

Asset-Challenge Shifts of Rural and Remote Communities in the Global Context of Climate Change: A Systematic Review through the Natural-Built-Social-Environment Triangulation

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Table of Contents

<i>Executive Summary</i>	<i>ii</i>
Background	ii
Objectives	ii
Results	ii
Key Messages	iii
Methodology	iv
<i>Full Report</i>	<i>I</i>
Background	1
Objectives	2
Methods	3
Part One - Data Curation	3
Part Two - Data Management - Screening and Extracting Data:	4
Part 3 - Data Analysis:.....	5
Results	6
Quantitative Results.....	6
Qualitative Results.....	11
Rural and Remote Communities and CCCID – The Social Environmental Domain	12
Environmental Awareness	12
Migration and Displacement – A Social Problem	13
Resilience and the Disaster Cycle	14
Vulnerabilities	15
Rural and Remote Communities and CCCID – The Built Environmental Domain	17
The Disaster Cycle and Resilience – The Built Environment	18
Migration – A Built Environment Perspective	19
Retrofitting	20
Sustainable Planning	21
Rural and Remote Communities and CCCID – The Natural Environmental Domain	21
Impacts on the Natural Environment in Rural Communities	22
Mitigation and Adaptation Strategies	23
Connections to the Social and Built Environmental Domains	24
Implications	24
Conclusion	25
Knowledge Mobilization Activities	26
KM Activity 1 - Advancing Academic Research and Beyond:.....	26
KM Activity 2 - Informing Non-Academic Stakeholders:	27
KM Activity 3 - Advancing Research Uptake:	27
Bibliography	29

Executive Summary

Background

Climate change and climate-induced disasters (CCCIDs) are among the most notable threats facing the world today, devastating the natural, built, and social environments. In Canada, the threats caused by CCCIDs have disproportionately impacted rural and remote communities, placing the communities' unique assets—such as their place-based knowledge and culture, localized community bonds, and stunning environmental landscapes—at substantial risk. CCCIDs place rural and remote communities in marginalized states due to economic downturn, out-migration, and resource insecurity, blurring the lines between their assets and challenges. Despite the critical threat that CCCIDs pose to Canada and the global community writ large, there is a systematic review and comprehensive analysis deficit of rural and remote community-specific knowledge as it relates to the challenges of CCCIDs on the natural, built, and social environments. This deficit jeopardizes knowledge mobilization for rural and remote communities in the context of CCCIDs and weakens the prospect of moving practice and policy initiatives and solutions forward.

Objectives

Positioned in a rapidly changing Canadian and global climate wrought with environmental harms, this project aims to identify CCCID knowledge specific systematically, comprehensively, and critically to rural and remote communities within the natural-built-social environment triangulation that could potentially improve the existing and potential policies and practices that serve rural and remote communities, thus building resilient and sustainable communities in Canada and beyond. The objectives of this project are to (1) Synthesize the current knowledge of CCCID-driven impacts within the natural-built-social-environment triangulation of rural and remote communities that reshape their assets and challenges; (2) Identify research gaps among the existing rural and remote community studies focusing on CCCID-driven asset-challenge shifts associated with rural and remote communities' natural, built, and social environments; and (3) Inform practice and policymaking by providing critical information and evidence-based strategies that build CCCID-specific resilient and sustainable rural and remote communities, at home and abroad.

Results

The quantitative results showed that the social environment domain was the most extensively researched in the context of rural and remote communities with over 85% of the literature having a relationship to the social environment. Meanwhile, the natural environment as a distinct entity received

the least attention. Geographically, there was an imbalance of coverage with articles being predominantly focused on Asia, Africa, and North America.

The qualitative results were divided between the three domains of the natural-built-social environment triangulation, where themes within each domain emerged and connected the domains to one another. For the natural environment, within rural and remote communities, climate change had major impacts on land and water systems that could disrupt the ecological balance and cause environmental degradation within the communities. Combined with the social environment, this generated climate adaptation behavior to protect the lands and water from environmental harm. Further, the natural environment domain provided information about environmental mapping and monitoring in rural and remote communities to identify potential problem areas within the natural environment.

In terms of the built environment domain, rural and remote communities have been extensively researched regarding disaster preparedness and resilience. Specifically, research has examined how built environments such as homes, commercial buildings, and infrastructure have been retrofitted based on localized knowledge to adapt and mitigate CCCIDs in the future. Further, in connection with the social environment, migration behavior was a key theme in the literature. In post-disaster contexts, rural and remote communities may have different resources and needs than their urban counterparts, which can contribute to monetary resources being allocated to temporary housing, reconstruction, and culturally appropriate resettlement planning.

The social environment domain had the most robust research findings and thematic elements, serving as a key connecting piece to the other two domains. Differing perspectives of environmental awareness were prevalent and resilience played a major role in adaptation, mitigation, response, and recovery from CCCIDs. Social structures also played a key role in migration behavior in rural and remote communities. Due to structurally-based social inequalities, rural and remote communities can see large-scale displacement due to CCCIDs and human movement within the community and between rural and urban areas. Finally, CCCIDs catastrophically disrupted the assets of rural and remote communities like community connectedness, as the COVID-19 pandemic created challenges to be as connected physically as in pre-pandemic times.

Key Messages

Future research should continue to examine the impacts of CCCIDs on rural and remote communities especially as it relates to marginalized communities and underserved populations within the rural and remote areas (e.g., 2SLGBTQ+ individuals, homeless populations, racial and ethnic minorities, etc.). Further, additional research must be done in the natural environment domain since our review revealed that it was under-researched.

Policy collaboration with Indigenous and Tribal communities can promote their unique environmental and land- and water-based knowledges to build connections with Tribal communities and rural and remote communities without Tribal status. These policy connections and collaborations can enhance services and resources among all rural and remote communities in Canada and beyond, by leveraging a key asset of rural and remote communities—community connectedness. Policy, practice, and research collaboration can build knowledge of the advantages rural and remote communities bring to the table regarding CCCID impacts. This will lead to a comprehensive understanding of rural and remote communities’ assets to the built, social, and natural environmental domains in the context of climate change and disaster.

Policy at the local, provincial, and federal levels must begin enhancing the funding to build rural and remote communities’ resilience capacities in the wake of CCCIDs by allocating for nuanced housing and infrastructure funds that allow these communities to properly retrofit and adapt buildings, roads, and other critical infrastructure based on CCCID impacts and needs.

Methodology

This project used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach to guide this systematic literature review. Using multiple keywords and datasets, the research team identified an initial literature pool of 5336 publications. The research team developed inclusion and exclusion criteria per the project’s research objectives to systematically evaluate each publication’s eligibility through two steps: title and abstract screening followed by a full-text review. This resulted in a total of 308 publications for the final analysis. Using mixed methods—univariate analysis and thematic inquiry—the research team identified the findings and synthesized the results into actionable recommendations for future policy, practice, and research.

Full Report

Background

Climate change and climate-induced disasters (CCCIDs) are among the most pressing and prevalent threats facing human societies (IPCC, 2022). According to the Intergovernmental Panel on Climate Change (IPCC) climate change alone has had strong adverse effects on mental health, disease, displacement, inland flooding, infrastructure damage, and economic sector damage (IPCC, 2023). Beyond climate change, environmental hazards such as sea level rise, glacial melting, extreme temperatures, droughts, wildfires, and COVID-19 (Sacks et al., 2021) have been drastically devastating to the natural environment (e.g., ecosystems, natural resources, and agriculture)(Baicha, 2016; Gonzalez et al., 2022; Mugari et al., 2019), built environment (e.g., civil infrastructure, housing, and commercial buildings)(Costin, 2021; Englhardt et al., 2019; Miyaji et al., 2021), and social environment (health, well-being, resilience, culture, and social institutions) (Batterham et al., 2022; Schnorr-Baecker, 2021; Wu & Chen, 2023) within rural and remote communities (Brown et al., 2021; Samuel et al., 2019; Wu, 2021; Wu et al., 2022)—defined by areas with populations under 10,000 people (Asad et al., 2021).

On a global scale, the natural environment and natural resources (e.g., farmland, forests, tropics) supports rural residents' livelihoods through the agricultural sector; however, increased instances of drought, flooding, and wildfires, place perpetual strain on the land used for farms, ranches, orchards, and grazing land for livestock (NOAA, n.d.). In addition, rural and remote communities' housing markets attract residents from urban city centers. However, storms, hurricanes, sea level rise, and glacier melt destroy rural and remote communities' built environment (e.g., housing and infrastructure), ultimately resulting in high costs for maintenance and reconstruction due to their isolation and remoteness from the professionals who maintain and supply critical infrastructure (Chirisa & Nel, 2022). The vital social environment in rural and remote communities has been disrupted by CCCID-driven depopulation (Fletcher et al., 2020), removing the sense of community and cultural identity, which is a historical strength of these communities (Vodden & Cunsolo, 2021) These interconnected asset-challenge shifts within the natural-built-social-environment triangulation have triggered complex short-, mid-, and long-term impacts, accelerating out-migration on an international scale (e.g., climate refugees) (Tahir, 2022). This, in turn, corrodes rural and remote communities' assets resulting in large-scale, CCCID-specific vulnerabilities and marginalization. This marginalization ultimately reduces rural and remote communities' capacity to mitigate, prepare for, respond to, adapt to, and recover from CCCIDs, affecting their residents' overall health and well-being (Vodden & Cunsolo, 2021)

In a Canadian context, the climate crisis is much more alarming as according to the Government of Canada's National Issues Report, observed warming is nearly double the global average (Warren & Lulham, 2021). The climate emergency directly affects Canada's vast and diverse rural and remote communities, as these communities are often disproportionately impacted compared to urban city centers (Bush & Lemmen, 2019; Vodden & Cunsolo, 2021). CCCIDs have been shifting the dynamics of Canadian rural and remote communities' unique assets (e.g., social capital, community connectedness, localized and Indigenous knowledges), tilting the scales toward climate crisis-compounded challenges such as changing demographics, isolation from policymakers and governmental actors, and accessibility issues regarding infrastructure for health, technology, and communication (Vodden & Cunsolo, 2021).

The direct and indirect impacts within the natural built-social-environment triangulation have been reducing rural and remote communities' existing assets (e.g., natural resources and landscapes, affordable housing, and strong social connections) and increasing rural and remote communities' adaptive challenges to CCCIDs (Burford & Robertson, 2021; Wale et al., 2022; Williams et al., 2013). However, the identification and synthesis of these CCCID-driven impacts within the triangulation remain unclear. Specifically, there is a distinct, comprehensive deficit regarding a systematic review and analysis of CCCID-related knowledge, strategies, and outcomes for rural and remote communities. This deficit has holistically marginalized Rural and remote communities and jeopardized rural and remote community dwellers' health and well-being. Therefore, there is an urgent need to comprehensively identify, synthesize, and understand CCCID and rural and remote community-associated knowledge, strategies, and outcomes in the natural-built-social environment triangulation to effectively build their resilience and adaptive capacities.

Objectives

A knowledge synthesis of information regarding CCCIDs in rural and remote communities will yield actionable knowledge, enhanced practice, and empirical evidence-based policy, that can help build rural and remote communities' resilience capacities and overall sustainability because of the continuing shifts from rural community assets to marginalization due to CCCIDs. This comprehensive knowledge synthesis will offer a unique model that leverages a natural-built-social environment triangulation to promote healthy and resilient communities in Canada and worldwide. Therefore, this project utilizes the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach to comprehensively identify and synthesize the state-of-the-art CCCID-driven knowledge, practices, and policies that address the asset-challenge shifts within the rural and remote communities' natural-built-social-environment triangulation. This knowledge synthesis and the resulting outcomes will provide necessary insights into building stronger, healthier, more sustainable, and more resilient rural and remote communities in Canada and beyond in the context of global CCCIDs.

Positioned in the rapidly changing landscape of climate change and increasing disaster impacts and losses, this project aims to critically identify the asset-challenge shifts that are impacting rural and remote communities specifically due to CCCIDs within the innovative natural-built-social environment triangulation. The three CCCID and rural and remote community-targeted objectives include:

Objective 1 - Displaying the current knowledge landscape of CCCID impacts on rural and remote communities: By systematically examining and synthesizing CCCID knowledge, strategies, and outcomes to provide increased coping and resilience capacities within the natural-built-social environment triangulation of rural and remote communities that reshape their assets and challenges;

Objective 2 - Identifying rural and remote community and CCCID research gaps: By comprehensively examining the strengths and deficits among the existing rural and remote community studies centered on CCCID-driven asset-challenge shifts associated with rural and remote communities' natural, built, and social environments; and

Objective 3 - Informing rural and remote communities and CCCID practice and policymaking: By providing critical information and evidence-based strategies that build CCCID-specific resilient and sustainable rural and remote communities, at home and abroad, while also promoting transdisciplinary, cross-sector research, practice, and policymaking through knowledge translation, dissemination, and mobilization.

Methods

Built on the extensive impacts that CCCIDs have on rural and remote communities in Canada and globally, this systematic review project was guided by an overarching research question: What are the current knowledge and knowledge deficits of CCCID-specific challenges associated with the natural, built, and social environments that reduce the rural and remote communities’ assets and increase their challenges and marginalization? Using the PRISMA guidelines (Page et al., 2021)—a widely accepted technique for reporting systematic reviews as well as meta-analyses—our research team collected data to answer the research question through three distinct steps. The three steps as outlined by the PRISMA method include data curation, data management, and data reporting—analysis and synthesis of data.

Part One - Data Curation

As previously mentioned, research regarding CCCID impacts on rural and remote communities has been widely examined across academic outlets including peer-reviewed journal publications, edited volumes, books, and conference proceedings. Therefore, our research team chose six (6) multidisciplinary academic databases to comprehensively identify publications, especially in the social sciences, humanities, and environmental sciences. The chosen databases included EbscoHost, Embase, ProQuest Central, PubMed, Scopus, and Web of Science (see Table 1). The research team also identified three groups of subject matter keyword groups that reflect the components within the research project objectives and research question which included “climate change and climate-induced disaster,” “rural and remote communities,” and “triangulation” (see Table 2).

Table 1. Databases and Identified Literature

Database	Identified Publications	Duplicates Removed	Total Publications
EbscoHost	2439	502	1937
Embase	147	127	20
ProQuest Central	2704	1409	1295
PubMed	556	309	247
Scopus	1592	1	1591
Web of Science	897	651	246
Total	8335	2999	5336

Table 2. Keywords

Keyword Groups	Keywords
Climate Change and Climate-Induced Disaster	"Climate" OR "Disaster*" OR "Heat Wave*" OR "Earthquake*" OR "Extreme Temperatur*" OR "Hurricane*" OR "Flood*" OR "Drought" OR "Wildfire*" OR "COVID-19" OR "Climate Change"
Rural and Remote Communities	"Rural" OR "Farm*" OR "Agricultur*" OR "Remote communit*" OR "Town*" OR "Village*" OR "Tribe*" OR "Nonmetropoli*" OR "Migration*" OR "Agrarian*"
Triangulation	"Natural Environment" OR "Built Environment" OR "Social Environment"

Within each keyword group, the Boolean operator “OR” separated keywords. Additionally, the Boolean operator “AND” separated the keyword groups themselves. This mechanism was used in each of the database searches to extract all of the related publications. The research team further filtered publications by year (2013-2023) and language (English). Where applicable, the research team also used the search functionality to search titles, abstracts, and keywords to limit the results to the most relevant publications. The 8335 references from the database searches were then uploaded into Covidence, an online systematic review tool that facilitates screening, extracting data, and completing analysis (Covidence, n.d.). The Covidence tool automatically removed 2999 duplicate articles, resulting in an initial dataset of 5336 total publications that moved to the second step in the screening process.

Part Two - Data Management - Screening and Extracting Data:

In the initial stage of part two, the research team screened the 5336 identified publications by their titles and abstracts. The team established criteria associated with the three primary research objectives to assess the publication eligibility and suitability for analysis. To reduce potential biases or screening mistakes, publications were screened by two members of the research team independently (JJ and BO). Once the title and abstract screening took place, a third researcher (KB) resolved any outstanding disagreements. This initial title and abstract screening removed 4932 unrelated publications, moving a total of 404 to full-text screening.

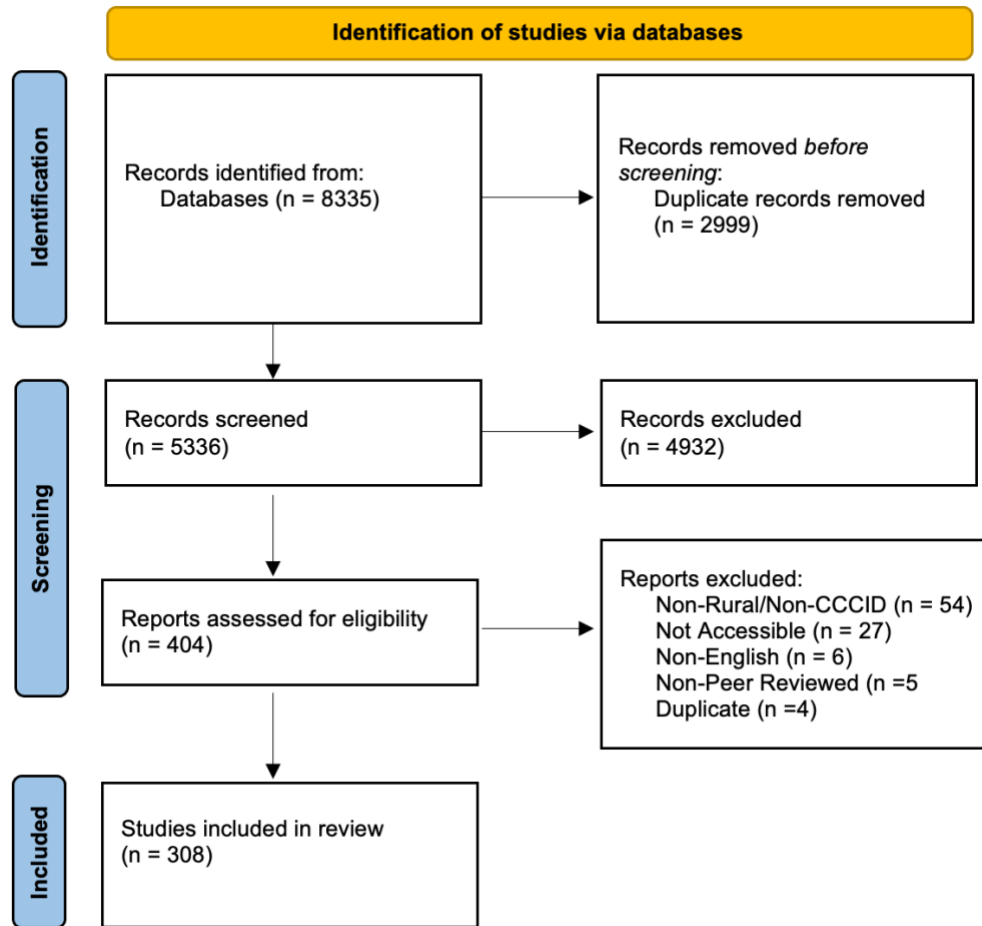
Identical to the title and abstract screening stage, the full-text review of each publication was undertaken independently by two researchers (JJ and BO). At this stage, the two researchers thoroughly examined the publication strengths and deficits through clearly defined inclusion and exclusion criteria:

1. The publication includes an examination of Rural Communities/Populations, Remote Areas, Small Towns, Villages, Tribal Communities or Farming Communities as the focus of analysis within the context of CCCID and the natural-built-social environment triangulation.
2. The publication describes the strengths and/or deficits of CCCID and rural and remote communities research, to advance research, practice, and policy that may identify the shifting nature of assets and challenges within rural and remote communities in the context of CCCIDs and the triangulation.
3. The publication focuses on contributing rural and remote community-led and/or -informed policy and decision-making that promotes community and societal well-being, resilience, and sustainability.

The full-text review removed 96 publications—54 did not meet the inclusion criteria, 6 were not in English, 5 were non-peer-reviewed articles, 4 were duplicates, and 27 articles did not allow full-text access. After the full-text review, the research team extracted 308 publications for final data analysis. The research team completed the extraction process by creating a template in Covidence that allowed for data from the publications to be transferred to a spreadsheet containing all necessary information. Two members of the research team (JJ and BO) transferred all of the required data independently. A third member of the team (KB) completed the consensus, a step that resolves any discrepancies between the two researchers’ extracted data. Once completed, the data was exported into CSV and Microsoft Excel formats for analysis. These datasets were inventoried and published in the online data repository at Dalhousie University, Dalhousie Dataverse @ Borealis. The inventorying of data for public use

promotes the reuse of data among researchers, practitioners, policymakers, and other similar stakeholders with related interests. Figure 1 indicates the entire data curation, screening, and extraction process.

Figure 1. Flowchart of PRISMA Approach



Part 3 - Data Analysis:

The research team implemented a mixed-method approach for data analysis. Specifically, the team utilized quantitative univariate analysis and qualitative thematic inquiry to identify, synthesize, and analyze the results and offer recommendations. Four research team members (BO, JJ, KB, LT) independently and collectively conducted each analytic approach, and full-team meetings were conducted to resolve any disagreements in the analysis process. In addition, full-team meetings were utilized to administer recommendations based on the entire analysis.

During the extraction phase, three researchers (BO, JJ, KB) identified several fields that publications often addressed and that were based on the primary research objectives. For example, data extraction fields included the type of rural community, type of hazard, and study location. These fields constructed the categories for the statistical analysis. The extraction process allowed for two researchers (BO, JJ) to select categorical data from the publications, while one researcher (KB) resolved conflicts to reach a final consensus. This data was then extracted and analyzed by one researcher (BO) who created analytic charts and graphs showing frequency and descriptive data based on the entire dataset.

Similarly, two researchers (JJ, LT) conducted a thematic analysis to complete the qualitative portion of the research. Since the overarching goal of this project is to identify CCCID knowledge related to rural and remote communities within the natural-built-social environment triangulation, the triangulation served as the initial qualitative thematic categories that guided the coding process. The two researchers conducted deductive coding and developed sub-themes within each larger category independently, before discussing and finalizing the sub-themes. Following deductive coding, the researchers used inductive coding to build out the sub-themes accordingly to provide rich, descriptive data analysis of the publications. The following section presents the quantitative and qualitative analytic outcomes. The research team discussed and synthesized the outcomes to determine potential practice and policy recommendations while also merging quantitative and qualitative results to outline future research directions.

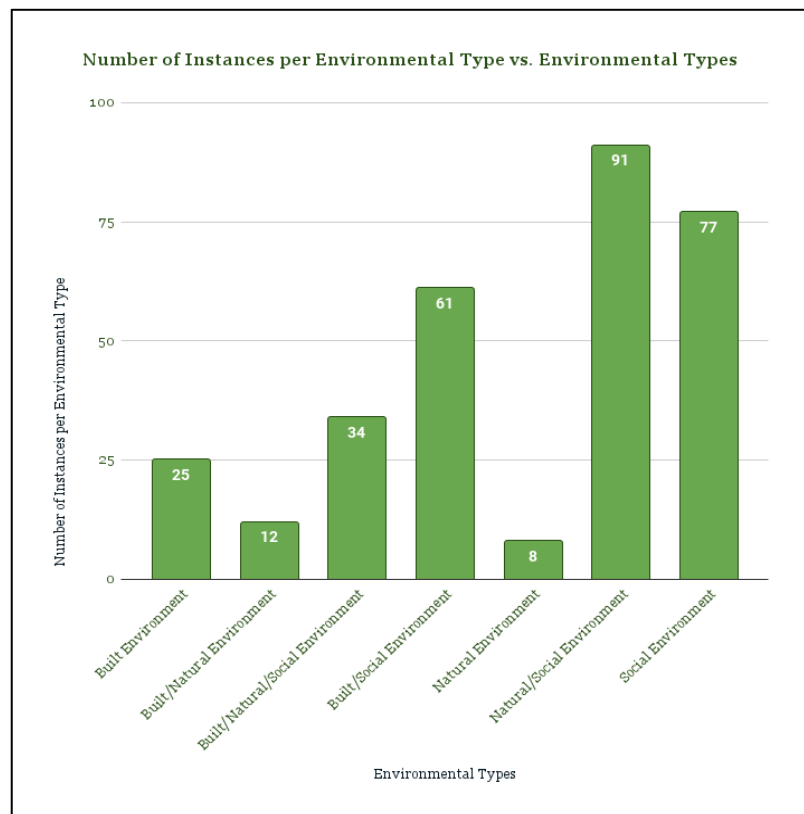
Results

Quantitative Results

For the quantitative data analysis, the research team categorized the publications based on overarching topic areas such as the triangulation, the rural community type, the hazard type, and the geographic location of the study. The team categorized the publications into the topic areas in order to calculate frequencies and descriptive statistics to evaluate the current research landscape of CCCID impacts on rural and remote communities within the natural-built-social environment triangulation. These frequencies and descriptive statistics offer insight into the current research gaps and the areas in the research that have been extensively studied.

When examining the natural-built-social environment triangulation the research team categorized articles based on what domain of the triangulation was the central focus of the publication (Figure 2). Notably, the publications are weighted heavily towards impacts on the social environment. All of the top four categories, >85% of articles, dealt with the social environment as a category of study. Furthermore, it is interesting that the natural-social environment is the most represented category in the research, while the natural-built environment and natural environment categories are the two least represented. This may be, in part, due to selection bias, as our criteria specifically searched for keywords associated with communities and

Figure 2. Environmental Triangulation Article Count



human settlements. However, it may also point to an interest in tying CCCIDs to tangible human impacts.

The research team also examined the geographic location of the publications included in the systematic review (Figure 3). When the publication specifically listed the geographic location of the study, Asia (40.3%), Africa (22.0%), and North America (12.5%) were the most common research locations continentally. In terms of country-specific research, the three most common countries by research location were China (10.1% - 35 articles), the United States (8.1% - 28 articles), and India (7.0% - 24 articles), followed closely by Indonesia (5.2 - 18 articles) and Australia (4.6% - 16 articles) (Figure 4). In terms of a Canadian context, Canada only made up 1.7% of the research articles, meaning further research is needed regarding the triangulation, CCCIDs, and rural and remote communities. Furthermore, very little research was conducted in South America. It is critical to continue conducting work in under-researched countries as their findings could influence mitigation and adaptation strategies in other areas of the globe.

Figure 3. Countries Included in Publications by Continent

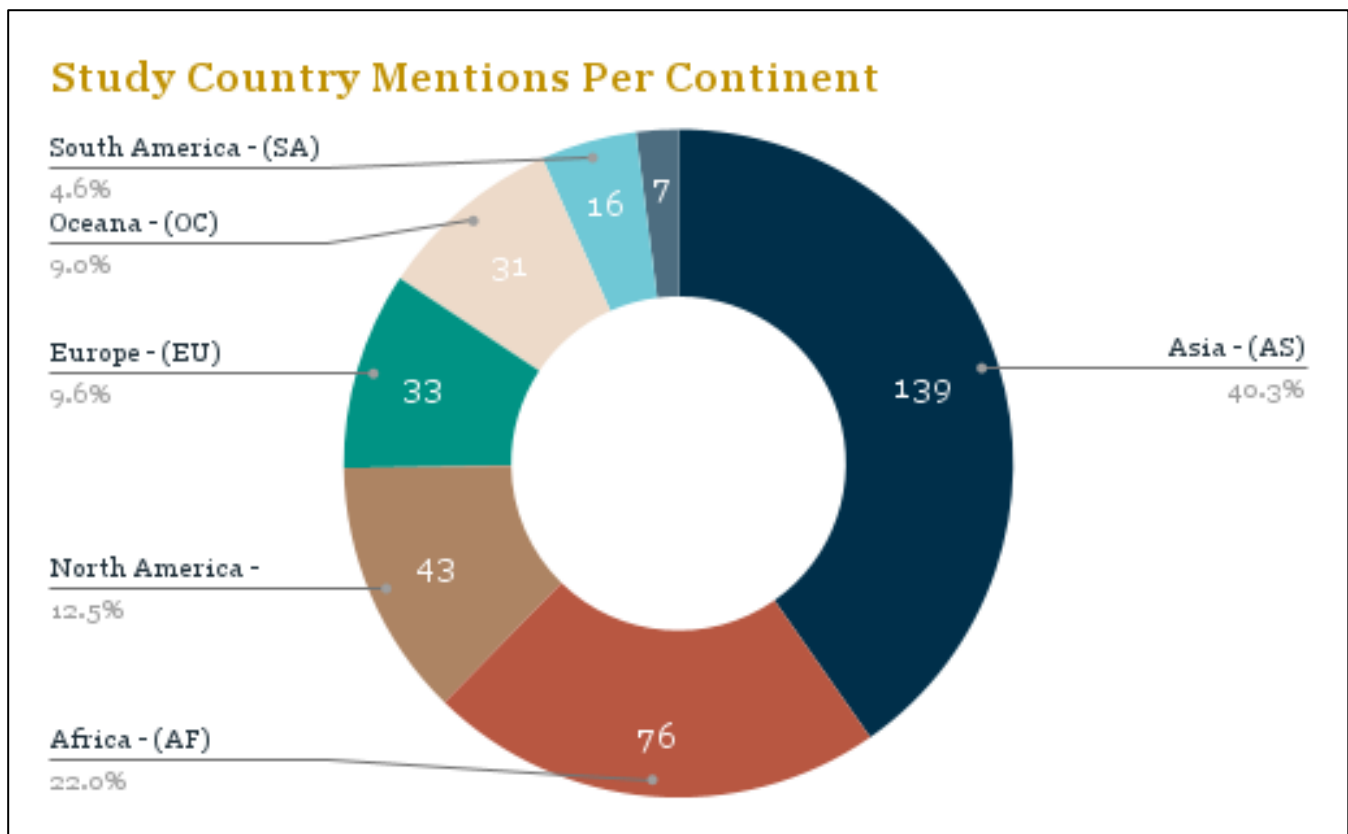
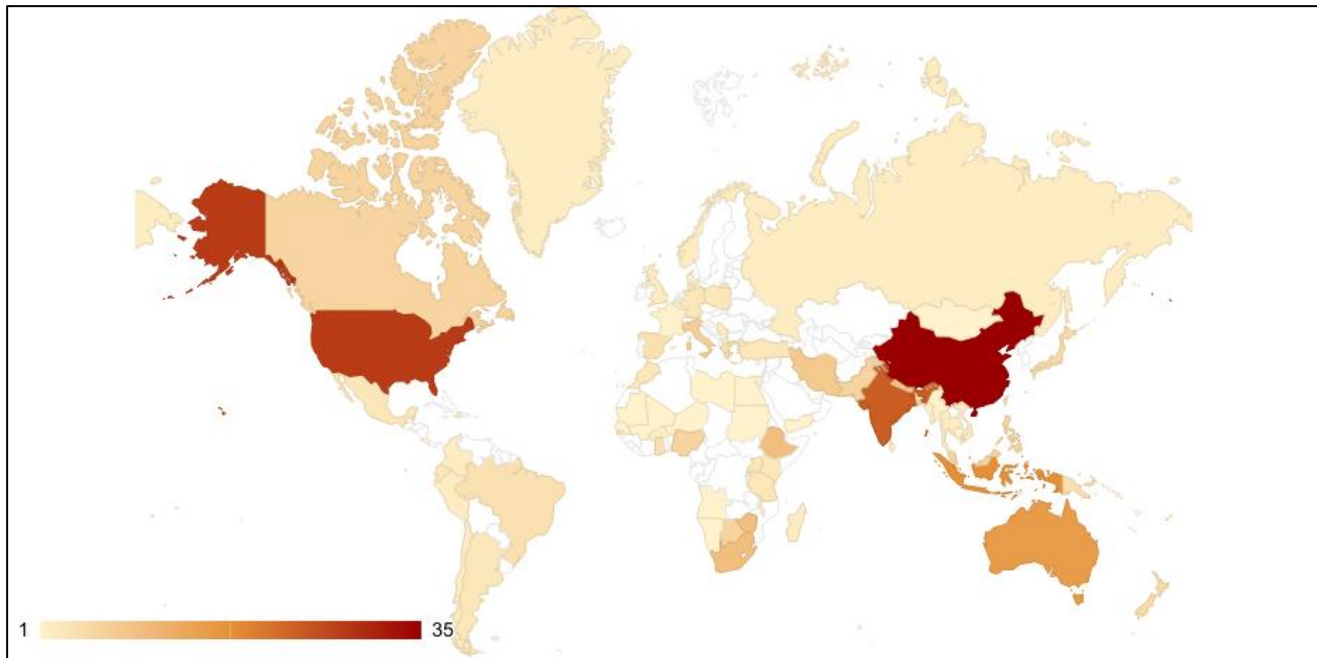
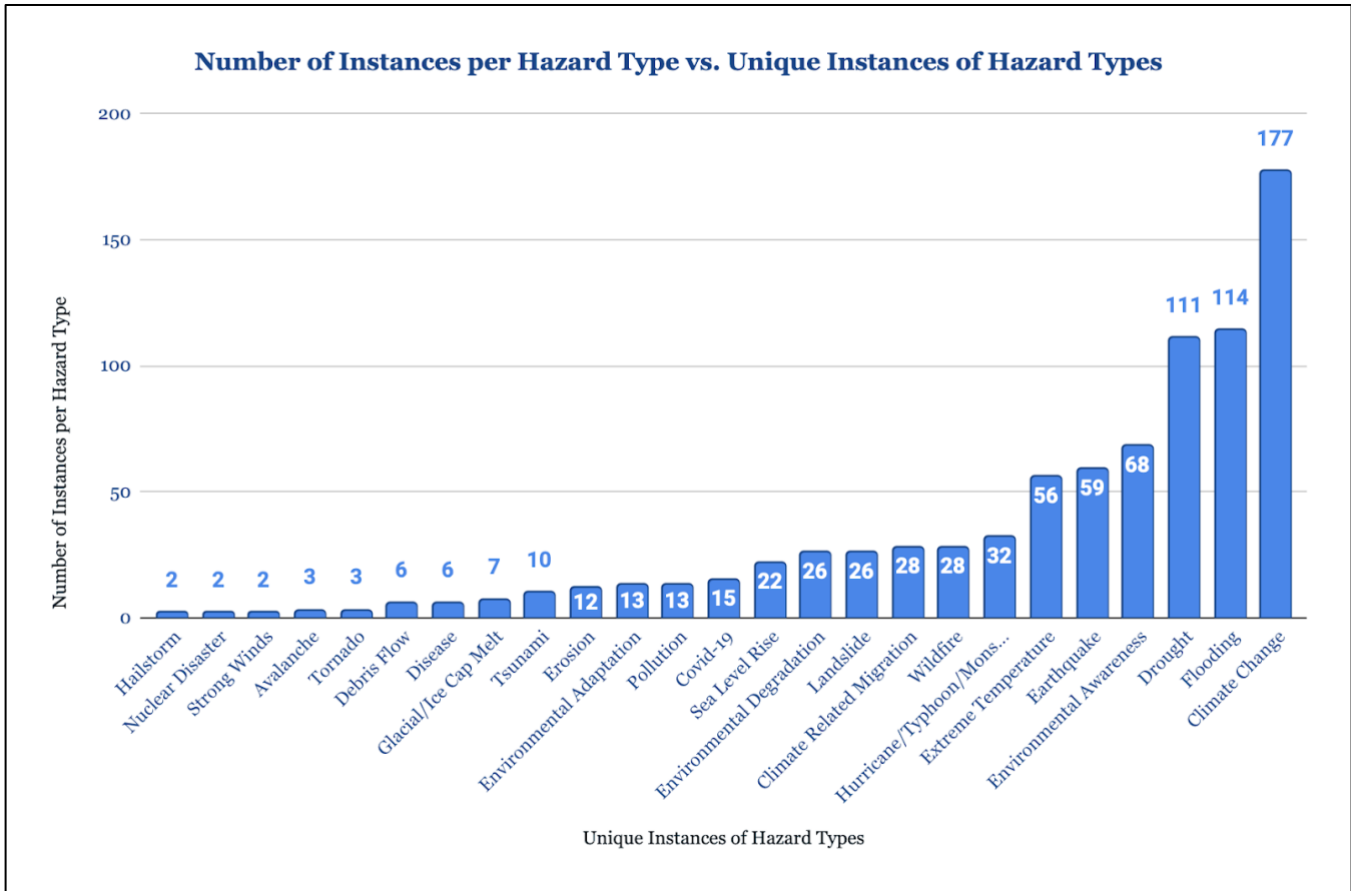


Figure 4. Map of Countries Included in Reviewed Publications



Publications included in the review were also categorized by hazard type (Figure 5). The research team included instances of environmental hazards (e.g., climate change, hurricanes, floods, earthquakes), environmental harms (e.g., pollution, disease, environmental degradation), and environmental actions (e.g., environmental awareness, environmental adaptation, environmental migration). Climate change was the most prevalent topic, appearing in 21% of the publications. Indeed, other topics similar to climate change also appeared in the review including environmental awareness—which included human perceptions of climate change and human agency in climate change—and environmental adaptation. Interestingly, there was a disparity in the number of research publications on environmental awareness (8.1%) and environmental adaptation (3.1%), which may indicate a condition of growing awareness of climate issues but a lack of responsibility in changing our own socio-economic processes which perpetuate them. Beyond climate change, a number of disasters were identified as occurring more frequently/having significantly more research dedicated towards them. This included flooding (13.6%) and drought (13.2%) both typically associated with global climate change in their respective articles. After these two hazards are earthquakes (7.0%), extreme temperatures (6.7%), and hurricane/tropical storm events (3.8%).

Figure 5. Frequency of Hazard Types in Publications



Finally, the research team categorized hazard type by the type of rural community examined in the publications. The team initially categorized the publications by the rural community type (Figure 6). Overall, most of the publications did not specify the type of rural community the study took place—only that the community was rural. However, other studies specified the type of rural community such as farming or pastoral communities, villages, or Tribal communities. Hazard types were then examined by rural communities to identify any unique disparities or trends (Figure 7). Based on the data, there were no strong variations between rural community types. The one exception was that drought research occurred often in farming and pastoral communities, which makes sense considering the impacts droughts have on farming communities and agricultural outputs.

Figure 6. Rural Community Types Mentioned in Publications

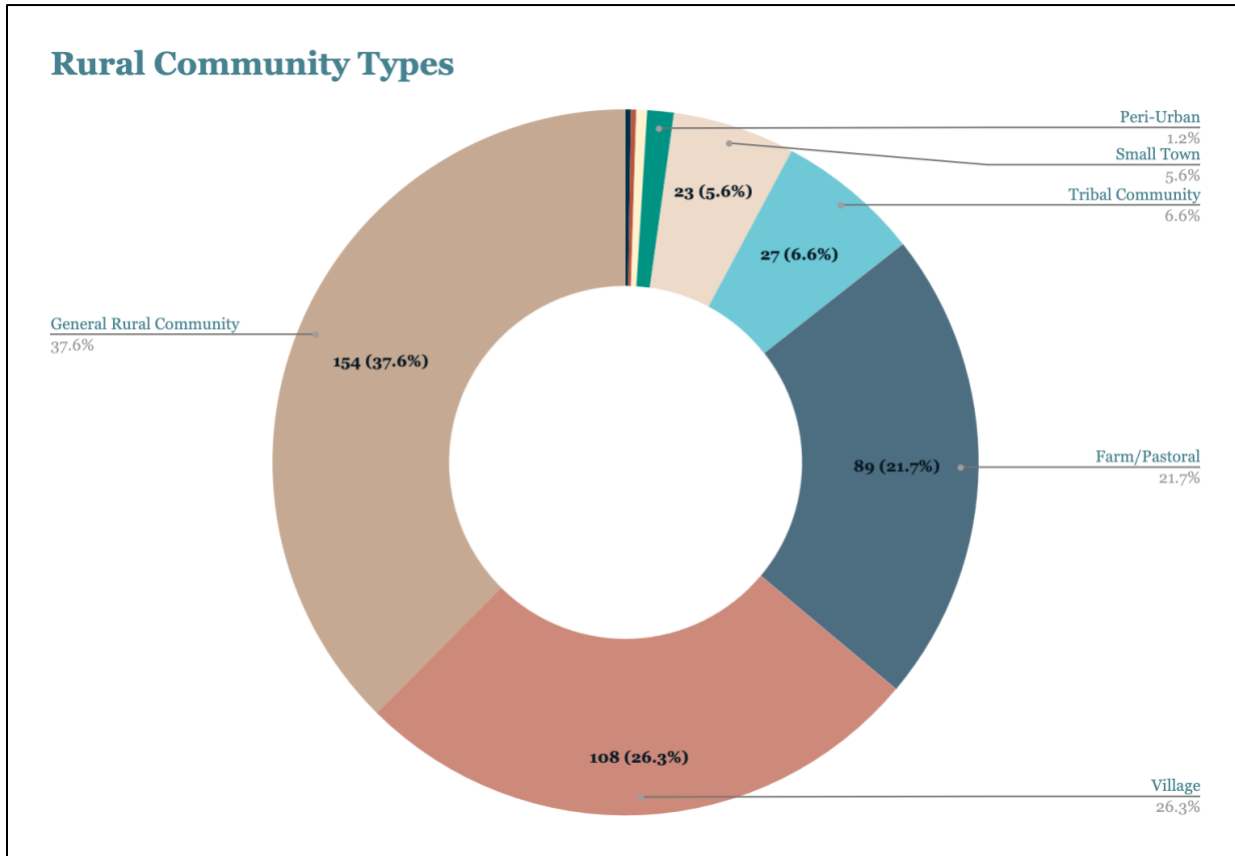
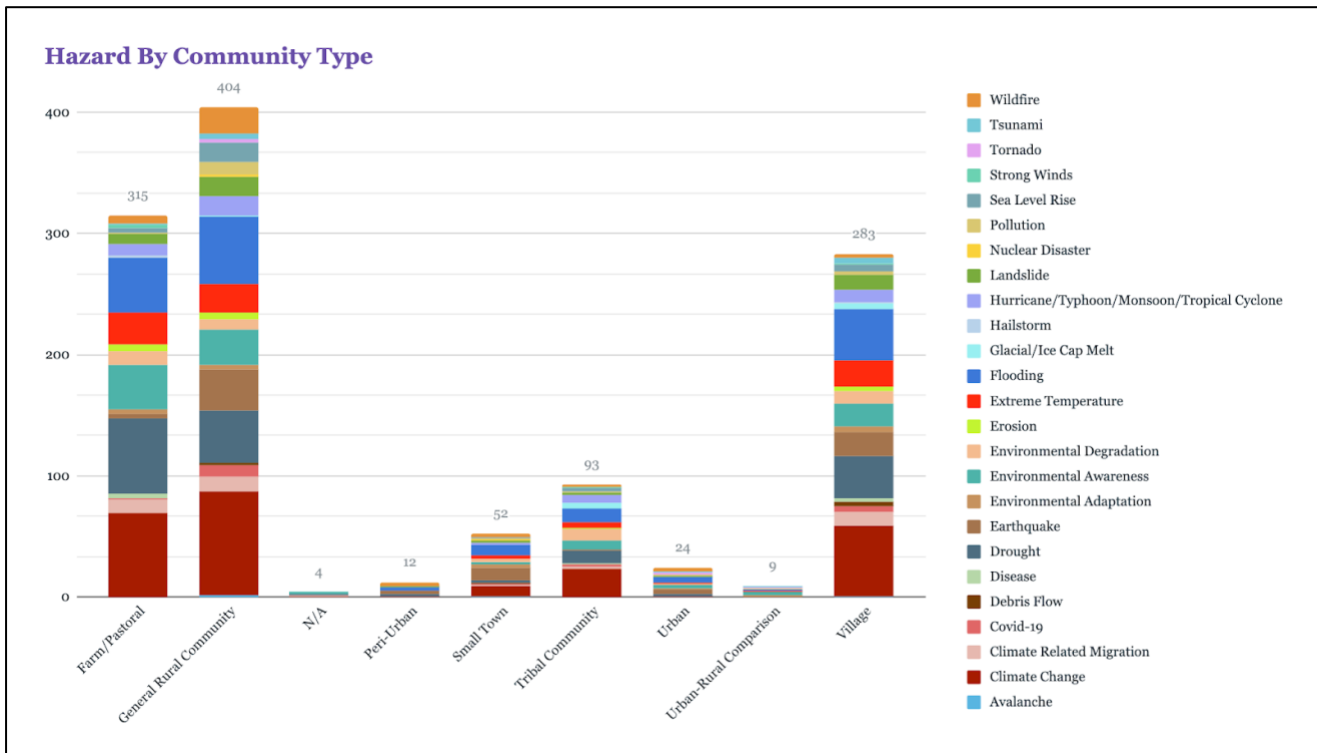


Figure 7. Hazards by Rural Community Type



The next section details the qualitative results of the CCCID and rural and remote community-related studies within the natural-built-social environment triangulation. The triangulation informed the thematic elements for the qualitative analysis as the overarching themes included the natural environment, the built environment, and the social environment. Research team members used the data from the quantitative analysis to divide articles into overarching categories. Then, sub-themes were formed through a more descriptive coding process. Each of the sub-themes is included under each overarching category in the following sections.

Qualitative Results

This section describes the qualitative themes that were uncovered regarding CCCID and rural and remote communities within the natural-built-social environment triangulation. The overarching themes mirror the triangulation and sub-themes are included within each larger category of natural environment, built environment, and social environment. The social environment contained the largest number of articles; therefore, there were four sub-themes within the category. The first sub-theme, environmental awareness, examines the climate change perceptions and perspectives of rural and remote community members including farmers and Indigenous peoples. The second sub-theme focuses on climate-induced migration. Migration and resettlement have been the result of sociocultural factors merging with the dire impacts of CCCIDs, drastically impacting those in rural and remote communities. The third sub-theme examines elements of the disaster cycle as they relate to resilience. The resilience theme examines how rural and remote community adaptation, mitigation, response, and recovery from CCCID-related impacts contribute to resilience. Finally, the fourth sub-theme explores emerging vulnerabilities within rural and remote communities that are a result of CCCID. These types of vulnerabilities include pollution, environmental degradation, resource exploitation, and mental health and well-being impacts. Each of these vulnerabilities contributes to the marginalization of those living in rural and remote communities.

The second overarching theme is concerned with the built environment within rural and remote communities and how CCCIDs impact infrastructure, homes, and buildings. Four sub-themes also emerged in the reviewed literature within the built environment context in rural and remote communities. Similar to the social environment, disaster resilience emerged as articles focused on the built environment side of preparedness, reconstruction, and recovery. Further, migration was a second sub-theme that specifically showcased the planning and built aspects of relocation and resettlement. The third subtheme was retrofitting. This theme examined how the built environment within rural and remote communities could be retrofitted to better withstand CCCID impacts in the future. Finally, sustainable planning was the fourth sub-theme within the built environment category. This sub-theme focused on how sustainable planning practices in rural and remote communities could have substantial impacts on the built environment and community members—which is directly aligned with the social environment domain of the triangulation.

The final overarching theme focuses on the natural environment, which had the smallest number of articles specifically within its category (i.e., not combined with other domains). Although the natural environment itself did not account for many of the reviewed publications, due to the nature of CCCID-related research, the natural environment served as the “pivot point” for the triangulation, connecting the other domains. Within the natural environment category, two subthemes of research emerged including ecosystem impacts from CCCIDs and ecosystem mapping and spatial planning. Beyond these two small

sub-themes, we will argue that the natural environment connects the other domains within the triangulation.

Rural and Remote Communities and CCCID – The Social Environmental Domain

Research examining CCCIDs and rural and remote communities within the social environment domain was the most common among the publications collected in the systematic review. Several themes emerged from the research teams' codes that focused specifically on the social environment. The first theme examined environmental awareness (i.e., perceptions or perspectives on CCCIDs). The second theme focused on migration and displacement for those living in rural and remote communities. The third theme explores the disaster cycle (i.e., mitigation, preparedness, response, and recovery) as it relates to the resilience of rural and remote communities. Finally, the fourth theme focused on the social vulnerabilities that emerge due to CCCIDs for rural and remote community members. It is important to note that some articles may have elements of multiple themes, as these themes are not mutually exclusive.

Environmental Awareness

Environmental awareness—meaning CCCID perceptions and perspectives throughout this section—was one of the major thematic elements that emerged during the data analysis process and has been extensively researched within rural and remote communities (Hesam et al., 2021; Konchar et al., 2015; Lemahieu et al., 2018; Okafor et al., 2022; Van Praag, 2021; Wei et al., 2020). Past studies have shown that in rural and remote communities, localized perceptions and perspectives have been a critical aspect of their overall social environments. This is especially true in agricultural communities (Jiri et al., 2017; Kibue et al., 2015; Tadesse et al., 2015; Valizadeh et al., 2022; White & Selfa, 2013) and Indigenous communities (Basdew et al., 2017; Hill & Zhuang, 2017; Leonard, 2014; Weaver, 2015).

Farming and pastoral communities can be significantly impacted by CCCIDs and farmers' insights into climate change and adaptation have been at the forefront of research to address this issue. For example, Ubisi and colleagues (2017) distributed a questionnaire to farmers in a South African province to investigate the perceived effects of climate change on crop production. Their results showed that farmers were impacted by both climate-related and non-climate-related shocks, as many saw food insecurity and monetary insecurity because of crop loss. In terms of climate, farmers experienced droughts and extreme temperatures that led to several social vulnerabilities including a reduction in the viability of their livelihoods. In Iran, farmers and their communities were found to frequently discuss their perception of the significant impact climate change has had on agriculture as well as noting that it poses a significant risk for future generations (Valizadeh et al., 2022). These examples show the unique perspectives that farmers and agricultural communities have on CCCIDs within the social domain of the triangulation, as the resulting impacts of CCCIDs directly affect their overall livelihoods and potential future livelihoods of the next generations.

Indigenous and Tribal communities and small village communities have also shared their perspectives on CCCIDs through local and Indigenous ways of knowing in the current body of research (Anwar, 2021; Mitchell, 2018; Pascht, 2019; Rukema & Umubyeyi, 2019; Supentri et al., 2019). For example, Indigenous Alaskans in the United States have a profound understanding of the potential impacts of climate change due to their deep connection to the land and sea that has sustained them for thousands of years. This connection allows the community members to be in a good position to develop

adaptation and response strategies (Chapin et al., 2013). Chapin and colleagues (2013) go further by suggesting that Western ideologies can benefit from an Indigenous perspective of CCCIDs:

Commonly expressed indigenous worldviews recognize people as integral components of the ecosystems they inhabit, connected by both biophysical and spiritual ties, and motivated by respect for the natural environment and its human, non-human, and spiritual residents. This ethic of respect and reciprocity dictates a responsibility to foster the long-term well-being of all of Earth's residents. This is consistent with a paradigm of stewardship that seeks to shape trajectories of change in ways that foster ecological resilience and human well-being. This perspective can contribute substantially to efforts that foster global sustainability (p. 60).

As this quote demonstrates, in the context of climate change humans must view themselves as integral parts of the greater whole. The overarching theme of environmental awareness is exemplified perfectly in this quote as different rural, farming, and Tribal communities have different perspectives on the evolving climate.

Migration and Displacement – A Social Problem

The second thematic element that emerged within the social-environmental domain was the effects of CCCIDs on rural and remote community migration. The research under this theme spans displacement, relocation, and resettlement, to climate-related migration overall. Forced migration, relocation, and displacement are social problems that several studies have examined in the past several years (Cortés, 2016; Igić et al., 2020; Islam & Shamsuddoha, 2017; Speelman et al., 2017; Suckall et al., 2017; Yee et al., 2022). Climate-related migration has posed large-scale sustainability issues for rural and remote communities globally. For example, in Himalaya, risks associated with CCCIDs have contributed to the out-migration of rural male youth. Because of work, food, and livelihood insecurity, rural males have left in order to be able to send money back to their families. However, this migratory pattern has disrupted the balance of work within the communities, placing a burden on rural women (Tiwari & Joshi, 2015). Cortés (2016) echoes this from a Chilean perspective:

...the prolonged droughts, increased erosion, scarce job opportunities and educational development in the communities, and other factors derived from climate change have caused the migration of the younger population to urban areas in search for better and more stable working conditions (Alfaro et al., 2015) ...the latter has brought about the depopulation of the agricultural communities and the disappearance of some of their cultural traditions (p. 3).

This quote from Cortés (2016) perfectly exemplifies the immense problem facing rural and remote communities due to climate change-related migration. Not only are younger generations migrating to larger cities, thus impacting agricultural economies, but the out-migration is also impacting deeply held social traditions and culture.

Also related to climate-related migration, research has studied resettlement, relocation, and displacement due to CCCID impacts. Indeed, in their study in Bangladesh, Islam and Shamsuddoha (2017) found that CCCIDs have caused mass displacement, which deeply impacts the most vulnerable populations within the communities such as women, children, older adults, and those with disabilities. Indeed, when examining post-tsunami resettlement in South Sri Lankan villages, Seenapatabendige and De Silva (2023) found that “dissatisfaction over the resettlement housing was mainly due to cultural mismatch and cultural misunderstanding” as the communities are structured in a village-style that “help to build strong bonds among neighborhood that share and care the daily life of each other” (p. 214). This

example shows the importance of rural and remote communities' social bonds related to housing and resettlement after CCCID-related impacts. Furthermore, migration within the social environment is deeply connected with the built environmental domain, strengthening the triangulation as a whole. These connections will be explored further in the built environment section on migration, displacement, and resettlement in rural and remote communities.

Resilience and the Disaster Cycle

The third theme that emerged during the qualitative thematic analysis of the publications was an examination of CCCID impacts on rural communities related to resilience throughout the entire disaster cycle. The publications within this theme spanned mitigation to CCCIDs in rural and remote communities (Abdeldayem et al., 2020; Ao et al., 2022; Bhattachan et al., 2018; Halarma, 2022; Holmes et al., 2021; Wyss, 2018), disaster management, response, and recovery (Dube et al., 2021; Dube et al., 2018; Hou & Wu, 2020; Platt et al., 2020; Pu et al. 2021), and risk reduction (Ao et al., 2021; Gleed, 2017; Liu et al., 2017). These aspects of the disaster management cycle each have distinct impacts on building rural and remote communities' resilience. For example, following tornadoes in rural Alabama in the United States, Holmes and colleagues (2021) note that:

...rural communities in the South are situated largely beyond the limits of government protection... Formally under the authority of a distant government lacking both regulatory and enforcement capacity, Beauregard is peripheral to disaster planning processes. Rural access to services is uneven, local authorities are under-resourced, and local planning processes are not embedded in the rural community. Thus, vulnerability to disasters was an effect, in part, of a planning regime that failed to make adequate provisions to mitigate risk (p. 1510).

This quote shows the connection between the disaster management cycle and rural and remote community resilience. Mitigation, a key part of the cycle, was not properly assessed for the rural community exemplified in the research excerpt. This is due, in large part, because local governance is under-resourced, and the rural community is beyond the purview of federal or state government action. Therefore, those residing in rural and remote communities such as the one in Alabama face a structurally lower resilience-capacity starting point than their urban counterparts.

Because of the unequal starting points for resilience-building capacities that rural and remote communities are subject to, these communities must build proper adaptation strategies that bolster resilience. In the review of the literature, rural and remote community adaptation was a major aspect of the sub-theme of resilience within the disaster cycle (Chen et al. 2023; Elysa et al., 2020; Narayan et al., 2020; Tang et al. 2023; Zhang et al., 2018). For example, Uyttewaal and colleagues (2023) examined rural areas in European countries and assessed how social contexts impacted wildfire adaptation. Their study found several dynamics that enabled wildfire adaptive capacities including knowledge exchange, proactive rural residents, further environmental awareness, and sustainable rural development. Meanwhile, barriers to adaptive capacities included disconnects within the social fabric of the community, low fire ecology awareness, loss of localized fire knowledge, and lack of local funding (Uyttewaal et al., 2023). They go on to note that, "local interactions and relationships related to community identity, communication networks, and associations can greatly shape local adaptive capacity..." (Uyttewaal et al., 2023, p. 21). This quote connects back to community connectedness—a distinct asset of rural and remote communities that have been shifting due to CCCID impacts. Examining the quote from Uyttewaal and colleagues (2023), community connections can build further

adaptive capacities to CCCIDs. That, in turn, can build community-level resilience. Furthermore, this study was not the only research in our review that examined differing adaptive capacity strategies to build resilience to CCCIDs. Vildosola and their co-authors (2022) explored how amphibious communities in the Amazon could adapt to the changing climate and rising sea levels while living on the water. They also noted key aspects of resilience including strong cultural values and interpersonal networks (Vildosola et al., 2022). Meanwhile, other studies focused on sustainable adaptation techniques to build resilience to CCCIDs (Garakani et al., 2020; Wang, 2016).

Tying these ideas together, Alston and colleagues (2018) provide a study on a farming community in Australia that was impacted dually by CCCID and government-related policy that impacted their water supply. They detail a social justice-oriented approach to adaptation and resilience that highlights the importance of community connectedness and identity and governmental support. They state that they have been focused on:

...providing greater clarity on ways to build socially sustainable communities in northern Victorian dairy communities that have been critically affected [by changed water policies] ... transformative adaptation in areas affected by environmental issues is critically dependent on equal recognition of, and attention to, ecological and social systems. This attention must include an analysis of power differentials, of social processes, and of equity and justice ... the MDB Plan did not effectively spell out a process of transformative adaptation founded on social justice and therefore not only increased the marginalization of those without power to influence the process, it was also widely viewed as unfair and unjust (Lukasiewicz and Baldwin, 2014, Lukasiewicz, 2017). Further, at its most basic the Plan required people in the affected areas not only to absorb change, but to adapt their very identity – or their view of themselves – their livelihoods, their environment, and their place in the world (Alston et al., 2018, p. 101).

This quote from Alston and colleagues (2018) exemplifies the theme of climate adaptation and resilience while tying together the other examples from the review. The government plan examined in their research provided harsh limits to the availability of adaptation techniques requiring a call for a justice-oriented solution. The authors note that the disconnect between the government actors and the rural farming community caused a shift in their local identity, creating difficulties in adaptation to the CCCID-related problems that were exacerbated by government policy. A justice approach and an investigation into power dynamics would ensure the requisite resources for proper adaptive capacity-building and it would help build the resiliency of a deeply impacted community.

The study by Alston and colleagues (2018) highlights how CCCID impacts (not to mention, unjust legislation) can further harm residents in rural and remote communities. The following section examines the final theme within the social environment domain, which focuses on vulnerabilities experienced by rural and remote communities that stem from the effects of CCCIDs.

Vulnerabilities

The final sub-theme that emerged during the qualitative analysis of the social environment domain was vulnerabilities to rural and remote communities caused by CCCIDs. Rural vulnerabilities to CCCIDs have been examined in the literature extensively (Abd Majid et al., 2019; Hildalgo, 2015; Ikhsan et al., 2021; Journeay et al., 2022; Kantamaneni et al., 2020; Phalkey, 2020; Pradyumna et al., 2023). However, the vulnerabilities in this section focus primarily on pandemic-related issues, physical

and mental health problems, pollution, and resource exploitation and scarcity that CCCIDs have placed on rural and remote communities.

Although CCCID impacts on rural and remote communities' most vulnerable populations have been extensively researched, the COVID-19 pandemic has introduced a new wave of research that has explored disparate impacts on rural residents. Infectious disease, such as COVID-19, has been exacerbated by anthropogenic climate change (IPCC, 2023). Rural and remote communities have been profoundly impacted by the pandemic, increasing their already heightened vulnerabilities. For example, Yusoff and colleagues (2022) examined the socioeconomic effects of the pandemic on rural communities in Malaysia, finding that the economically active population, income, and education, all decreased during the pandemic across rural, remote, and rural-urban landscapes. Similar findings occurred in Khambule's (2022) study on the impacts of COVID-19 on small-town informal economies and workers in South Africa. Results showed that these workers, unprotected from labor laws and social security:

faced the greatest consequences of the ongoing COVID-19 pandemic. This is evident in that most participants cited various challenges, such as the loss of income because of the lockdown restrictions, running out of food and savings, inability to afford rent and other living expenses, loss of assets and setbacks in paying employees. These findings respond to the paper's research question by revealing the impact of the pandemic in the livelihoods of informal workers. Further impact can be noted in that over 50% of informal workers reportedly struggled to recover more than half of their pre-COVID income during the early phases of the economic recovery period. (Khambule, 2022, p. 13).

This quote shows that within small towns and rural and remote communities, CCCIDs impact the most marginalized at higher levels, indicating the depths of effects these communities face due to CCCIDs.

Indeed, beyond economic challenges, COVID-19 created large-scale health disparities within rural and remote communities as well. Downing and colleagues (2021) identified a need for increased funding to rural and remote communities to increase services such as telehealth beyond COVID-19. Further, they describe the critical need for enhanced healthcare services in rural communities since "rural communities have been especially disenfranchised during the pandemic" (Downing et al., 2021, p. 359). The continued disenfranchisement of rural and remote communities during COVID-19 is clear. However, CCCIDs beyond COVID-19 have direct impacts on the physical and mental health of rural residents worldwide (Batterham et al., 2022; Schaafsma et al., 2021). For example, Gutierrez and LePrevost examined the literature on how climate change impacts human health in the southeastern United States. They use a climate justice framework to explore how climate disparities impact the health of people living in rural areas in southeastern states. The authors note that "many of the health issues...are related to chemical or biological contaminant exposure as an indirect result of climate change effects, including increasing temperatures and water quality and quantity concerns" (Gutierrez & LePrevost, 2016, p. 189). These health impacts on rural residents are not unique as research has shown impacts on well-being (Li et al., 2022; Wu, 2020) and mental health (Eisenman et al., 2015; Hieronimi et al., 2022) as well.

Finally, rural and remote communities have experienced increasing vulnerabilities due to CCCID impacts on resources. For example, Indigenous populations view the land and water as vital resources to their communities, and climate change and pollution can have major effects on those resources (Chlachula & Lugovaya, 2018). Moreover, CCCIDs create widespread resource insecurity and scarcity

for rural and remote communities, further damaging their livelihoods (Gupta et al., 2019; Jackson et al., 2020; Samuels et al., 2022). For example, in rural Zimbabwe, Dube and colleagues (2018b) note:

The floods have been a threat to development and humanity, affecting human lives, destroying property and damaging the environment. Whilst flooding has been impacting the communities, a high level of poverty has also been negatively affecting households in the district. Most people in the district are poor and lack basic necessities and needs that include decent shelter, food and clean water. However, flooding has worsened their poverty situation through affecting their livelihoods. Floods have damaged already unsuitable shelters, affected food stocks and also contaminated water sources. These two problems have therefore negatively affected development programs and initiatives in the district (p. 2).

This quote highlights how CCCIDs, such as floods, exacerbate existing social problems like poverty by destroying homes, environmental surroundings, and agriculture and livestock that is used as a means for work and food. This, in turn, perpetuates and worsens the poverty and hunger experienced in the rural district of Zimbabwe examined in the study by Dube and others (2018b).

Although this section focused specifically on the social environment domain in the triangulation, that is not to say there are no connections to the natural and built environments. For example, in terms of farming and agricultural perspectives, Kibue and colleagues (2014) note that there is a “complex interaction” (p. 79) that occurs in agricultural production because of the impacts on both the social and natural environment. Indeed, the above passage by Dube and colleagues (2018b) mentions the impacts floods have on the rural residents’ built environment *and* natural environment affecting the social domain regarding livelihoods and social problems like poverty and hunger. Finally, environmental awareness and migration also connect to the other domains. As CCCIDs become stronger and more frequent, the natural environment will not provide the necessary resources for social life to thrive, leading to the need for additional awareness and adaptive capacities or future climate-driven migration or displacement. Moreover, worsening and increasing CCCIDs directly threaten the built environments within rural and remote communities, resulting in the need to adapt their built environments to the changing climate or the need to migrate to a new home to escape CCCID catastrophes.

Rural and Remote Communities and CCCID – The Built Environmental Domain

This section provides the qualitative analysis for research on CCCIDs and rural and remote communities within the built environment domain of the natural-built-social environment triangulation. Our review and analysis indicate that the built environment in rural and remote communities has been devastated by the effects of CCCIDs. Like the social environment domain, there is an abundance of research that focuses on the entirety of the disaster cycle within rural and remote communities related to resilience building in the built environment. Additionally, migration—while traditionally understood as a social process—saw unique built environmental impacts related to resettlement planning and relocation. The third sub-theme that emerged within the built environment domain of the triangulation focused on retrofitting homes, buildings, and infrastructure in rural and remote communities to withstand CCCIDs. Finally, the research team identified a fourth sub-theme dealing with sustainable planning practices for rural and remote communities to mitigate CCCIDs and properly conduct sustainable adaptation planning.

The Disaster Cycle and Resilience – The Built Environment

The first theme that emerged within the built environment domain reflected the connection between rural and remote communities' built environment and the disaster management cycle and resilience building. Similar to the social environment domain, there has been a large amount of research that has focused on disaster management, rebuilding, reconstruction, recovery, and preparedness in the literature (Holmes et al., 2021; Hou & Wu, 2020; Isahak et al., 2021; Journeay et al., 2022; Mallik et al., 2023; Liu & Wang, 2015; Yatmo et al., 2021). However, it is important to note that resilience is also a key concept within CCCID-related literature in the built environment domain.

Resilience is discussed by Dube and colleagues (2018a, 2021) related to the built environment following flooding in rural Zimbabwe. Often in CCCID research, resilience is the ability to “bounce back” from environmental harms (Tierney, 2019). However, current conceptualizations note that resilience should be framed as not only “bouncing back” but “bouncing forward” (Tierney, 2019). This is shown through a built environment lens as Dube and colleagues (2021) describe “building-back-better” regarding infrastructure in rural Zimbabwean communities. The authors state that building-back-better should be a mandatory expectation in a post-disaster context as it “creates safer, resilient, and more sustainable communities” (Dube et al., 2021, p. 709). Further, the built environment resilience created through a build-back-better campaign can directly impact the resilience of the rural and remote communities facing CCCID-related harms.

When rural and remote communities are struck by disaster, there are often not the same resources for response and recovery as urban city centers. Therefore, their reconstruction and recovery often mobilize local resources in disaster scenarios. Following an earthquake in Indonesia in 2018 devastated local villages, local community members mobilized their resources to begin the recovery efforts (Koopman, 2021). In another example, the Wenchuan earthquake in China had widespread effects, with massive losses resulting from built environment failures (Wang et al., 2017). Wang and colleagues (2017) go on to state:

The failures of built environment caused by the Wenchuan earthquake can be classified into two categories of the disaster chain: (1) earthquake → failures of built environment → social impacts, and (2) earthquake → landslides/mudflows/quake lakes → failures of built environment → social impacts. The destruction of the built environment was mainly attributed to improper land use planning, to the actual seismic intensity levels of the Wenchuan earthquake exceeding the designed seismic fortification intensity levels of the local buildings, to the lack of strict implementation of seismic design codes, and to unqualified construction (p. 04017058-7).

This quotation demonstrates how the earthquake caused devastation to the built environment such as residences, businesses, and other commercial buildings while at the same time directly impacting the social environment of residents throughout the province. Furthermore, Wang and colleagues (2017) speak specifically to the impacts of the built environment within rural communities stating:

There were significant disparities in dwelling destruction and income between rural and urban dwellers...rural dwellers with low educational levels often lack the skills required to enter professions that could provide higher income than that afforded by the traditional professions of agriculture, forestry, and animal husbandry...The area affected by the Wenchuan earthquake...had limited capacity to provide resilience-based resources and had inconvenient transportation systems, aggravating the poverty and economic marginalization of local rural

communities. Because of limited resources and low income, rural dwellers lacked the financial capitals and technical skills to construct resilient dwellings (p. 04017058-7).

This excerpt exemplifies the disparities between rural and urban built environments and how vulnerabilities of the built environment can have devastating impacts on rural residents. Indeed, Wang and their co-authors (2017) demonstrate the interrelated nature of the social and built environments, supporting the natural-built-social environment triangulation used for this literature review and analysis. Due to deteriorating social conditions such as low education and poverty, rural residents were unable to build adequate shelter causing their built environment to be vulnerable to CCCIDs. Thus, when the Wenchuan earthquake struck, harm was disproportionately placed on rural communities and their residents. This shows the importance of both built environment resilience, but also ensuring that rural residents have the proper and sufficient resources to build resilience following CCCIDs.

Migration – A Built Environment Perspective

The second sub-theme within the built environment domain reflects how the built environment influences migration, mirroring the migration theme in the social environment domain. In large part, the literature associated with this theme focused on resettlement and relocation planning related to housing, commercial buildings, and other infrastructure following CCCID (Garakani et al., 2020; Tauber, 2015; Zhang et al., 2020; Zhao et al., 2022). Interestingly, research also focuses on the localized efforts of sustainably building temporary shelters following the displacement of rural and remote community residents following CCCIDs. For example, in Northeast India, the built environment is drastically impacted by CCCIDs, resulting in the mass displacement of residents. Therefore, the community members use bamboo as a sustainable and environmentally friendly construction alternative to erect temporary shelters to house displaced persons (Dev & Das, 2021). Indeed, while utilizing localized knowledge to rebuild post-disaster, it has also been shown to be important to consider the cultural appropriateness within a particular settlement when rebuilding. Pasupuleti (2013) describes the challenges that occur when these considerations are not taken:

...expansion has complicated the access for local communities to sustain their daily livelihood necessities. The only way to access the family members...and to participate in village activities is through the state highway that passes along the village. Prior to the tsunami, everything and everyone was considerably near and dear...the resources required for people's cultural lives and livelihoods were rarely spread in geographical space. Now in this relocation context, the expanded and fragmented geographical spaces possess a new character that has interrupted their access to resources in many ways (p. 32).

This quote from Pasupuleti's (2013) research shows the importance of culturally appropriate built environments in a CCCID context. When the communities were relocated after a tsunami affected their homes and livelihoods, the built environment in the relocation area did not adequately meet their cultural needs. This point is echoed by Tauber (2015) as they describe housing projects implemented by NGOs in post-tsunami rural India. Similarly to Pasupuleti's (2013) findings, the cultural appropriateness of the resettlement structures was of the utmost importance. Tauber (2015) states that:

...in the course of rural post-disaster reconstruction, there is a crying need to appoint the "right" personnel having, first of all, the capacity to comply with the social dynamics at project level, and, second, being able to address those aspects critical for the realization of people-oriented housing. Architects can be a valuable resource for both the NGO and the villagers...

key to this is, among other considerations, a thorough understanding of the rural (building) culture, its abilities and requirements, the strategic interplay of various roles and abilities during the course of an intricate building process... (abstract, para. 3).

This builds on the findings mentioned previously, as there is a distinct need to use cultural knowledge and culturally appropriate practice when constructing new settlement sites for rural communities that have been displaced due to CCCIDs.

Although the built environment component of migration, resettlement, and displacement focuses largely on constructing new settlements for CCCID-displaced rural and remote communities, the connection to the social environment is clear. Forced migration due to CCCIDs, as mentioned previously, has been studied extensively over the last decade (Fussell et al., 2022; Marchiori & Schumacher, 2011). The growing crisis induced by CCCIDs has caused massive levels of human displacement (IPCC, 2023) which has both social (e.g., health, well-being, community connectedness) and built (e.g., housing, culturally appropriate settlements, infrastructure) environmental implications. As CCCIDs continue to destroy the built environment, the social fabric within communities—especially rural and remote communities—can begin to unravel as residents search for new settlements, temporary shelters, or entirely new countries. This places a major stressor on already vulnerable and disproportionately impacted populations, showing the deep connection between the social, built, and natural environments within the context of migration and CCCIDs.

Retrofitting

This subtheme focuses on how retrofitting the built environment within rural and remote communities builds resilience capacity and prepares rural and remote communities for CCCID impacts in the future. Current publications have discussed vulnerability assessments in risk reduction and disaster preparation (Anhorn, 2015; Wiśniewski, 2020); building retrofitting to combat disasters such as flooding (Susilorini et al., 2023), wildfires (Costin, 2021), earthquakes (Wyss, 2018; Sechi et al., 2022); and rural energy retrofitting (Abouaiana & Battisti, 2023) and climate-friendly transport (Tønnesen, 2022) to improve resilience.

Rural and remote communities are more vulnerable to CCCID (Wyss, 2018; Manapragada & Icy, 2022). Specifically, Wyss (2018) pointed out that “in most great earthquakes 80% to 100% of those killed are from rural settlements, not from cities” (p. 1991). Residents in rural and remote communities showed poorer adaptation to heat than urban populations (Martín, 2022). Therefore, the focus of mitigation and adaptation strategies needs to shift from urban centers to rural and remote communities (Wyss, 2018). Retrofitting can be an effective adaptation strategy for CCCID. For example, the Government of Bangladesh and NGOs have supported the rural housing improvement initiatives in disaster-prone areas in Bangladesh (Kashem, 2019). The rural housing improvement practices ranged from “raising plinth of the houses” to “strengthening weak areas of traditional house structures and maintaining some design principles to make houses resistant” (Kashem, 2019, p. 422). Based on a case study on climate change’s impacts on the rural development in Serbia, Igić et al. (2020) provided implications for adaptation strategies to improve resilience:

(1) Decision making must be on local level and as a long term process with multifunctional - comprehensive approach; (2) Risk assessment and management must be part of every local strategic document - defined contextually depending on the specificity of each municipality; (3) Every municipality has different types and degrees of vulnerabilities, exposure and sensibility,

and so measures for adaptations must be “customized” for every settlement depending on the specific spatial, development and natural context. (p. 1)

Current research also reveals that the adaptation strategies of vulnerable residents in rural and remote communities are intertwined with their livelihood challenges (Kashem, 2019; Moyo, 2020). Because of the high costs of disaster-resistant housing retrofitting, disadvantaged households in rural and remote communities could not afford housing improvement (Kashem, 2019; Moyo, 2020), which requires meaningful investment and financial support from governments and other stakeholders for vulnerable residents in rural and remote communities (Moyo, 2020).

Sustainable Planning

This sub-theme discusses how sustainable planning practices in rural and remote communities help the built environment and community members better respond to CCCID. Sustainable planning plays a pivotal role in effective mitigation strategies for environmental change caused by climate change. Current publications have identified different approaches to achieving sustainability and enhancing climate change adaptation, including spatial planning (Busayo, et al., 2019), 4Ps’ approach (predict, prevent, protect from and prepare for flooding) (Gleed, 2017), vulnerability assessment of the built environment to climate hazards (Papathoma-Köhle et al., 2010), and so forth.

Specifically, Arnold et al. (2021) suggested climate resilience and hazard mitigation with built-environment interventions helped address adaptive capacity in rural communities. The development of a climate and health adaptation plan involving public participation could effectively address barriers to adaptive capacity, such as “a lack of public awareness, a lack of or difficulty understanding climate information, a lack of leadership, and limited coordination and competing priorities” (Arnold et al., 2021, p. 1). Another example is that green infrastructure, which includes eco-roofs, permeable pavement, and green alleys and streets, can be “sustainable, smart solutions to wide-spread stormwater issues” caused by climate change-induced frequent heavy rainfall (Aspacher & Alam, p. 309). This research finding demonstrates that sustainable planning that acknowledges the interconnection between natural and built environments in rural and remote communities helps enhance resilience capacity.

Current literature has also discussed scenarios in sustainability and adaptation planning (Bateman et al., 2016; Meilianda, 2019; Bukvic et al., 2023). For example, Bateman et al. (2016) used a spatially explicit integrated model to predict the impacts of climate change on land use and found that climate change had a direct impact on agriculture land use patterns and indirect effects on water and ecological quality. Meilianda et al. (2019) investigated coastal land use and land cover change in Banda Aceh, Indonesia, with sea-level rise scenarios. As the coastal area of Banda Aceh would face a high risk of future sea-level rise, Meilianda et al. (2019) suggested that “sustainable coastal management taking into account the disaster risk should, therefore, be incorporated within the decision making for the protection of the coastal area” (p. 1). These examples show that simulation and scenarios in sustainability facilitate adaptive planning for CCCID and enable stakeholders to anticipate and respond effectively to potential challenges and uncertainties.

Rural and Remote Communities and CCCID – The Natural Environmental Domain

This section shows the results regarding the natural environment in rural and remote communities. Two sub-themes emerged after the examination of the publications: (1) the impact of climate change and disasters on the natural environment in Rural and remote communities and (2) mitigation and adaptation

strategies. A small percentage of the publications focused only on the impact of climate change on the natural environment in rural and remote communities. The majority of the articles addressed the relationships between the changing natural environment and the built and social environment. This reflects the interconnections between the natural, built, and social environments in rural and remote communities.

Impacts on the Natural Environment in Rural Communities

Climate change has led to the frequent occurrence of extreme weather events and had major impacts on land and water systems (e.g., drought and vegetation response, water supply, and irrigation) in Rural and remote communities (Dharmasiri & Jayarathne, 2021; Lourenco et al., 2023; Mallik et al., 2023). This further caused environmental degradation and impacted agriculture, food security, the economy, and the well-being of residents in Rural and remote communities. Lourenco, Woodborne, and Fitchett (2023) found an increasing frequency of drought in the Angolan Highlands over the past 40 years. Because Rural and remote communities in Angolan Highlands highly relied on rain-fed agriculture, the increasing frequency of droughts made this region more vulnerable. Furthermore, “[the] strong relationship between precipitation and vegetation, anthropogenic pressure on the landscape, and increased drought occurrence are likely to lead to potential environmental degradation in future” (Lourenco et al., 2023, p. 115).

Similar trends of the changing natural environment in rural and remote communities were identified in regions. For example, climate change affected water demand and supply routes in Anger province which is located in the Oromia regional state, of Ethiopia (Dawit, Dinka, & Halefom, 2022). Coastal erosion led to land scarcity and declining land access, threatening coastal communities in Sagar, Indian Sundarbans (Mallik et al., 2023). Farmers in the dry zone of Sri Lanka were well aware of the impact of climate change on the natural environment (Dharmasiri & Jayarathne, 2021). The participants in Dharmasiri and Jayarathne’s study perceived (1) “an increase in ambient temperature resulting in more heat stress”; (2) “frequent and severe occurrence of extreme rainfall anomalies”; and (3) an “increasing trend of natural calamities” (p. 261). These changes influenced humidity, temperature, and soil conditions, which significantly impacted agricultural and crop production (Dharmasiri & Jayarathne, 2021). Farmers in the coastal region of Iran perceived greater impacts of drought on “food security, agriculture, economy, education, immigration, and the natural environment than those in the adjoining mountainous region” (Hesam, 2021, p. 489).

Schweitzer and Povorozyuk (2022) found that the environmental change impacted the ice roads connecting the town of Tiksi with the rest of the Republic of Sakha during the winter. “As ice roads become unstable, less predictable and shorter in use duration, the supply of goods is heavily affected and becomes more irregular” (Schweitzer and Povorozyuk, 2022, p. 304). These examples show that the environmental change caused by climate change has made the future unstable and unpredictable, which in turn impacts the built and social environment in Rural and remote communities (Dira & Hewlett, 2016; Mallik et al., 2023).

Environmental degradation caused by climate change disproportionately impacted residents in Rural and remote communities due to their direct dependence on natural resources (Schaafsma & Gross-Camp, 2021). Based on the results from focus groups in rural communities in Rwanda and Malawi, Schaafsma and Gross-Camp (2021) suggested a correlation between the natural environment and rural residents’ well-being:

Environmental degradation was often seen as a determinant of negative impacts on well-being for most well-being dimensions. For example, deforestation was linked to droughts that were associated with lower agricultural productivity. Other problems included floods, declining soil fertility, water quantity and quality, reduced land availability, and crop raiding by wild animals. When natural hazards or environmental degradation threatened the stability and provision of these ecosystem services and resources, participants often reported a decline in multidimensional well-being (p.13).

This quote reveals that climate change and disasters have significant impacts on Rural and remote communities' natural environment, and environmental degradation further increases the vulnerability of the rural population and hinders their resilience capacities. Therefore, land and water scarcity are not only a climate crisis but also a socioeconomic crisis (Pompeii, 2020). Mitigation and adaptation strategies are needed, especially concerning the protection of land and watersheds.

Mitigation and Adaptation Strategies

Climate change and its impacts on the natural environment in Rural and remote communities have created challenges to resilience (Zhang et al., 2018; Yang et al., 2020). Actions, such as sustainable agricultural practice, policy attention, public participation, and effective monitoring, are required to respond to the negative impacts (Busayo et al., 2019).

To cope with the changing natural environment in Rural and remote communities, farmers and local communities learned new skills (Panyasing et al., 2023) and used different adaptation strategies (Dharmasiri & Jayarathne, 2021). For instance, adaptation strategies employed by farmers in the dry zone in Sri Lanka included:

transforming from intensification to more intensification that can be identified as Climate Smart Agriculture; crop diversification and adaptation of drought tolerance crops; transforming from agriculture to animal husbandry; and out-migration of unemployed or evicted youth from agriculture to non-agriculture. (Dharmasiri & Jayarathne, 2021, p. 254)

This quote reflects that, at the micro level, farmers are making proactive efforts to adapt to climate change. Local knowledge and wisdom also play an important role in disaster mitigation (Anwar, 2021; Mugari et al., 2019; Sugiyama, 2020). Anwar (2021) suggested that the Minangkabau community had local wisdom of disaster mitigation, including “human norms and attitudes towards nature; norms before a disaster occurs; and post-disaster policies” (p.1). This local wisdom could “regulate infrastructure and social structure in disaster mitigation” (Anwar, 2021, p.1).

Specifically, current publications have suggested that ecosystem mapping and spatial planning are ways to utilize local wisdom and identify potential areas prone to or experiencing environmental degradation such as drought or flooding (Portalanza et al., 2019; Pujiasmanto et al., 2021). Pujiasmanto et al. (2021) pointed out that ecosystem services and mapping studies had been developed rapidly these years, and “ecosystem function and service maps” (p.1), with the benefits of “visualizing additional information, reducing costs, showing different scenarios and contributing to the identification of vulnerable zones” (p.8), could be a helpful tool for decision-making regarding climate change. A case study in Mdantsane, South Africa, indicated that spatial planning was crucial to improving sustainability, climate change adaptation, and resilience (Busayo et al., 2019).

A collaborative partnership between the local and state could strengthen the effects of local knowledge in addressing the negative impacts of climate change on Rural and remote communities'

natural environment (Panyasing et al., 2023). The participation of local communities through the bottom-up approach to gaining local knowledge can provide a better understanding of the changing environment and contribute to a more sustainable future (Mugari et al., 2019; Sugiyama, 2020).

Additionally, enhanced environmental monitoring can assist Rural and remote communities in improving mitigation and adaptation strategies (Baicha, 2016; Dun et al., 2021). Dun et al. (2021) applied interferometric synthetic aperture radar (InSAR) technology to disaster early warning and monitoring in complex mountainous areas and suggested that, compared to traditional GPS surface monitoring, InSAR was less costly and with less human interference (Dun et al., 2021). This research finding demonstrates that advances in technology can make monitoring and early warning more effective, thus contributing to the enhancement of adaptation strategies and resilience building in rural and remote communities.

Connections to the Social and Built Environmental Domains

Although the natural environment domain within the triangulation had the fewest number of articles as a standalone category, the connection to the social and built environments is clear (i.e., the natural-social environment category had the largest number of articles). The natural environment domain within the larger natural-built-social environment triangulation served as the connecting point between the other domains when examining the research on CCCIDs and rural and remote communities. Climate change and natural hazards are, by definition, comprised within the natural environment. Therefore, as social life and built environments are introduced into the natural environment, CCCID-related impacts will directly affect the other two domains. This is seen with the flood events impacting the built environments in Zimbabwe (Dube et al., 2018a) or as droughts cause out-migration from rural communities in Chile (Cortés, 2016). The natural environment plays a pivotal role in connecting the other pieces of the triangulation in the examination of CCCID impacts on rural and remote communities globally.

Implications

The findings of this systematic literature review on CCCIDs and rural and remote communities within the natural-built-social environment triangulation have several distinct implications for future research, policy, and practice. Future research must focus on the unique aspects of the natural environment and its relationship to rural and remote communities—specifically concerning ecosystem management and land and water systems. Furthermore, the natural environment domain was the least commonly researched within the triangulation. While the social and built environments are vital to rural and remote community well-being and resilience capacities, it is critical to continue investigating the ecological systems that are impacted by CCCIDs and may have implications down the line for people and animals living in rural and remote communities.

Additional research initiatives should also focus on historically marginalized and underrepresented populations that are disproportionately impacted by CCCIDs. The literature has shown that those living in rural and remote communities are disproportionately impacted by CCCIDs; however, theories of intersectionality can build robust research programs that investigate marginalized populations *within* rural and remote communities who may face compounding impacts. For example, future research initiatives could examine 2SLGBTQ+ individuals, racial and ethnic minorities, and older adults, who reside in rural and remote communities and may face disparate and layered impacts to CCCIDs.

From a policy and practice perspective, policy initiatives must be enacted to provide needed resources to support adequate services, resources, supports, and research. Policy collaboration with

Indigenous communities and Tribal communities regarding CCCIDs and rural and remote communities can allow Indigenous peoples to share and showcase their environmental knowledge to surrounding communities to help understand the connections that Tribal communities and rural and remote communities without Tribal status have concerning the three domains in the triangulation. Furthermore, collaborating on policy, practice, and research will bring attention to the distinct advantages that rural and remote communities bring to the table regarding CCCID impacts, allowing for a complete understanding of rural and remote communities' assets within the natural-built-social environment triangulation in the context of CCCID.

Finally, Canadian government policy at municipal, provincial, and federal levels must incorporate increased funding to build rural and remote communities' adaptive capacities and resilience in the wake of CCCIDs. For example, improved housing and infrastructure policy and funding can offer assistance to rural and remote communities to properly retrofit and adapt buildings, roads, waterways, and other critical infrastructure based on their unique CCCID impacts and needs. This, in turn, can provide a nascent way forward in building stronger community adaptation and resilience for rural residents. Furthermore, government leaders, service practitioners, and other municipal entities must provide Tribal leaders and Elders a seat at the decision-making table, encouraging Indigenous knowledge as a mechanism for climate and disaster adaptation and protective action because of their rich histories, understandings, and connections to the land and water.

Conclusion

There has been empirical evidence that shows that climate change and climate-induced disasters (CCCIDs) profoundly impact the natural-built-social environment triangulation of rural and remote communities in Canada and across the globe. Research spanning multiple disciplinary fields has been conducted showing how CCCIDs disproportionately impact the natural environment (natural resources and agriculture), the built environment (housing and civil infrastructure), and the social environment (well-being and social life) of rural and remote communities, thus devastating their collective resilience capacities and critically shifting their assets and challenges furthering their marginalization. Using the widely accepted PRISMA approach, the research team identified 308 publications that adhered to inclusion criteria and employed a mixed-method (quantitative univariate analysis and qualitative thematic inquiry) approach to conduct the data analysis. The quantitative analysis gave an overview of the frequencies, descriptive statistics, and metadata that were coded by the research team. Quantitative results showed that extensive amounts of social environment research had been conducted within the context of rural and remote communities and CCCIDs. However, the natural environment had far fewer studies when examined as a sole environmental entity. When combined with the social environment, the two categories had the most total articles, implying that there are profound connections between human social life and the natural environment. The quantitative analysis also provided information about the studies' geographic location, hazard types, and rural and remote community types. This information illustrated the present deficits in knowledge and the knowledge surpluses.

The quantitative data also informed the initial coding categories for the qualitative thematic analysis. Using the natural-built-social environment triangulation, the research team constructed the first three overarching thematic categories based on those triangulation domains. Within each of those domains, the research team conducted additional coding to find relevant sub-themes that deeply describe the state of the literature. Within the social environment, sub-themes examined environmental

awareness, climate-related migration, resilience, and vulnerabilities rural and remote communities face due to CCCIDs. The built environment domain also had four sub-themes including resilience, migration, retrofitting, and sustainable planning. Based on the first two themes in the built environment domain, it is clear that there are connections within the entire triangulation. For example, while migration is a social process that involves people moving from one place to another—in this case, due to CCCIDs—there is also a distinct built environment component to it as communities must consider resettlement housing construction and relocation planning. Finally, the natural environment domain was under-researched when examined alone. The two themes within this domain of the triangulation included climate impacts on the natural environment in rural communities and mitigation strategies specified to the natural environment alone. However, when the natural environment was combined with the social environment, it became the largest categorical domain. This shows how the natural environment serves a key function in the triangulation as it connects the built and social environmental domains.

As with any research project, there are limitations to the systematic literature review that must be engaged. First, publications from the years 2013 until 2023 were examined, thus severely limiting the overall number of articles that could have been selected. Due to these selection criteria, there could be classic research publications on the topic of CCCIDs and rural and remote communities that would have been omitted that could have otherwise greatly informed this project. In addition to the search dates, only English-language articles were included in the review. This filtering process may have resulted in the adoption of a Eurocentric scope, limiting research conducted by scholars who do not publish in English, including Indigenous scholars. As mentioned in the quantitative analysis section, there may also have been unintentional selection bias regarding the articles examining the natural environment. Because the search criteria were examining rural and remote communities, it may have excluded articles with solely an environmental focus. Finally, like any qualitative study, intercoder reliability can be a concern. As only two research team members coded the final qualitative data, this project could have benefitted from additional coders and additional coding iterations.

Knowledge Mobilization Activities

The following knowledge mobilization activities have been planned primarily to advance a continuous stream of knowledge translation from the academic sector to inform cross-sectoral practice, service, and policymaking in Canada and globally. In the Canadian and global efforts to solidify and build upon rural and remote communities' assets while responding to CCCID-related challenges, these knowledge mobilization (KM) activities aim to build the adaptive and resilience capacities of individuals, communities, governments, businesses, and nonprofits in rural and remote communities facing the ever-growing threat of CCCIDs. Due to the interconnected nature of the natural, built, and social environments and the relationships between rural and remote communities with their urban counterparts, these efforts contribute to the sustainability and resilience of rural and remote communities *and* all communities worldwide. Using Phipps and colleagues' knowledge mobilization strategies, considered a "co-produced pathway," our research team has three KM activities planned to enhance benefits to research, non-academic knowledge users, and to other related stakeholders.

KM Activity 1 - Advancing Academic Research and Beyond:

This KM activity has three distinct components including (1) training seed persons, (2) open-access data and publications, and (3) multi-stakeholder conference presentation. Regarding training seed persons, this project will build the research trainees' knowledge regarding rural and remote

communities' shifting assets and challenges associated with CCCIDs. Within their communities, the trainees will serve as seed persons, sharing the project outcomes and their experience conducting research with residents of rural and remote communities. That connection will stimulate the overall interest in participating in rural and remote community-centered research, practice, and policy stimulating these residents' interest in participation in rural and remote community-driven research, practice, and policymaking specific to strengthening rural assets and adaptive capacities. For open-access data and publications, the final dataset will be published in an open-use, online data repository through Dalhousie University Dataverse @ Borealis promoting data reuse. Two open-access journal publications are also planned in top-tier academic journals in the interdisciplinary fields of rural studies and CCCID– *Journal of Rural Studies* and *Climate Risk Management*. Open-access publishing promotes academic knowledge influence on practitioners, policymakers, other researchers, and related knowledge users. Finally, a workshop will be hosted with academics, federal, provincial, and municipal representatives, non-profit organizations, researchers, media outlets, and other stakeholders, focusing on how the social environment-specific consequences could promote rural residents' participation in their communities' ecological, economic, and social reconstruction and recovery.

KM Activity 2 - Informing Non-Academic Stakeholders:

This KM Activity expands beyond the traditional academic knowledge translation and mobilization channels by incorporating the non-academic sector and stakeholders into the dissemination and mobilization process through three parts including (1) a short animation video, (2) a one-page infographic, and (3) a project webpage. Studies have shown that video materials attract more viewers than text while also providing individuals with higher information retention (Stafford, 2017). The proposed video will apply a whiteboard-style animation to discuss the findings and explain research outcomes, specifically detailing how rural and remote communities are impacted by CCCIDs within the natural-built-social environment triangulation. Furthermore, a one-page infographic will be created to showcase the key findings in a manner that is accessible to all. Finally, each of the first two components along with other related project outcomes will be available for public use and download via a project-specific webpage. These components within KM Activity 2 will allow the knowledge obtained through the project to be translated, disseminated, and mobilized through non-academic channels, benefitting rural and remote community members in Canada and beyond.

KM Activity 3 - Advancing Research Uptake:

The research team has longstanding, established connections with public, private, and nonprofit sectors that particularly focus on rural and remote communities and CCCIDs in Canada and internationally. The team will share project outcomes with their networks and connections to advance the uptake and further mobilization of the project findings. The team will also encourage agencies, organizations, and partners to evaluate findings, especially regarding how research outcomes could inform professional practice, services, and policy in rural and remote communities. Further consultation will take place between the agencies and the research team regarding application possibilities to develop and/or improve services, programs, and policies related to rural and remote communities. Ongoing feedback will be requested, and collaboration will occur to review the outcomes and identify new challenges concerning improving, building, or modifying practices, policies, and programs to better serve rural and remote communities. Agencies can then evaluate research-informed recommendations and the impacts on rural residents including social, health, and

other dimensions that directly impact the quality of life in rural and remote community development processes. These results will provide researcher and agency partnerships to improve rural-CCCID-related interventions.

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