reframed, elevated in their distinct roles, and integrated within and along with other approaches. When adopted as usual, the narrow view in GEC research limited the legitimacy and scope of qualitative case study research to an exploratory approach, relegating it to a supplementary role in mixed methods. However, the approach was a robust method in best satisfying contextualism, the most significant among the pillars of this study. Therefore, the study didn't treat the qualitative case study (data and analysis) under a paradigmatic loyalty of interpretivism/constructivism or pragmatic

mixed methods, but its qualities and relevance in exploring contextually situated environmental change conditions were elevated to generate locally relevant realities and knowledge systems. This approach was used to identify and validate change realities that are parallel and integrative with the positivist environmental change framework through pluralism (Figure 1). This is in line with one of the fundamental arguments of this paper that the limitation in most of the studies in GEC is treating case studies along with the hierarchical relationships between paradigms.

For instance, the vulnerability models used in the study successfully elevated the distinct roles of qualitative and quantitative case studies. Grounding the study in pluralistic philosophy, the study created methodological space to elevate participatory and interpretive techniques to generate variables to be integrated with established variables used for survey-based quantitative tools and to situate both within the broader strategic objective of understanding socio-ecological change. For example, household surveys quantified livelihood vulnerability to climate change, while context-specific non-climate changes acquired equivocation. Therefore, traditional boundaries that often separate case studies into paradigmatically exclusive orientations—such as the positivist focus on measurable causal relationships versus the interpretivist or constructivist focus on meaning-making and lived experience were deliberately transcended. This shift allowed a qualitative case studies to transcend mere description, enabling researchers to draw explanatory inferences and explore causal mechanisms in-depth. This paper show that the study has contributed to these shifts, as it was guided by pluralistic philosophy, and rigorousness was one of the central philosophical arguments of the study. However, one of the fundamental arguments of this paper is that most of the

studies in GEC research are characterized by hierarchical relationships between paradigms.

Similarly, though these are crucial paradigms that emphasize on substantiating positivist hypotheses by interpretivist or constructivist approaches for the subjective meanings, contextual realities, and intricate within case units, these paradigms were hierarchically designed and shown different positions in most of the studies. However, this study demonstrate how a reconfigured case study strategy interdependencies genuinely dismantled these epistemic hierarchies and achieved complementarity. This process is beyond simplistic integration of qualitative and quantitative methods and data for triangulation, but contextually situated multiple realities, and diverse knowledge systems, while the triangulation was an aspect used for the robustness of findings by combining multiple sources of evidence, such as interviews, focus groups, surveys, remote sensing data, and participatory mapping.

The integrative logic of quantitative and qualitative case studies allowed the study to balance empirical rigor with contextual sensitivity. Additionally, by taking into account community viewpoints and lived experiences, the strategy's context-sensitivity guarantees that the analysis stays rooted in local realities. When discussing the effects of climate change and livelihood adaptations, this kind of local context-specific attention is crucial because more generalizations might miss micro-level dynamics.

Cases as a unit of analysis were used as one of the approaches used to unpack complex socio-ecological systems in the study area, but it was synergistically integrated with case study as a research method under the umbrella of this case study research strategy. A key aspect of this pluralistic orientation was the use of a case study as an approach to selecting the unit of analysis. Agro-climatic variations in Western Ethiopia provided a natural entry point for

delineating case units, where *dega*, *woinadega*, and *kola* represented an ecological and livelihood gradient (Appendix). These cases allowed the study to trace environmental change along climatic and altitudinal differences, with particular emphasis on climate change dynamics such as temperature shifts, rainfall variability, and ecological responses. This component foregrounded climate change as one axis of environmental transformation, illustrating both the differential exposure of communities and the adaptive strategies they pursued in varied ecological settings.

Second, the socio-ecological cases (highland versus lowland valley) of the Anger Watershed, provided the lens to explore socio-ecological variations, particularly those linked to non-climate environmental changes (Figure 2(b)). The agro-climatic framing was not considered sufficient by itself; it was synergistically combined with political ecology cases to extend the scope of inquiry into non-climate dimensions of environmental change. Here, processes such as LULC dynamics, tenure arrangements, and resource competition were foregrounded, enabling the study to trace how institutional and political-economic contexts intersect with environmental stressors. By combining ecological-livelihood gradients with socio-political divisions, the study ensured that both climate and non-climate stressors were systematically captured within the same framework. Finally, the case study as a unit-selection approach was embedded in a larger framework where it interacted with the case study as a methods (Figure 1).

Comprehensive case study strategy framework

The comprehensive case study strategy framework in this study was not adopted as a

pre-existing template but rather emerged as the product of synergistic integration of multiple case study methods. Each approach, whether case study as a unit of analysis, as a methodological tool, or as a broader research orientation was first elevated in its distinct role and allowed to contribute its own methodological and epistemological strengths (Figure 1). Instead of subordinating one approach under another, the study acknowledged their autonomous capacities and then strategically wove them into a single overarching framework. In doing so, the comprehensive case study strategy became both cumulative and integrative, uniting diverse ways of constructing knowledge about socio-ecological systems in Western Ethiopia.

A crucial step in this process was recognizing the distinct roles and complementarities among case study approaches. For example, case study as a means of selecting units of analysis provided ecological and socio-political entry points into the study, distinguishing between agro-climatic gradients of *dega*, *woinadega*, and *kola* (Figure 2(a)), and socio-ecological divisions of highland versus lowland valley (Figure 2(b), Appendix). At the same time, case study as a research method supplied the practical techniques of data collection and interpretation, ranging from household surveys and key informant interviews to institutional analysis. Finally, the case study as a strategic orientation provided the philosophical umbrella under which seemingly disparate tools and epistemologies were meaningfully integrated. Each role was distinct, but the synergy among them transformed their collective application into a comprehensive research strategy.

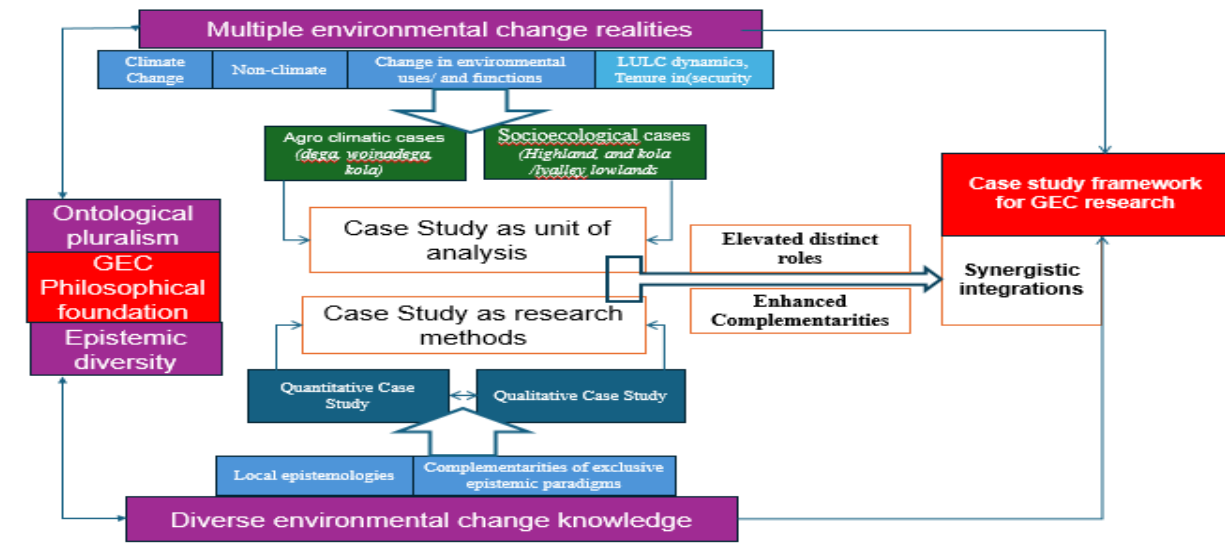


Figure 1: Case study strategy framework for GEC study

The following illustrations on how LULC sciences, political ecology, and climate change sciences were integrated in the study was used to provide practical process of synergistic integration of case study methods, cases as unit of analysis, and disciplinary reflections and potentials. The two complementary types of case units—agro-climatic cases of *dega*, *woinadega*, and *kola* (Figure 2 (a)), and socio-ecological cases of highland vs lowland valley of the Anger Watershed (Figure 2(b)) were explicitly nested and cross-linked. Agro-climatic units provided an ecological and livelihood gradient to test climate-sensitive hypotheses (exposure, sensitivity, adaptive practice variation). Political ecology units exposed institutional, tenure and power differentials that structure land access, LULC trajectories, and adaptation choices. Field work intentionally sampled identically across both axes so that, for example, a *kola* site in the valley could be compared to a *kola* site in a socio-politically stressed lowland. This cross-axis design allowed the study to detect interactions how the same agro-climatic exposure produces different outcomes under different tenure regimes or political economies.

Though the processes were not mutually exclusive, the parallel activation of quantitative and qualitative case study strands was another synergistic integration process. This was a deliberate activating of quantitative and qualitative case-study research as co-equal methodological strands rather than sequencing one after the other. Quantitative case-study work (structured household surveys, standardized livelihood indicators, and remote-sensing derived LULC metrics) supplied measurement, comparability, and spatial-temporal patterning. Qualitative case-study work (semi-structured interviews, focus group discussions, life histories, participatory mapping and timelines) supplied meaning, context, and local explanatory frames. From the outset both strands shared sampling frames, case boundaries, and core research questions so that numerical patterns could be probed with grounded narratives and local claims could be verified or contextualized with spatial/temporal data. This parallel activation ensured that findings from one strand routinely informed instruments, sampling, and interpretation in the other (e.g., survey modules added questions that emerged from FGDs; remote sensing epochs chosen to match local memory of key events).

The synergistic integration was implemented as an iterative inference cycle that the quantitative patterns (e.g., spatio-temporal variations in LULC, and climate change situations) suggested provisional hypotheses; qualitative engagement tested and elaborated causal narratives; those narratives in turn suggested new quantitative causal factors (e.g., not only climate change but LULC and tenure insecurity). Each cycle tightened causal inference while preserving openness to multiple, coexisting explanations of climatic drivers, LULC dynamics, tenure insecurity, or policy interventions. Therefore, the result was a transformed case study research strategy in which disciplinary boundaries (political ecology, climate science, LULC science of remote sensing) and epistemologies (positivist measurement, interpretivist meaning, constructivist local knowledge) were become synergistically integrative and functionally interoperable. Methodological choices were not defended by paradigm but by fit to question, case, and scale, when a study is guided by the pluralistic philosophical framework. The final synthesis delivered explanations that were spatially explicit, temporally reflexive, socially grounded, and sensitive to both climatic and non-climatic drivers, precisely because methods and units were integrated in a synergistic, iterative, and contextually anchored way.

Specifically, one of the typical synergistic integration was reflected in the construction of temporal frames for LULC and tenure system analysis. The study elevated the distinct qualities and complementarity of both LULC science and political ecology. One of the positivist's limitations of imposing uniform, arbitrary time intervals for LULC change detections were solved in this synergistic integrations—political ecology provides framing of meaningful time intervals. The local narratives, and institutional timelines were used for the identified moments of major policy

shifts, and associated land use and tenure dynamics. These socio-politically informed breakpoints then guided the selection of change periods for remote sensing LULC data, producing temporal slices that were meaningful to local actors and analytically sensitive to the forces driving LULC change. This reflexive temporal framing improved the interpretability of spectral change and helped distinguish politically driven land conversions from gradual LULC dynamics.

The study operationalized a two-way synthesis of political ecology frameworks used for hypotheses about where, when, and why LULC change; remote sensing provided spatially explicit evidence to test and refine those hypotheses. Therefore, the interpretive insights (e.g., claims about land grabs, or global food security agendas) were spatialized through micro-level classification, while unexplained spatial clusters or abrupt land-cover transitions were flagged by imagery. This iterative processes converted both political ecology and remote sensing from a standalone technique into a diagnostic instrument embedded within socioecological inquiry. Moreover, the integration enhanced the study's capacity to address multifaceted environmental change challenges and interplay between socioeconomic, institutional, and environmental factors, offering a nuanced understanding of the local community's livelihood outcomes, adaptation strategies, and ecosystem transformations. The strategy proved indispensable in unraveling these complex interactions, demonstrating its capacity to accommodate multiple disciplinary lenses while maintaining contextual sensitivity in exploring the localized global environmental change.

The framework proposed in this paper indicates how case study methodologies could be pluralistically integrated and transformed into a comprehensive research strategy capable of dealing with the complexities of GEC. By

synergistically integrating case study as a unit of analysis and case study as a research method, this framework answers to growing calls for pluralistic, integrative, and context-sensitive methodologies in environmental change research [16,18–21].

This paradigm makes an important contribution by explicitly rooting itself in the philosophical plurality of diverse environmental change realities. Localized GEC processes evolve at the interface of biophysical, social, and institutional systems, and cannot be effectively comprehended using single-disciplinary lenses [7]. By drawing on the potentials of multiple case studies, this framework operationalizes the epistemic plurality that is widely advocated in sustainability science [11,22–24]. In this framework, the concept of elevating distinct roles emphasizes the importance of retaining each case study approach's particular strengths while integrating them into a larger synergistic design. For example, the qualitative case study offers a stronger ability to delve deeply into context-specific realities, capturing meanings, lived experiences, and socio-political factors that determine local vulnerability. This level of investigation contrasts with the quantitative case study, which is more suited to producing generalizable patterns, doing quasi-experimental assessments of susceptibility, and quantifying the links between stressors and outcomes across instances. When these distinct responsibilities are elevated, they generate potential for greater complementarity. They work together to advance beyond combined application and towards integrated explanatory power, resulting in firmly grounded in place and analytically rigorous across scales.

The framework ultimately enhances the understanding of diverse environmental change by integrating local epistemologies with comparative scientific analyses that elucidate adaptation logics frequently neglected by traditional science [25], while scientific

datasets continue to be integrative, offering empirical rigour and generalizability. Their synergy is crucial for advancing both academic debates and practical policy in Ethiopia, where land use competition, resource governance, and climate variability converge to shape rural vulnerability [26,27]. This framework signifies a methodological advancement by transforming case study from rudimentary techniques to a holistic, synergistic research strategy for GEC research. Its emphasis on pluralism, integration, and contextual uniqueness makes it ideal for rural settings in Ethiopia, where environmental change processes are complex, contentious, and deeply ingrained in socio-political contexts.

CONCLUSIONS

This study introduced a case study as a comprehensive research strategy. It was the strategy oriented by the interactive effects of the relevance of the study for case-based distinct realities, informed by theoretical alternatives, and reflexive environmental change research. Practically, grounding the study in pluralistic philosophy was a crucial step in transforming the case study into a comprehensive research strategy. It builds on the traditional case studies but extends them in three key ways. First, the study shifts all types of case approaches from paradigm loyalty to pluralism. This was the initial explicit design for methodological and epistemological integration, which elevated each approaches (case studies as a research methods of qualitative and quantitative case study, and as units of analysis on agro-climatic cases of *dega*, *woinadega*, and *kola*, and socio-ecological divisions of highland versus lowland valley) without subsuming one into the other. Second, this initial orientation facilitated the complementarities as the study was grounded in pluralistic philosophical framework. Moreover, it synergistically integrates these paradigmatically exclusive case study approaches into a systematic

framework. Thus, the pluralistic process of elevating the distinct roles of each approach, complementarities, and synergistic integration were transformed the case study from a simplistic tool to a strategy.

Transforming a case study into a research strategy has numerous methodological implications including the roles of integration guided by pluralism as a principle in designing a study. The process enhanced the legitimacy of the strategy beyond solving epistemic limitations in addressing multiple environmental ontologies, worldviews and paradigms, enabling researchers to draw explanatory inferences, explore causal mechanisms in-depth, and generate middle-range theories. This positions the study's strategy within a growing movement in environmental research toward complexity-sensitive methodologies—the strategy that acknowledges non-linearity, feedback loops, and the need for multiple forms of evidence. Similarly, it shifts the roles of case study from a bounded investigation into a multi-scalar strategy, connecting micro-level realities, meso-level watershed dynamics, and macro-level national and global processes.

This framework has significant conceptual and theoretical implications by uncovering the potential suitability of the strategy for environmental change research, such as vulnerability to double/multiple exposure and system thinking. Specifically, our cases illustrate climate and non-climate change drivers as parallel forces, not only mutually reinforcing processes in shaping vulnerability. The strategy was shown greater potential to serve as a systems thinking tool, architecture enables a GEC study to see the socio-ecological system as a whole, including feedbacks and unintended consequences.

This paper has practical implications regarding the strategy's greatest potential to bridge research and policymaking. Instead of producing fragmented findings, the strategy

enabled the co-production of insights that speak simultaneously to climate adaptation, institutional governance, livelihood resilience, and ecological sustainability. By centering on flexible and local case units, the strategy exposes gaps in conventional frameworks of GEC, offering pathways for policy reforms, development practices, and advocacy. This paper calls for greater recognition for this strategy in complex GEC, mainly in Ethiopia and similar countries in the global south. Specifically, future researchers should expand case study strategy networks to other regions for cross-context learning used in designing frameworks strong on local insights without sacrificing nuance.

CRedit authorship contribution statement

The author (i.e. Gemechu Yigezu Ofgeha) has sole contribution to the development of the manuscript and approved its submission for publication. Moreover, the author has read and agreed to the final submitted version of the manuscript.

Declaration of competing interest

The author declares that there is no conflict of interest.

Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Ethics approval and consent to participate

The initial studies received ethical approval from Wollega University Research Ethics Approval Committee of College of Social Sciences (Reference Number: WUGC 0015/D-18/12/2019). The letter issued by the committee was used to request permissions from concerned bodies in the study area before the commencement of data collection. The consent of the participants during data collection was obtained by verbally explaining the purpose of the study, the duties and

responsibilities of the researchers, and the participants. The ethical issues related to this study, including anonymity, confidentiality, voluntary and informed consent, were addressed. Permissions of concerned bodies to get access to the study site and participants were obtained before the commencement of data collection. The survey data, field notes, and other documents of participants' responses were kept confidential. Moreover, all methods were performed in accordance with the relevant guidelines and regulations of the Wollega University Research Ethics Approval Committee of College of Social Sciences.

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Appendix: Mapping case studies as unit of analysis in the study

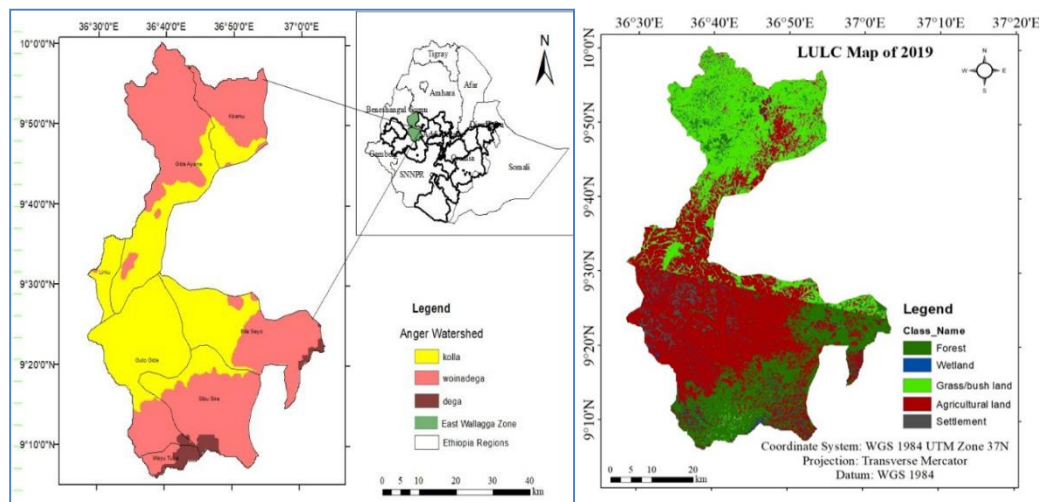


Figure 2: a) Climate cases, b) Non-climate political ecology cases