Methodologies and Approaches to Build Climate Change Resilience of Upland Communities in Vietnam: A Systematic Review

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Abstract

There are different methodologies and approaches that have been applied for data collection and analysis in climate change studies in order to contribute to building resilience and reducing livelihood losses for communities. Therefore, there is value to comprehensively synthesizing existing research methodologies and approaches that have been used to investigate vulnerability, adaptation, and policies to build climate change resilience of upland communities in Vietnam and find out the strengths and weaknesses of the applied methods and approaches. A systematic review method was used to select and analyze 73 articles for the period 1997–2023. Findings show that: (1) fewer studies have been published for upland communities than lowland and coastal areas in the agricultural sector within the climate change context; (2) most of the studies were conducted at community or commune levels; (3) qualitative methods were more common than quantitative due to the availability of data; (4) socioeconomic indices were the main indicators used for analyzing integrated production system approaches; (5) there were no studies about ecosystem-based and natural-based adaptation; and (6) very few studies about institution, policies, combine quantitative and qualitative method and applied watershed or landscape approaches. These conclusions further explicate the implications for methodologies and approaches in climate change research in upland areas to seek strategies and interventions for helping communities increase resilience.

Keywords: agriculture; approach; climate change; methodology; upland; Vietnam

Introduction

The speed of climate change (CC) over the past few decades has impacted all aspects of life (Gao, Chen, and Memon, 2024). People in exposed areas seem to be increasingly vulnerable in the context of faster and increased intensity and frequency of extreme weather events (Akinyi, Karanja Ng'ang'a, Ngigi, Mathenge, and Girvetz, 2022; Béné et al., 2016;

Phuong et al., 2018). Recently many CC studies are becoming available to enable adaptation and increase resilience (Briz, Garmendia, Marcos, and Gandini, 2024). These studies have focused on different climate issues such as climate risks (Dutta, Bouri, Rothovius, and Uddin, 2023), CC vulnerabilities (Hoang, Momtaz, and Schreider, 2020), CC resilience (Kien et al., 2023), CC adaptation (Le & Vo,

2020), or CC mitigation (H. Nguyen, Harper, and Dell, 2023). Besides that, these studies have also been conducted at different levels (from global to household levels), sectors (such as agriculture, forestry, health, water, education, or infrastructure), and regions (such as coastal, lowland, or upland).

Different methodologies and approaches have been applied in CC

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studies for data collection and analyses (Berrang-Ford, Pearce, and Ford, 2015). Each research method and approach has its strengths and weaknesses in providing research results and thereby contributing a basis for the process of policy recommendation solutions, awareness and identifying issues relating to CC and environment to support stakeholders in increasing resilience, especially targeting vulnerable groups. Berrang-Ford et al. (2015) indicated that to more efficiently contribute to build resilience and reduce livelihood losses for communities, it is important to comprehensively compile existing research methodologies and approaches used to evaluate processes of adaptation and implementation of CC policies. One of the most effective ways to map research that has been done to draw out lessons and identify appropriate approaches and methodologies in CC studies in the future for improving resilience of vulnerable communities.

For communities in low and lower-middle income countries, such as Vietnam, the agricultural sector plays a central role in supporting rural livelihoods and economic growth (Le Thi Hong Phuong et al., 2018). At the same time, agriculture is strongly affected by many CC challenges such as temperature changes, unpredictable rainfall patterns, increased flooding levels, and drought (Luu, Whitney, Biber-Freudenberger, and Luedeling, 2022). Especially, people in upland areas are susceptible to disasters and CC because of their reliance on agriculture and forest resources, a lack of financial resources and alternative livelihood options, poor infrastructure, and an unstable market (Landicho, Le Van, and Ximenes, 2023; Tran, Vu, Ngo, Tran, & Ho, 2022). Although there have been several studies on the effects of CC conducted in upland areas of Vietnam, each

study has used different methodologies and approaches. However, evaluation of which methods and approaches are most commonly used, effective, and appropriate has not been conducted so far. In addition, systematic reviews on methods, approaches, and tools in CC research in Vietnam are also limited. The aim of this study is to provide insights into how CC-related issues in upland communities in Vietnam have been investigated and what themes in the agricultural sector have been the focus of previous research to build households' and communities' resilience. Therefore, the critical research questions pursued in this article are (1) what are the methods and approaches to investigate vulnerability and to support building CC resilience of upland communities in Vietnam, and (2) what are the strengths or weaknesses of these methods and approaches?

Methodology

The study applied the steps and systematic review method suggested by Higgins and Green (Higgins and Green, 2011). The advantage of employing this method is that researcher bias can be limited and made visible (Hong, Biesbroek, and Wals, 2017). There were two main steps: in the 1st step, related variables were included for searching. This step provided a general picture of CC research in Vietnam and information on the number of published scientific documents/articles in different areas of concern in this study. The second step narrowed down and focused on key terms of research questions and the inclusion and exclusion criteria, which depended largely on the results of step 1. The data collection process is depicted schematically in Figure 1.

First, an initial assessment of the literature was performed in Google Scholar to develop a query including

similar concepts that are common in specific academic communities. Based on the research questions, the resulting query, consisting of three blocks to identify keywords were used to search academic articles, reviews, articles in press, and conference papers in two scientific databases available on SLU digital library (Scopus and Web of Science, WoS) (Supplementary Table S1). Scopus and WoS were chosen for searching data to prevent either European (Scopus) or American (WoS) bias.

Second, we applied four variables in the reference databases: (1) year from 1997 to 2023; (2) accepted only peer-review articles; (3) accepted only subjects: Agricultural and biological science, Social science, Environmental science, Veterinary science, and Multidisciplinary; and (4) accepted only English language. The year 1997 was selected as the starting point because the Kyoto Protocol was adopted. When the results from the searches in the two databases had been merged and overlaps between Scopus and WoS excluded, the database contained 1372 articles.

In the next step, manual scanning of titles, abstracts, and keywords allowed us to progressively focus. Articles relating to technical issues, migration, and multiple-country scale were excluded, for example, articles on drought-tolerant crop varieties or water harvesting techniques. As a result, 388 articles were selected to map overview CC research in Vietnam by year, region, province, extreme event, theme, gender, and types of responses (adaptation, mitigation, resilience, vulnerability; Supplementary Table S2). When analyzing the full texts, only articles focusing on upland communities were selected ($n = 73$).

The full texts of all 73 articles were carefully re-read, analyzed, and hand-
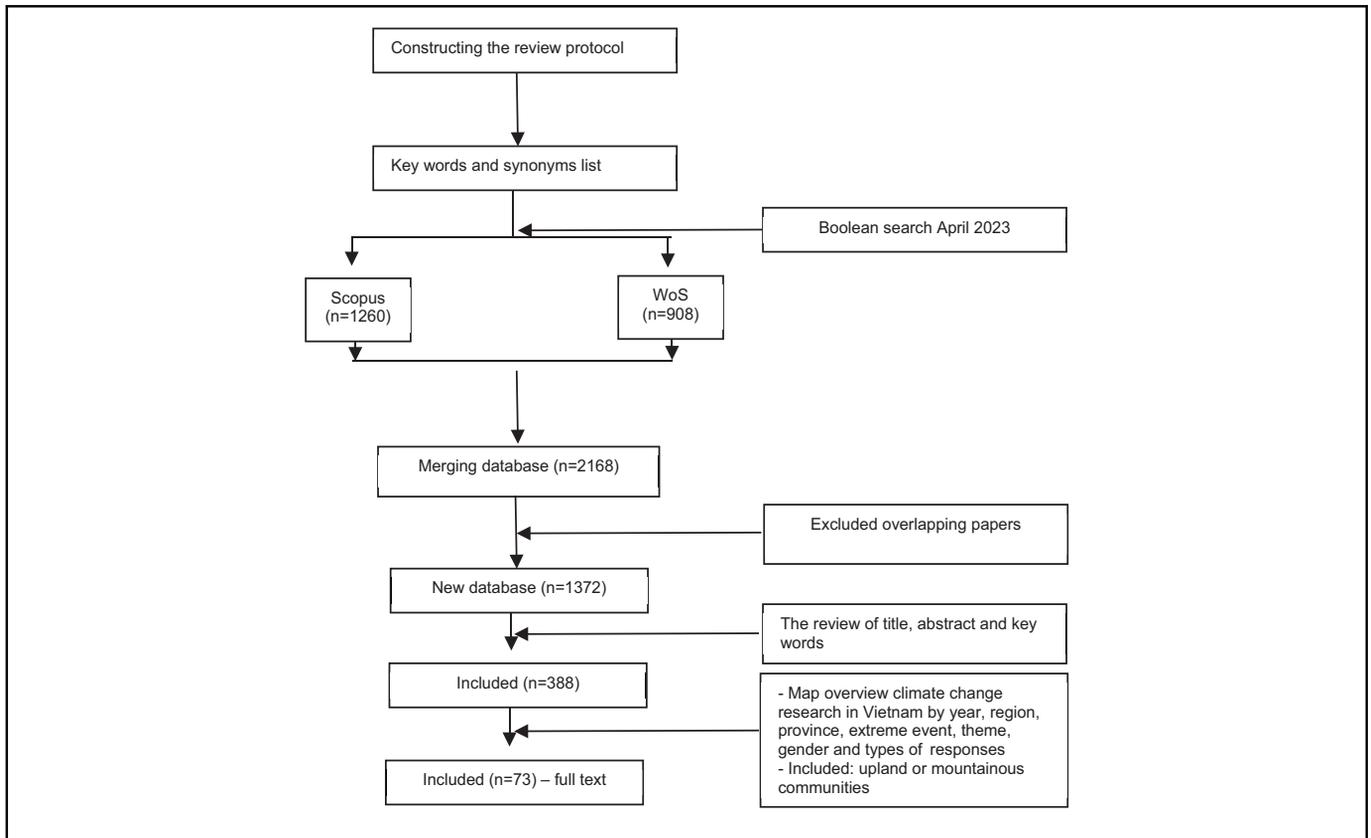
Figure 1. Data collection process, based on Phuong et al., (2017).

coded using data extraction (Supplementary Table S3). The table was designed to provide data to answer the research questions and included the following categories: bibliographic information (author, year of publication, regional focus, thematic scope, sector, and level of research); the approaches; the methodologies; and strengths or weaknesses of each approach and methodology. In this study, the strengths were understood as issues that support the effectiveness of feedback, such as finance, institutions, policies, suitability for adoption, and sustainability, while the weaknesses were understood as problems that create constraints in the execution of methodologies and approaches (Cerna, 2013; Turnheim et al., 2015). Strengths and weaknesses of the research methodologies and approaches were identified and analyzed based on a set of evaluation criteria, including holism, compreh-

ensiveness, convenience, presence of cross validation, generalizability, inclusion of data required, time consumption, and complexity. The data extraction table presents the results literally, without the interpretation of the authors. We evaluated the important changes and thematic scope of literature. This was followed by an analysis of the ways approaches and methodologies are conceptualized in the literature, and an analysis of the strengths and weakness of each approach and methodology based on information available in selected articles with the integration of other relevant literature.

Results

Overview of Climate Change Research in the Whole of Vietnam (n = 388)

Figure 2a–d presents a descriptive overview of CC research in Vietnam based on our systematic review of

the 388 articles. The results show that the number of studies on adaptation, mitigation, and resilience to CC in Vietnam has increased rapidly; 96 percent of the analyzed articles were published after 2012 (Fig. 2a). This is in line with observed scientific progress on CC research (Le Thi Hong et al., 2017).

Although the CC thematic scope varied, the majority of the articles were related to adaptation, vulnerability, and resilience (Fig. 2b). Integrated themes such as adaptation-institution, impact-vulnerability, policies, adaptation-disaster, mitigation-impacts, and adaptation-digital were hardly found. In terms of sector scope (Fig. 2c), the majority of studies focused on agricultural production, farm livelihood, climate data, and forecasting. The results show a diversity of regional focus (Fig. 2d), but most studies
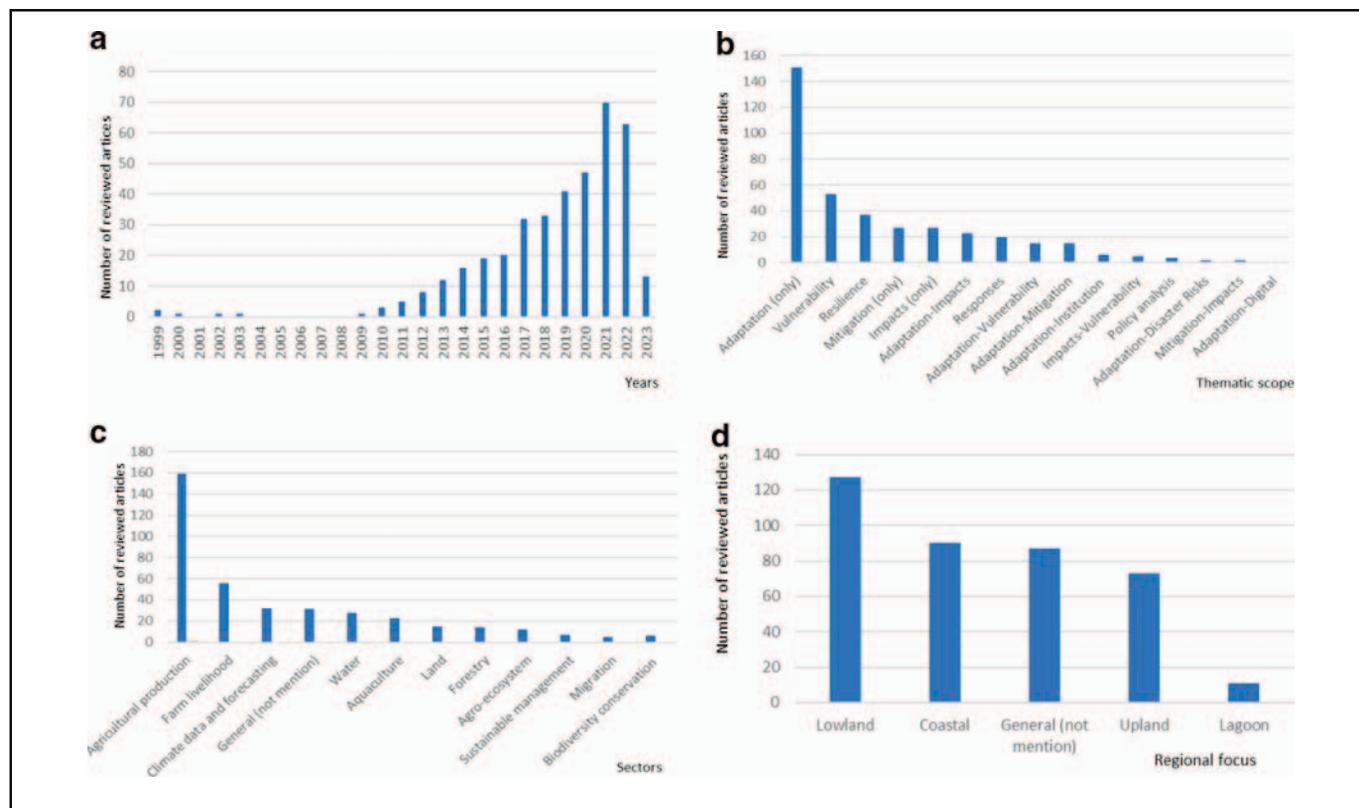
Figure 2. Distribution of articles covering all Vietnam by year for time period 1997–2023 (a); thematic scope (b); sectors (c), and regional focus (d).

focused on lowland areas (*n* = 127), coastal areas (*n* = 88), and upland areas (*n* = 73). In addition, around 23 percent of the reviewed articles did not mention any regional focus of the research. When dividing the reviewed articles based on the characteristics of ecological-economic regions of Vietnam, many reviewed studies were based on research carried out in the Mekong River Delta (*n* = 125) and Central Vietnam (*n* = 103), whereas few studies were conducted in the Central Highland (*n* = 7), and Southeast (*n* = 7). Particularly, only five studies included ddistinctly dissimilar regions, and the rest (*n* = 68) only included one region, or only similar regions. The majority of studies (*n* = 372) did not consider gender issues; 16 articles mentioned gender, but no studies included gender aspects in a systematic way.

Overview of Climate Change Research in Upland Vietnam (**n** = *73*)

The full texts read focused only on the 73 articles about upland communities. It means that upland is the criterion for the selection of articles for full-text reading. Figure 3 presents result of full text reading and grouping of articles into different categories, which include year of publication, thematic scope, sectors, and location (province). Gender issues were also one of the grouping criteria for data analysis, but the results indicated that none of the reviewed articles included research on gender dimensions.

Regarding the years in which the articles were published, a peak was seen from 2019 to 2021 and a decline in 2022 (Fig. 3a). Whereas one of the years before 2019 included more than

5 documents, this increased to 10, 13, and 21 in 2019, 2020, and 2021, respectively. This observation confirms the notion that the recent effects of CC in upland areas formed the impetus for an increase in research on climate and resilience in general. Related to the thematic scope, the majority of studies focused on adaptation (*n* = 39), and resilience (*n* = 10). Studies on CC mainly included the sectors of agricultural production (*n* = 30); farm livelihood (*n* = 13); and climate data and forecasting (*n* = 11). On the other hand, research on sectors such as biodiversity, forests, land, and water resources was very limited. Based on information from selected articles, studies were grouped into 6 levels, including national (*n* = 5), regional (*n* = 9), provincial (*n* = 4), district (*n* = 9), communal (*n* = 11), community (*n* = 29), and individual
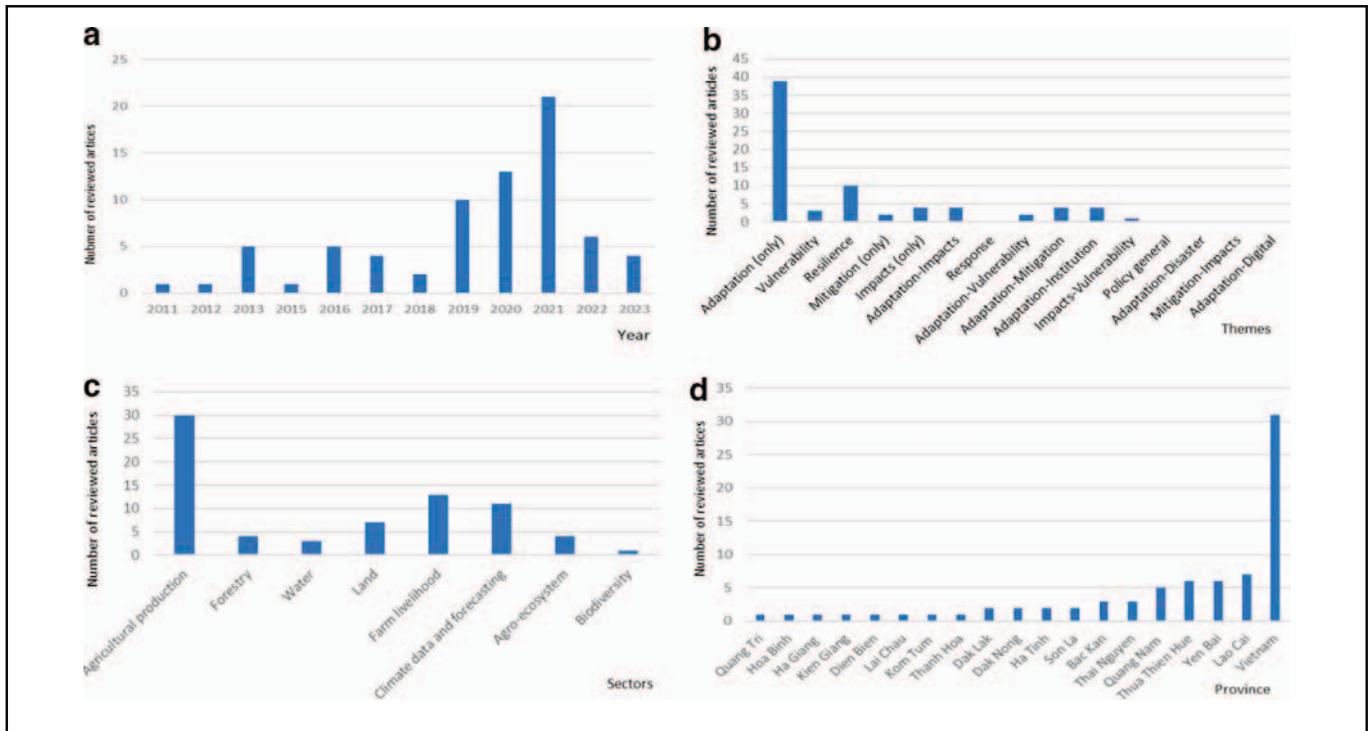
Figure 3. Distribution of articles covering upland Vietnam by year for time period 1997–2023 (a); thematic scope (b); sectors (c), and province focus (d).

($n = 2$) levels. The results showed a variety of analytical scales, but most studies focused on commune and community levels.

Research Methodologies

The research methodologies include two categories: one regarding quantitative and qualitative methodologies and the other regarding statistical models/analysis. The first category includes three sub-categories: quantitative, qualitative (and qualitative, with description), and mixed between qualitative and quantitative methods. The second category includes six sub-categories, which are indices-based, regression, geospatial analysis (GIS), forecasting modeling, Ricardian modeling, and other modeling. Table 1 summarize the methodologies and statistical models from the reviewed articles.

Among the 73 reviewed articles, qualitative methods were most common

(e.g ., (Beckman, 2011; Bui, 2021; Chen, Tsay, Yen, and Matsumoto, 2012; Huong, Bo, and Fahad, 2017; 2019)), followed by quantitative methods [e.g., (Booth, Jovanovic, Ho, and Miller, 2013; Bui, Tsangaratos, Ngo, Pham, and Pham, 2019; Huong

et al., 2019; Loi et al., 2022; Tri, Dat, and Truong, 2019)], while studies combining both types were relatively few [e.g., (Bos et al., 2020; Cuesta, Cai, Madrigal, and Pecorari, 2023; Do, Vu, Catacutan, and Nguyen, 2021; Huynh et al., 2019; Pham et al.,

#	Table 1. Mapping of Research Methodologies and Data Evaluation Methods		
#	**Methodologies**	**Number of Articles (n)**	**%**
1	Quantitative only	23	32
2	Qualitative only	37	51
3	Mixed quantitative and qualitative	13	18
	Data evaluation methods	**Number of articles (n)**	**%**
1	Indices-based and descriptive (no modeling)	25	34
2	Regression	18	25
3	GIS-impact assessment or projection	9	12
4	Extreme-event-forecast modeling	11	15
5	Ricardian modeling	2	3
6	Other modeling	8	11

GIS, geospatial analysis.

2017)]. Qualitative methods were generally applied to collect and analyze data on people's perceptions derived from individual interviews and group discussions, while quantitative methods normally used observed data for modeling (Bera and Daněk, 2018; Le Dang, Li, Bruwer, and Nuberg, 2014; Mertz, Mbow, Reenberg, and Diouf, 2009; Phuong et al., 2018; Sen, Bond, Dung, et al., 2021; Sen, Bond, and Hoang, 2021). Most of the qualitative studies had applied comparatively general methodologies (Bruun, 2020), conceptualization (Sen, Bond, and Hoang, 2021), case studies (Pham, Nong, and Garschagen, 2021), and integrated or mixed methodologies (Phuong et al., 2023).

Quantitative methodologies have, on the other hand, been proved as powerful methods to evaluate climate impacts or interventions through their simulation and projection functions (Huong et al., 2017; Mulia et al., 2020). Quantitative research has often applied specific tools and software such as the landslide-induced tsunami simulation model (LS-Tsunami) (Duc et al., 2020); the Soil and Water Assessment Tool (SWAT) (Huong and Son, 2020) or the QPSO-CDTtreeEns model (Ngo, Pham, Nhu, et al., 2021). To make progress, these software need to be integrated with different tools utilized in the climate discourse such as geographical information systems (Loi et al., 2022); computer science (Huynh, Pham, et al., 2020); climatic modeling (Huong et al., 2017; Manh and Ahmad, 2021a), or new data acquisition technologies (Hoang and Bui, 2018).

A combination of qualitative and quantitative methods offers a holistic approach (Bosma et al., 2016), providing different sources of information to cross-validation and to ensure the accuracy of research results (Manh and Ahmad, 2021b), and allowing a better understanding of the intersection between perception and recorded data (Cuesta et al., 2023). However, the quantitative methods also have their weaknesses. The major weaknesses are the low availability of data and a lack of measurement criteria [e.g ., (Bosma et al., 2016; Do et al., 2021; Huynh et al., 2019; Nguyen, Pham, Nguyen, and Dang, 2019; Nhi, Khoi, Trang, Ty, and Fang, 2022)] as well as often a lack of consistency among available data and data sources (Le, Sun, Choy, and Kuleshov, 2021). These might be among the reasons that more research on CC related issues employed qualitative methodologies than quantitative ones.

Regarding data evaluation methods, indices-based methods and regression were found to be the most widely used. Index-based methods have been employed to assess CC impacts, vulnerability, or resilience. Regression was used to analyze factors affecting adoption decisions (Byrareddy, Kouadio, Mushtaq, Kath, and Stone, 2021; Gronow, Brockhaus, Di Gregorio, Karimo, & Yla-Anttila, 2021; Thang, Dung, and Van Hoang, 2013) or factors affecting CC resilience and climate vulnerability (Casse, Milhøj, and Nguyen, 2015; Cullen and Anderson, 2017; Ha, Kuhling, and Trautz, 2020; Nguyen and Leisz, 2021; Phuong et al., 2023; Sen, Bond, Winkels, Linh, and Dung, 2020). They were commonly employed for qualitative methodologies. Extreme-event forecasting models and GIS are found to be relatively frequently employed. GIS was used to project/forecast the scale and intensity of CC (Do et al., 2021; Hoang and Bui, 2018; Phuong et al., 2023) or other order to assess CC impacts and vulnerability (Bosma et al., 2016; Huynh, Pham, et al., 2020; Huynh et al., 2019; Loi et al., 2022; Nguyen, Hoang, Oborn, and van Noordwijk, 2013). The remaining models were used to forecast the intensity and/or frequency of extreme events (Bui et al., 2019; Cheung et al., 2018; Dang, Burkhard, Muller, and Dang, 2018; Duc et al., 2020; Ngo, Pham, Nhu, et al., 2021; Nguyen et al., 2019) or land use and CC effects on water and sediment flows (Huong and Son, 2020; Huyen et al., 2017; Nguyen, Cochrane, and Pahlow, 2022; Nhi et al., 2022; Son and Binh, 2020; Tri et al., 2019) and other simulation purposes (Dang et al., 2018; Huong et al., 2019; Ngo, Pham, Nhu, et al., 2021; Nguyen and Kieu, 2022; Pham, Reardon-Smith, and Deo, 2021).

Research Approaches and Indicators

The research approaches used reflect the geospatial scale and comprehensiveness and realism of the research contents. Based on all articles that met the criteria for inclusion, we grouped the research approaches into 11 groups (Table 2). There had not been any research published about ecosystem-based adaptation or nature-based approaches in the Vietnamese uplands. The approaches found in the reviewed articles included landscape approach (Bos et al., 2020; Do et al., 2021; Nguyen et al., 2013; Nguyen and Kieu, 2022), watershed approach (Duc et al., 2020; Huong and Son, 2020; Huyen et al., 2017; Nguyen et al., 2019; Nhi et al., 2022; Tri et al., 2019), ecological approach (Chen et al., 2012; Cheung et al., 2018; Hoang and Bui, 2018; Pham et al., 2021), community-based approach (Huynh, Le, et al., 2020; Manh and Ahmad, 2021a, 2021b), ecosystem-based approach (e.g., (Bui

Table 2. Mapping of Research Approach in Climate Change Studies in Upland Areas

I	Approaches	General Definitions from Reviewed Papers	Reference Example	Number of Articles (n)	%
1	Ecosystem-based adaptation approach	N/A	N/A	0	0
2	Nature-based approach	N/A	N/A	0	0
3	Social network approach	The social network approach is a social selection mechanism that focuses on explaining how beliefs affect the coordination of action by actors choosing to have ties because of belief similarity and social influence with others on how their beliefs change.	[54] (Gronow et al., 2021)	1	1
4	Community-based approach	The community-based approach uses an overview of several phases including situation analysis (stakeholder analysis and participatory assessment), planning, and then the explanation of the different aspects of community mobilization and empowerment from leadership and management structures to community-based action planning, monitoring, and evaluation.	[31] (Huynh et al., 2019)	3	4
5	Climate extreme-event approach	The climate extreme-event approach is an approach based on climate extreme events and considers, analyzes, and evaluates the process from the manifestation, impact, and response strategies of people, communities, local governments, and ecosystems that can be overcome the effect of the event.	[72] (Ngo et al., 2021)	3	4
6	Landscape approach	The landscape approach is "systems-level" approach which emphasizes the natural systems upon which humans depend. It allows for the proper functioning of the overall ecosystems of which these services are a part as well as allows for multi-stakeholder negotiations in planning sustainable landscapes that can support livelihoods and development while maintaining and restoring environmental services.	[30] (Do et al., 2021)	4	5
7	Ecological approach	The ecological approach is a strategy approach that considers environmental factors and ecosystem services as the main factors for sustainable and conservation development. It looks at the integrated management among different components of the ecosystem such as soil, trees, water, and living resources. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems.	[80] (Simelton et al., 2015)	4	5
8	Watershed approach	The watershed approach focuses on water governance, hydrologically defined geographic areas, relevant natural resources including land, water (both ground and surface water flow), living resources, and the livelihood of communities that depend on the watershed. This approach helps to strategically and comprehensively address resource priorities across the populations living to remain healthy for the environment.	[65] (Huyen et al., 2017)	6	8
9	Ecosystem-based approach (EbA)	The ecosystem-based approach (EbA)focuses on understanding relationships between natural hazards and ecosystem services and can thereby help to improve the quality of life of communities as well as the health of the environment. The EbA strongly links to the practices in the ecosystem in terms of natural resource management, achieving good environmental status, and emphasizes humans as a part of the ecosystem.	[64] (Dang et al., 2018)	9	12
10	Sustainable livelihood approach	The sustainable livelihoods approach is a way of thinking about the objectives, scope, and priorities for development activities to improve the understanding of the livelihoods of communities that are impacted by risks. It considers the interaction between social and environmental processes and supports formulating policies related to the adaptation of different groups of people which consider from the perspectives of livelihood risk and social cohesion.	[19] (Beckman, 2011)	18	25
11	Integrated production system approach	The integrated production system approach makes use of the effectiveness and validity of systems approaches and tools in structuring and solving complex issues in agricultural research and development under the interwoven relationships between environmental and human factors. This approach addresses the current knowledge gap and the need for using integrated approaches and decision support systems for unraveling ill-structured and/or complex issues of climate change adaptation.	[58] (Ha et al., 2020)	25	34

et al., 2019; Dang et al., 2018; Fujihara et al., 2016; Mulia et al., 2020; Pham et al., 2017)), extreme-event approach (Ngo, Pham, Hoang, et al., 2021; Ngo, Pham, Nhu, et al., 2021; Nguyen et al., 2022), social network approach (Ha et al., 2020), sustainable livelihood approach (e.g., (Beckman, 2011; Booth et al., 2013; Bos et al., 2020; Bruun, 2020; Sen, Bond, Winkels, Linh, and Dung, 2020)), and integrated production system approach (e.g., (Beckman and Nguyen, 2016; Byrareddy et al., 2021; Casse et al., 2015; Cullen and Anderson, 2017; Do, Nguyen, and Nguyen, 2021)). The related indicators analyzed include socio-economic indicators, ecological indicators, a combination of socio-economic and ecological indicators, livelihood indicators, and technical indicators (Table 3).

Table 2 shows that the integrated production system and sustainable livelihood approaches were the most common approaches among the reviewed articles. Sustainable livelihood and integrated production system approaches both used socio-economic and livelihood indicators for the analyses. These approaches rely on different livelihood capital among the collected and analyzed information(Beckman and Nguyen, 2016; Huong et al., 2017). Therefore, the approach is quite comprehensive on many different aspects of the community as well as the surveyed/

researched farmers (Nguyen and Drakou, 2021; Pham, Nong, and Garschagen, 2019).

The social network approach focuses on how relationships between different stakeholders or policy actors contribute to the policy process or to decisions for appropriate activities (Gronow et al., 2021). This approach applies socio-economic indicators for understanding the relationships between economic, social, environmental, and cultural factors. Therefore, results of research findings may be comprehensive in terms of these factors (Gronow et al., 2021; Halbherr, Maat, Talsma, and Hutjes, 2021; Hoang et al., 2014). However, the number of studies applying this approach is really limited, especially in the upland areas of Vietnam.

With ecological and ecosystem-based approaches, the spatial research scale depends largely on ecological conditions, particularly soil, water, tree/forest, and the corresponding ecosystem services [e.g., (Mulia et al., 2020; Pham et al., 2021; Simelton, Dam, and Catacutan, 2015; Son and Binh, 2020; Tran and Brown, 2019)]. The results showed that ecosystem-based approaches were also employed but less frequent, followed by watershed approaches. Ecological, community-based, and climate extreme-event-based approaches were also used but not as common (only 4–5 percent).

A majority of the reviewed articles used socio-economic indicators only, or in combination with ecological indicators (Table 3). Main socio-economic indicators used to analyze CC related issues were costs and benefits of climate impacts on agricultural production [e.g., (Bruun, 2020; Casse et al., 2015; Do et al., 2021; Gronow et al., 2021; Huynh, Le, et al., 2020)]; household livelihood activities (Byrareddy et al., 2021; Cullen and Anderson, 2017; Ha et al., 2020; Hoa et al., 2021), factors affecting adoption of adaptation strategies (Casse et al., 2015; Cullen and Anderson, 2017; Gronow et al., 2021; Huong et al., 2017; Huynh, Le, et al., 2020; Manh and Ahmad, 2021a), and a combination of socio-economic and ecological indicators such as biodiversity, soil health, water availability and quality [e.g., (Booth et al., 2013; Kath, Byrareddy, Reardon-Smith, and Mushtaq, 2023; Loi et al., 2022; Manh and Ahmad, 2021b; Nguyen et al., 2013)]. A moderately high number of reviewed articles used climate-related technical indicators, such as severity and frequencies of extreme events including drought (Tri et al., 2019), flood (Bui et al., 2019), flashflood (Ngo, Pham, Hoang, et al., 2021; Ngo, Pham, Nhu, et al., 2021), landslide (Duc et al., 2020; Hoang and Bui, 2018), rainfall (Chen et al., 2012), water allocation (Fujihara et al., 2016; A. Nguyen et al., 2022), and cyclone (Cheung et al., 2018). A relatively low number of the reviewed articles used livelihood indicators, which were developed based on sustainable livelihood frameworks [e.g., (Bui, 2021; Delisle and Turner, 2016)]. Livelihood indicators were normally applied to assess the vulnerability, adaptive capacity, or resilience capacity of households or communities to impacts (Bui, 2021; Cuesta et al., 2023; Hidalgo, Nam, and Phuong, 2020; Huong et al., 2019;

Table 3. Mapping of Research Indicators in Climate Change Studies in Upland Areas

#	Indicators	Number of Articles (*n*)	%
1	Socio-economic indicators	33	45
2	Socio-economic and ecological indicators	15	21
3	Ecological indicators	4	5
4	Livelihood indicators	7	10
5	Technical issues/indicators	14	19

Manh and Ahmad, 2021a; Sen, Bond, Winkels, Linh, and Dung, 2020).

Discussion

Methodologies Applied for Climate Change Research in the Upland: Strengths and Weaknesses

The review results showed that numerous methodologies have been employed to analyze the impacts of and resilience to CC in Vietnam's upland regions. They include quantitative methods, qualitative methods, and mixed methods (a combination of quantitative and qualitative methods). Quantitative methodologies often employed diversified modeling such as GIS, integrated assessment models (IAMs), and the Ricardian model for extreme-event-forecast or scenario analysis. However, qualitative methods are according to this study more widely used than quantitative ones in CC research in the uplands of Vietnam.

Both quantitative and qualitative research methods have their own strengths and weaknesses which have implications for the policy-informing potential of the performed studies (Creswell and Poth, 2018). Additionally, qualitative research has been considered by social scientists as the most convenient method due to the feasibility of data collection. Although it is often time-consuming, qualitative research can cover almost all aspects of rural life through people's perceptions and can capture social, economic, and ecological issues of climate impacts and adaptation, as well as people's preferences (Beckman, 2011; Beckman and Nguyen, 2016; Bos et al., 2020; Bosma et al., 2016; Sen et al., 2020). It is particularly useful when studying complex social phenomena, such as upland communities in Vietnam, where

there are diverse ethnic minorities with varied cultures and beliefs; high poverty rates; poor access to information; and low education levels (Creswell and Poth, 2018). Therefore, applying qualitative methodologies is well-suited for identifying livelihood vulnerabilities and resilience strategies embedded in local contexts.

However, from the 23 reviewed articles applying qualitative methods, it can be seen that qualitative research often focuses on specific locations, typically within an administrative boundary (communal scale), and relies on individual perceptions heavily influenced by culture, social characteristics, and the education levels of respondents. As a result, the findings are difficult to generalize to broader policy frameworks, a conclusion consistent with previous studies (Mwita, 2022; Silverman, 2016). Furthermore, qualitative methods are relatively subjective approaches, often based on expert perspectives for defining parameters and assigning weights.

Quantitative methods, in contrast, offer a more objective basis for analysis through the use of numerical data, statistical inference, and standardized weighting criteria (Pham et al., 2017). Quantitative methodologies rely on numerical data for modeling, which can minimize personal biases and subjectivity in interpretation. With large sample sizes and random sampling techniques, research findings could potentially be generalized to broader populations (Creswell, 2014). Moreover, these methods use different models to predict or forecast extreme events and, therefore, typically cover larger scales (e.g., watershed, landscape, ecological, or regional levels), enabling greater generalization (Doukas and Nikas, 2020). This makes

quantitative methods more useful to the government for reducing the impacts of CC. In fact, policy formulation generally relies more heavily on quantitative research (including modeling) than on qualitative research.

However, quantitative methodologies have their own limitations (Creswell, 2014; Hulme, 2007). In particular, the availability of observed data, necessary for modeling, is constrained, which limits the accuracy and robustness of model outputs (Creswell, 2014). Additionally, the frequent exclusion of some socio-economic indicators, particularly cultural values and local preferences, can reduce the applicability of suggested policies, as these factors play an important role in farmers' decision-making processes (Field, 2018). Furthermore, upland communities in Vietnam are vulnerable to diverse climate hazards, such as landslides, flash floods, and drought, three typical climate risks (Sen, Bond, Winkels, Linh, and Dung, 2020). These risks affect not only the livelihoods of upland communities but also downstream populations. As a result, modeling is a crucial method for policymakers and practitioners seeking to reduce negative impacts (Dessai, Lu, and Risbey, 2005). However, data availability and access to relevant databases remain critical issues in the country (World Bank, 2021).

Recognizing the complementary nature of both paradigms, the Vietnamese government and academic community have increasingly promoted mixed methods research to enhance the effectiveness and practical implications of research results, particularly related to CC (Huynh, Le, Le, and Tran, 2021; Le & Vo, 2020; Phuong, Biesbroek, and Wals, 2018). This mixed-method approach allows stakeholders to better understand

complex systems and provides more reliable information for decision-making than either methodology alone (Creswell, 2014; Do et al., 2021; Pham et al., 2017). Mixed methods also facilitate stakeholder participation and knowledge of co-production, thereby improving the credibility and usability of research outcomes in decision-making. Mixed-method and participatory modeling frameworks, for instance, integrating spatial analysis (GIS, remote sensing) with household-level surveys and co-designed scenario planning, should be expanded to overcome current weaknesses in data fragmentation and limited cross-scalar integration.

Given these methodological strengths and limitations, there is a growing need for more innovative and integrative approaches in CC research within Vietnam's upland regions. Existing studies, while valuable, often remain fragmented across scales and disciplines, limiting their ability to inform comprehensive resilience strategies. Addressing these gaps requires methodological refinement and cross-disciplinary synthesis to better capture the complex interactions between livelihoods, ecosystems, and climate processes. Future research on CC resilience in Vietnam's upland regions should therefore prioritize methodological innovation. It should advance toward more integrative and multi-scalar analytical frameworks that link household-level livelihood data with regional biophysical and climatic processes. Establishing longitudinal, open-access databases that combine socio-economic and environmental indicators will be crucial for enhancing model calibration, comparability, and reproducibility. Furthermore, the adoption of participatory and transdisciplinary research designs such as co-designed modeling, scenario-based planning, and agent-

based simulations can strengthen the integration of qualitative insights with quantitative prediction. Methodological advancement should also focus on embedding ecosystem-based and livelihood-centered metrics into resilience modeling to better capture coupled human and environment dynamics.

Research Approaches and Implications for Climate Change Resilience in the Upland Region

Climate impacts and vulnerability are influenced by a wide range of interconnected factors, including environmental, social, economic, and political elements (Nagano and Sekiyama, 2023). Climate vulnerability, consequently, affects various stakeholders differently, ranging from individuals and communities to governments and organizations (IPCC, 2022). It is not uniform and varies greatly across different regions and communities based on local conditions, histories, and cultural contexts (Nagano and Sekiyama, 2023). Therefore, a comprehensive, holistic, and inclusive approach that incorporates the perspectives and needs of all relevant parties is essential. This approach would capture a wide range of interconnected factors and the complex interactions among them, allowing researchers to tailor assessments to specific circumstances (Doukas and Nikas, 2020). Integrating multiple dimensions, such as exposure to climate hazards, sensitivity to impacts, and adaptive capacity, to provide a more complete picture of vulnerability (Ngo, Pham, Hoang, et al., 2021; Ngo, Pham, Nhu, et al., 2021; Nguyen et al., 2022). In short, a comprehensive research approach is essential for accurately assessing CC impacts and vulnerability, as well as for developing effective strategies to enhance resilience. It fosters a deeper

understanding of the complexities involved, leading to more sustainable and inclusive solutions (Phuong et al., 2023), particularly in complex geographic and socio-economically vulnerable communities in the upland areas.

The reviewed articles employed a diversity of approaches, with the sustainable livelihood and integrated production system approaches being the most common. These approaches commonly use indicator indices to capture all aspects of household livelihoods through five main livelihood capitals including human, financial, natural, social, and physical, and their interactions (Beckman and Nguyen, 2016; Huong et al., 2017). They are quite comprehensive and can be flexibly applied at various levels, from individuals to communities, regional, or national levels (Nguyen and Drakou, 2021; Pham et al., 2019). Additionally, these indicators cover multiple aspects of livelihoods based on respondents' perceptions, making them convenient for data collection (Pham et al., 2021; Sen, Bond, and Hoang, 2021). This might be the reason for their widespread use in CC research. However, the livelihood indicators used in CC studies were adopted from different sources and not validated against each other, and this has led to equal weights being assigned to all indicators (such as 2021a, Sen et al., 2020, etc). This may lead to unrealistic results and affect the study outcomes as well as limit policy applicability.

The watershed, ecological-based, and ecosystem-based approaches have been promoted by the Vietnamese government, as they are expected to provide fundamental scientific insights for sustainable environmental policies, particularly in

the National Action Plan for response to CC (Ngo, Pham, Hoang, et al., 2021; Ngo, Pham, Nhu, et al., 2021; Nguyen et al., 2022). However, few studies have been conducted in the upland areas of Vietnam using these approaches. This may be because the watershed approach often employs models, such as the Soil and Water Assessment Tool (SWAT) model (Huyen et al., 2017; Nhi et al., 2022), the Standardized Precipitation Index (SPI), the Drought Index (J), and the Ped Index (Ped) (Tri et al., 2019) primarily for water governance activities (Cohen and Davidson, 2011). In the context of CC, the watershed approach focuses on water resource governance, particularly in river basins (Cohen and Davidson, 2011). This approach provides strategies and policies for sustainable water governance initiatives and has identified significant challenges in its implementation (Duc et al., 2020; Huong and Son, 2020; Huyen et al., 2017; Nguyen et al., 2019; Nhi et al., 2022; Tri et al., 2019). For this approach, ecological indicators are often applied to explore changes in ecological systems around river basins, such as soil moisture, hydrological drought, or water assessments (Nhi et al., 2022; Tri et al., 2019).

Models commonly used in the watershed, landscape, ecosystem-based, and ecological-based approaches are comprehensive but are apparently frequently employed in the scientific publication on climate research. These approaches are in fact used by NGOs/international reports, regional case studies (USAID (USAID, 2018), UNDP (UNDP, 2023), IDH (KIT-Royal Tropical Institute, 2023)) and governmental agencies via reports, policies, and programs (e.g., National action plan on CC, 2012[1]; Vietnam national adaptation plan for the period 2021–2030 with a vision to 2050[2]; Vietnam National Biodiversity strategy to 2020 and vision to 2030[3]) but rarely published in widely recognized journals (Reed, Josh, Jos, and Terry, 2017). We thus found very few articles related to the landscape approach, and most of them were in lowland (Dang et al., 2021; Ho Huu et al., 2018; USAID, 2015)' coastal (Thinh et al., 2015) or in a general agricultural context (Tekken et al., 2017), while there were almost no articles for upland areas. In addition, the retrieved peer review articles used the landscape approach in Vietnam in the context of biodiversity conservation, ecosystem services and CC resilience (Zanzanaini et al., 2017). The preceding is arguing that there is little use of the watershed or landscape approaches in the CC for resilience of research in the uplands. CC requires projections on large scales and over the long term. Due to the complexity of Vietnam's geographic, socio-economic, and ecological systems, CC policies seem to rely heavily on quantitative methods, particularly those including modeling of climate scenarios. Qualitative methodology, livelihood indicators, and integrated production system approaches have, in contrast, not been emphasized in the national climate adaptation strategies or action plans. This may be due to the

[1]https://reliefweb.int/report/viet-nam/pm-approves-national-action-plan-climate-change

[2]https://www.preventionweb.net/publication/viet-nam-national-adaptation-plan-period-2021–2030-vision-2050#:~:text=The%20NAP%20specifically%20identifies%20objectives,ministries%2C%20sectors%2C%20provinces%20and%20external

[3]https://www.cbd.int/doc/world/vn/vn-nbsap-v3-en.pdf

context-specific dependency or the variations and complexity of socio-economic–ecological indicators.

The landscape approach is the most comprehensive, exploring the interconnections between people and nature in areas where productive land uses such as agriculture, livestock, and other human activities compete with environmental and biodiversity goals (Do et al., 2021; Nguyen et al., 2013). It also considers a spatial scale large enough to include all ecological, social, and ecosystem-related causes and effects of extreme climate events within the system (Nguyen and Kieu, 2022). The landscape approach often integrates both qualitative and quantitative research methodologies (Bos et al., 2020; Do et al., 2021; Nguyen et al., 2013; Nguyen and Kieu, 2022). Thus, it provides a reliable scientific basis for policymakers to formulate climate-responsive policies (Bos et al., 2020; Nguyen and Kieu, 2022). However, the number of studies employing the landscape approach remains limited. Instead, sustainable livelihood and integrated production system approaches are more commonly used in this research field. This may be due to the practical challenges of the landscape approach, which requires comprehensive data across multiple dimensions and scales (Folke et al., 2010), particularly across districts and provinces with different development priorities, policies, and socio-economic conditions (Sifuentes, York, and Fultineer, 2021; Tschakert and Dietrich, 2010). Integrating various socio-economic and ecological factors can make the research process complex and difficult to manage, potentially leading to unclear outcomes (Grigorescu et al., 2021). Furthermore, the landscape approach often requires significant time and resources (Metzger, Rounsevell, Acosta-Michlik, Leemans, and

Schröter, 2006), especially in highly diverse communities in complex landscapes. However, limited research funding and impoverished and time-constrained communities are clear limitations to this research. In summary, while the landscape approach offers valuable insights for addressing climate vulnerability, careful consideration of its complexities and challenges is essential for effective application. In the current context of CC, it is extremely necessary to study different aspects such as social, economic, and environmental as well as evaluate the beliefs, attitudes, and behaviors of relevant stakeholders.

Therefore, more research is needed on CC resilience, particularly in the uplands with cultural, social, and economic inclusive using integrated qualitative and quantitative methods and landscape approach to feed into policy processes from local to regional scale. Future investigation should focus on identifying which aspects of climate vulnerability remain underexplored, especially in relation to interactions between land-use transitions, ethnic minority livelihoods, and ecosystem service trade-offs. Empirical gaps persist in quantitative data collection and long-term monitoring of socio-ecological indicators, such as water yield variability, soil degradation rates, migration patterns, and adaptive behavior changes. These datasets could be systematically collected and harmonized by government agencies, universities, and NGOs to establish open-access databases for resilience assessment. Moreover, future research should extend its analytical units beyond household and community levels to meso and regional scales, where policy coordination, watershed governance, and inter-provincial cooperation become

critical for scaling up resilience. Besides that, integrative and multi-scalar analytical frameworks should emphasize explicitly connecting household livelihood dynamics with ecosystem and regional processes.

Future studies should also expand thematic coverage to address gender inclusion, institutional capacity, and governance dynamics, areas that remain insufficiently represented in upland resilience literature. Incorporating ecosystem-based and nature-based adaptation with livelihood frameworks would bridge environmental sustainability and social equity goals. Lastly, given that CC impacts transcend administrative boundaries, research collaboration across provinces and watersheds is essential to design coherent adaptation strategies that reflect ecological and socio-economic interdependencies.

Conclusions

From our structured review, we can conclude that fewer studies in the CC context have been reported for upland communities than for lowland and coastal areas in the agricultural sector. Most studies have been conducted at community or commune levels, and qualitative methods were commonly used. Quantitative methods were less used due to low availability of data for modeling and high costs for primary data collection. Social-economic indices were the main indicators used for analyses with the integrated production system approaches dominating. No studies were found about ecosystem-based and nature-based adaptation and mention lack of gender aspects. Very few studies were about institutions and policies or combining quantitative and qualitative methods. Watershed or landscape approaches

were applied in a few studies due to their complexity. Most of the studies have been delimited by the boundaries of the administrative areas of Vietnam. However, CC and its impacts are not confined by such boundaries; for example, projects related to REDD+, and dam and dyke construction are likely to involve more than one administrative unit. Responses or interventions based on such research might therefore not always be effective, although they may improve the situation more for some communities than others.

To address these gaps, further research is needed on collaboration and coordination across administrative units, and possibly other issues to hinder or enable resilience results. Advance methodological integration through mixed-method and multi-scalar frameworks that capture both livelihood and ecological processes. This calls for combining qualitative and quantitative methodologies, expanding analytical units beyond households and communes to include watershed and inter-provincial levels where coordination and governance play critical roles. Develop standardized, open-access databases collecting biophysical and socio-economic data under the coordination of the government, universities, and NGOs. Enhance participatory and transdisciplinary approaches that include community voices, local institutions, and gender perspectives in resilience assessment. Broaden thematic coverage to incorporate governance, institutional collaboration, and cultural dynamics areas often omitted in current upland research. Strengthen ecosystem- and nature-based adaptation studies and link them to livelihood and landscape frameworks

for holistic resilience strategies. Promote cross-boundary collaboration and data harmonization to ensure adaptation policies reflect ecological and social interdependencies. Evaluate adaptation effectiveness through impact-based monitoring and feedback mechanisms to inform scalable, evidence-based interventions. These conclusions further explicate for knowing the implications for methodologies and approaches in CC research in upland areas that seek strategies and interventions to help communities respond to CC and increase resilience.

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Authors' Contributions

P.T.H.L., and S.T.H.L.: Conceptualization, writing—original draft, investigation, visualization. S.D., I.Ö., P.T.H.L., S.T.H.L., and K.L.P.H.: Conceptualization, methodology. M.B., S.T.H.L., and P.D.L.: Conceptualization, supervision, resources. All the authors have read and agreed to the published version of the article.

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