



A global scoping review on sustainability, climate migration, and climate resilience of small and medium-sized cities (SMSC)

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ABSTRACT

Over the last decade, small and medium-sized cities (SMSC) have grown at a faster rate than major cities and are predicted to continue in this projection. Increasing extreme weather leaves SMSC, having lower adaptive capacity, ill-equipped to respond. Literature, however, has focused mainly on major cities. Therefore, analysis of the level of scientific research in SMSC is necessary. A scoping review was conducted in this work utilizing three search engines (Web of Science, Academic Premier Search, and Google Scholar) to discover SMSC research on three primary topics: sustainability, climate-induced migration, and climate resiliency. Since 1901, 6493 SMSC papers were published. Of these, 25 sustainability, 61 migration, and 57 climate resiliency papers on SMSC were identified and reviewed. Sustainability literature is lacking globally, mainly being conducted in European countries. Climate migration literature shows a clear underrepresentation of the role of SMSC in the global migration system. The resilience literature review demonstrated locational gaps by research theme and a need for more specific climate related hazard research globally. A lack of research means a lack of understanding of what consequences SMSC may face under a changing climate. This paper provides suggestions on focus areas for future SMSC research.

1. Introduction

Urbanization, characterized by increased population density and associated infrastructure development, is increasing worldwide (UNDESA, 2019). The year 2007 was the first time in history that more people lived in urban areas than in rural areas worldwide (Wimberley et al., 2007), with cities housing 55% of the world's population in 2018. The prediction is that more than two-thirds of the world's population is expected to live in cities by 2050, which amounts to 65% and 87% of the developing and developed worlds, respectively (UNDESA, 2019). With this expected acceleration in population of urban areas, much of the literature has focused on the growth and dynamics of large and mega cities. Comparatively, small and medium-sized cities (SMSC) are also expected to grow rapidly but have not received the same level of attention.

Globally, SMSC make up a significant portion of the total number of settlements and overall total population. Communities fewer than 500,000 account for the largest portion of the African, Asian, European, Latin American, and Caribbean populations (UNDESA, 2012). SMSC have experienced explosive urban population growth over the past two decades. Populations within SMSC are projected to rise by more than 32% between 2015 and 2030; whereas large and megacities are predicted to grow by 26% (Birkmann et al., 2016). SMSC differ from large cities in population size, revenue amount, variety of revenue streams, access to amenities, access to data,

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political power, and resources (Birkmann et al., 2016; Burayidi, 2018; Zwick et al., 2018). These limitations impact SMSC adaptability and highlights the need for critical research of these city types.

This global study on SMSC will analyze papers which focus on sustainability, resiliency, and migration. Sustainability within cities has grown into an important topic as urbanization increases more rapidly. Cities cover less than 2% of the earth's surface yet consume more than 75% of the globally available natural resources, are responsible for 70% of greenhouse gas emissions, and generate their own niche environmental consequences (GEF Secretariat, 2021; United Nations, 2015b). Moreover, cities face deteriorating infrastructure, lack of resources and basic services, and public health concerns which compromise a city's ability to exist sustainably (Washburn and Sindhu, 2010). In 2015, the United Nations set out a list of 17 Sustainable Development Goals (SDGs) for countries around the world to follow. SDG 11 seeks "to make cities and human settlements inclusive, safe, resilient, and sustainable" (United Nations, 2015a). One such implementation of this goal is through the development of SMART cities, which are cities that utilize technological advancements to improve the quality of life for residents. Mid-sized cities are at the forefront of this development, as the societal structure of these city types promote innovation and progress (Zwick et al., 2018). Given the anticipated exponential population growth of SMSC globally, it is imperative to determine the current state of SMSC sustainability and sustainable development research.

Vulnerability and exposure to natural hazards has increased as more people move into high-risk (i.e., higher potential for economic or human loss) areas. Since the 1980s, the proportion of people living in fluvial flood areas and coastlines has increased by 114 and 192%, respectively (UNISDR, 2013). Underlying systemic societal and socioeconomic issues further hinder a community's ability to truly be resilient. Informal settlements have been linked to higher surface temperatures and heat stress compared to formal housing developments, furthering the risks to already vulnerable communities (Mehrotra et al., 2018). Resiliency measures a community's ability to adapt, respond, and recover in the event of a natural disaster (Johnson and Blackburn, 2012). Residents of smaller communities are generally more vulnerable in the event a disaster strikes due to their diminished emergency response capabilities, lack of emergency medical care, poor hazard warning and emergency management, and poor infrastructure (Cross, 2001). Birkmann et al. (2016) demonstrates greater urban vulnerability exists within SMSC as compared to big and mega cities. Understanding resiliency within SMSC is vital to ensure continued and sustainable city development as the climate crisis will further worsen hazards in the future.

The act of migration is a natural human response to climatic pressures and is a major adaptation measure people will use in response to climate change in the future (Hunter, 2005; Rigaud et al., 2018; Robinson et al., 2020). Extreme events, like tropical cyclones, have led to the displacement of thousands of individuals. Climate induced extreme events and scarcity of resources gathers speed to drive migration as early as 2030 (Clement et al., 2021). In 2018, the World Bank reported on the impact of climate change on migration, estimating that by 2050 climate change could force more than 143 million people to move within their own countries (Semenza and Ebi, 2019). These numbers are important as SMSC around the world are likely to be the first recipients of displaced individuals. Robinson et al. (2020) found that those displaced by future sea-level rise scenarios relocated to counties slightly inland of their origin. Highlighting how SMSC have and will be affected by climate migration is essential to creating sustainable and resilient solutions considering this predicted displacement.

While SMSC have numerous disadvantages as compared to their large and megacity counterparts, these cities do offer social capital. Sense of community and connection or engagement, i.e. social capital, has been measured as a positive aspect of SMSC (Liu and Besser, 2003). Recker (2009) found that social capital had a positive relationship with a higher quality of life in rural Iowa communities impacted by sudden economic shocks. Strong community engagement is correlated to healthy local labor markets, lower poverty, and high quality of life in smaller cities (Peters et al., 2018). Some research points to social capital not being a straightforward benefit in SMSC. The ability of social capital to impact development is dependent on many factors like the prevalence of government support in community engagement (Onyx and Leonard, 2010). Bell and Jayne (2009) offer a review of several studies that tout the advantageous of social, cultural, and natural aspects of SMSC while discussing how these theoretical strengths hinder creative economic progress. While social capital is nuanced, it can be seen as a potential tool that SMSC may use to approach sustainable and resilient development.

Past research has highlighted the need to focus on SMSC separately from global cities in terms of establishing a research agenda, providing comprehensive definitions for these city types, and progressing the narrative on the importance of these cities within research. Bell and Jayne (2009) presented a historical review of SMSC providing insight into cultural, economic, and political aspects while also calling for a more collective approach to urban studies. Steinf et al. (2016) called for a multidisciplinary approach to SMSC research within the social science field that looked beyond the social capital and the view of smaller cities as a type of urbanization. Kumar and Stenberg (2022) argued the field of political science would benefit from additional focus on smaller cities. Previous reviews have not specifically looked at sustainability, climate migration and climate resilience research within SMSC. Therefore, the objective of this scoping review is to provide an informed state of the literature regarding research conducted on sustainability, climate migration, and climate hazards in SMSC and provide suggestions to set new pathways of future SMSC research.

2. Materials and methods

This study used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards to perform a scoping literature review (Brozovsky et al., 2021; Munn et al., 2018; Sucharew and Macaluso, 2019) in which research are conducted on the trends of SMSC in sustainability, climate resilience, and climate migration topics. This section details the study's precise methodologies, which were carried out in accordance with the referenced protocol. This literature review consists of three steps: 1) planning the review, 2) conducting the review, and 3) executing content analysis to identify themes and trends from the literature. This is done to better understand existing research conducted in SMSC on the topics of sustainability, climate resiliency, and climatic migration.

2.1. Planning the review

A scoping review can be conducted using several different methodologies that identify the breadth and depth of available evidence on a particular topic, including: Arksey and O'Malley's Methodology (Arksey and O'Malley, 2005), Levac et al.'s Methodology (Levac et al., 2010); Joanna Briggs Institute Methodology (Peters et al., 2015); the Cochrane Library Methodology (Higgins and Green, 2011), and PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) methodology (Tricco et al., 2018). PRISMA-ScR is one of the most used method for scoping reviews, as it provides a comprehensive and transparent framework for conducting a systematic search and synthesis of the available literature. PRISMA-ScR was adapted from the PRISMA guidelines for systematic reviews and meta-analyses to provide a structured and rigorous approach for conducting scoping reviews. PRISMA-ScR was chosen due to its methodological rigor, its comprehensiveness, and its transparency. By following PRISMA-ScR, researchers can ensure that their scoping review is conducted in a structured and rigorous manner and that the results are transparent and replicable.

To understand naming conventions in which SMSC are categorized and researched in different parts of the world, a categorization describing non-primary cities by population, function, and economic status was utilized (Fig. 1). Cities are largely classified by population around the world, but the population range criteria vary depending on the spatial and economic scale being investigated. Cities are classified as primary, secondary, and tertiary. With an economic presence that is nationally to globally significant, primary cities have populations that range from 150,000 to more than 50 million people. According to Roberts and Hohmann (2014), secondary cities have an economic impact that reaches the subnational level to subdistrict level and populations ranging from 150,000 to five million people. Tertiary cities have the least economic reach with populations ranging from less than 150,000 to one million people. Overlap between secondary and tertiary cities is recognized, but, for our purposes, a more detailed distinction between the two is unnecessary as both types are the focus of this review.

The definition of SMSC is difficult to pin down as the definition varies from country to country and paper to paper. Medium-sized cities, in many cases, are also defined as secondary cities. For this reason, population and city function are both important when determining city type (Roberts and Hohmann, 2014). In this paper, the following keywords were used to globally identify SMSC, based on population size and function delineation: "Small city or cities," "Medium city or cities," "Secondary city or cities," and "Tertiary city or cities." The "tier cities" naming convention was rejected because the meaning varied too frequently on a country-by-country basis and has also been used in contexts other than cities in research articles. The choice to use city or cities was made based on the initial design search in which "city" or "cities" were found within the main keywords for each of the topics of sustainability, climate migration, and climate resilience. Terms such as "town", "provinces", "municipalities", and "peri-urban" were not chosen as their definitions vary among disciplines and countries.

Two search engines were selected for this study: Web of Science (WOS) and Academic Search Premier (ASP). WOS searches various databases and consists of a wide range of multidisciplinary, peer-reviewed research articles. WOS results may be limited by citation distributions, but it consistently searches across publishers without bias toward journals produced by any one company. ASP, the largest scholarly, multi-disciplinary full text database, was selected to fill the constraints left by WOS.

2.2. Conducting the review

A total of six search queries were used in WOS and ASP, between the three topics of interest. The search was limited to title, abstract, and keywords and document types to "articles" and "papers". For each search the following Boolean (Dinet et al., 2004) was applied first to cover all possible iterations of the word "city":

ALL = ("small cit*" OR "medium cit*" OR "mid-size cit*" OR "secondary cit*" OR "tertiary cit*").

Order of City	Functional and Market Orientation	Supra 50 m +	Mega 10 m +	Metro 5-10 m	Meso 1-5m	Micro 0.2-1 m	Mini > 0.2 m
Global	Large multiple clusters of high value services and manufacturing engaged in global trade						
Sub-Global	Clusters of services and manufacturing engaged predominantly in regional trade						
National	National government, logistics, services and manufacturing centres						
Sub-national	Sub-national provincial Government, logistics, services and manufacturing centres						
District	District level Government, services and processing						
Sub-district	Resource rural-based service industry centre						

Fig. 1. Visualization of city types (Roberts and Hohmann, 2014).

This study consisted of reviewing three different topics; therefore, different keywords were applied for each of the three topics in addition to the SMSC language. The following are the Boolean statements used for each topic that were applied to the found SMSC articles:

- i. Sustainability: ((“sustain*” OR “assess*”) AND “indicat”)
- ii. Climate migration: ((“migrat*” OR “mobility” OR “climate refugees”) AND “climate change”)
- iii. Climate resilience: (“resilienc*” OR “climate change” OR “natural hazard”)

Sustainability involves a vast array of environmental, social, and economic challenges. The broad definition of the word sustainability means that it can be too imprecise for research without focusing on a particular element or domain. Additionally, sustainability is not a static idea, but one that constantly evolves and changes in response to new facts and viewpoints. This review paper concentrates specifically on sustainability assessment and indicators measures to narrow the focus to one that measures and monitors sustainability performance. This resulted in using the Boolean statement with different possible iterations of sustainability, assessment, and indicator for the sustainability research article review.

Climate-related migration is an increasingly important topic in the study of human mobility. Climate-related migration is different from other forms of migration, such as economic or political migration, as it is often involuntary and driven by environmental factors. Hence, this Boolean statement used migrant, climate refugees, and mobility as an “OR” statement and added climate change as an “AND” statement to ensure climate-induced migration was the focus of the review.

Climate resilience is a complex topic that involves a wide range of disciplines, including engineering, ecology, social sciences, public health, among others. The initial design search resulted in climate resilience research discussed without the word climate mentioned in the research papers. Therefore, to include all relevant research articles that can have elements of climate resilience, the Boolean statement included natural hazard, climate change, and possible iteration of the word resilience.

Keywords were truncated in order to expand the Boolean search to include all the morphological variations of the word. Truncations may increase errors in the search or limit the number of records retrieved in EBSCO search engines due to a default in the search engine thesaurus that is not applied to truncations (EBSCOConnect, 2018). Too many possible keywords (such as the inclusion of alternative British spelling) are applied to the thesaurus due to the truncation. Some search engines, such as Google scholar, do not allow for truncation because keywords are automatically stemmed, and the ‘root’ of the keyword is automatically identified and searched for by the engine (Queensland University of Technology, 2023). Sampson and McGowan (2006) and Salvador-Oliván et al. (2019) highlight considerations when using truncations to limit any errors. Keywords should be truncated to the shortest common root possible and only ends of words should be truncated. These recommendations were utilized in the creation of the Boolean statements

The PRISMA-ScR flow diagram depicted in Fig. 2 outlines the steps taken in the literature search and review. The number of documents were first reduced by removing duplicates between the two search engines. Then after reading the title abstract and

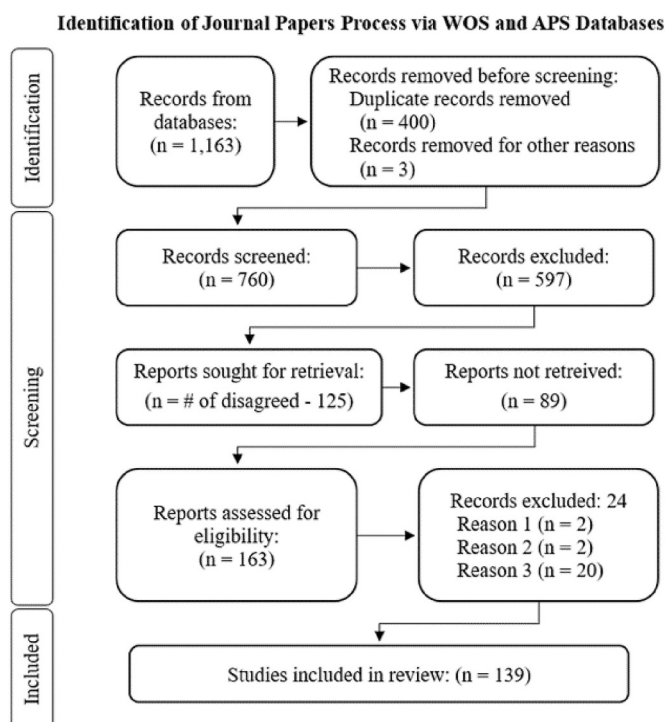


Fig. 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of literature search and review.

keywords of the papers unrelated articles were removed from the review. Only peer-reviewed journal articles published in English were evaluated to keep the number of relevant materials low and to assure the quality of the review. Three reasons were found to exclude papers in the final step of the screening process: 1) the paper was not a journal article (it was found to be a conference abstract symposium summary or book chapter); 2) the paper had incorrect definitions of sustainability,

migration or climate resilience upon further review; and 3) the paper could not be fully accessed. Book chapters were not included as only two were found and access was unfeasible.

Each set of articles were screened by two independent authors. If differences were found between these two reviews, a final decision of inclusion or exclusion was conducted by a third author to account for any biases in the process. As a last step, the Google Scholar search engine was used to conduct a literature search with the exact same search criteria in order to locate potential unidentified papers. No additional peer-reviewed papers were found.

2.3. Content analysis

The process of conducting content analysis entailed gathering and documenting information from the final papers used in the study to identify common themes and trends within the literature. Each article was read in its entirety. A standardized form (found in supplemental material) was used to record SMSC papers' data in order to determine temporal and spatial distribution of themes within each of the three topics. The standardized form was populated with metadata, such as year and place, for each paper. Additionally, categories and subcategories were ascertained and added to this form for each paper to guide the review process in order to expound changes in research themes over time and place.

3. Results

A general search yielded a total of 6493 papers for SMSC were found to be published to our knowledge since 1901, including 522 sustainability assessment, 433 climate-induced migration, and 208 climate resiliency papers. These original 1163 articles related to the three topics were reduced to 143 articles (25 sustainability assessment, 61 climate migration, and 57 climate resilience). Four papers were duplicates between the three topics, and are discussed in detail later. In total, 139 papers were included in the review and analyzed for research trends. The large drop in initial versus reviewed articles is explained through duplicate removal and due to abstract review demonstrating cursory links to topics.

Over 40% of the originally found 6493 SMSC papers were published within the last decade. Only 17% were published in the three previous decades (Fig. 3). The uptick of paper count in 1991 and 1993 is due to the publication called "Conference on the Small City and Regional Community". This conference is not annual and only the ninth and tenth conference publications were found in the database searches. Overall, SMSC papers focused on a wide range of research topics like community development, crime, employment, and health. Until the last few decades, most papers published centered on research within the United States and China. Awareness and education in the developing world, which has included climate change impact awareness, has increased leading to more publications. Wagner and Growe (2021) provide a systematic review of SMSC research trends within the last two decades. Our findings are comparable in the amount and exponential increase in publications with this timeframe. However, the focus of this scoping review is the

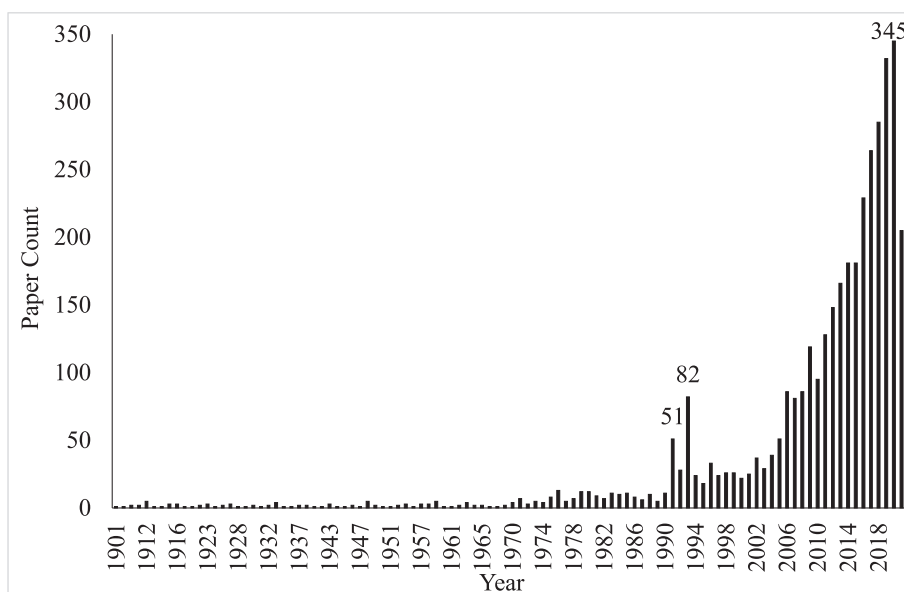


Fig. 3. Number of small and medium sized city papers by publication year.

trends within the three topic areas making it difficult to compare results beyond generalizations to other SMSC reviews conducted.

For the 139 papers reviewed in this study, the publication dates follow the same trend as all the SMSC papers with the majority being published in the last decade (Fig. 4). The climate migration SMSC research started in 1983, but most of the reviewed papers were published after 2010. Climate resilience and sustainability assessment SMSC research started in 2008 and 2009, respectively. Most of these papers were published within the last five years.

Many of the reviewed 139 papers focused solely on SMSC. Some provided a comparison by city sizes, including large, medium, and small cities. In terms of sustainability, 15 papers focused solely on SMSC, while the remaining ten compared SMSC to large cities. Approximately half of the climate migration papers (29 of the 61 papers) are SMSC only papers, whereas most climate resilience papers are centered on SMSC only (48 of 57 papers).

The research locations of the 139 papers differs between the three research topics (Fig. 5). Roughly 20% of SMSC sustainability assessment research was done in Italy. Climate migration and resilience research existed throughout Asian, African, and European countries, with many from the United States. Research within the United States was concentrated in the eastern states for climate resiliency papers, whereas climate migration research focused on the Great Lakes region (Fig. 6). A distinct lack of research is evident in the midwestern and western states in both climate resiliency and migration studies.

3.1. Combined topics overview of SMSC research and study limitations

This assessment paper reports a summary of research conducted on SMSC as identified in published journal articles. The scoping review was constructed to be comprehensive, but practical limitations exist. As noted above, search engine restrictions exist. Limiting the type of document chosen and language of article to only English also controls the results. The study does not provide a critical analysis on the quality and completeness of the findings, but rather, it looks at the sheer volume and types of articles published. Nonetheless, this study gives a thorough reading of the literature and identifies trends and spatial locations of research conducted. Considering the climate crisis and SMSC growth projections, it is necessary to administer this type of analysis that highlights the existing level of scientific research and capacity building in SMSC.

Four of the 139 SMSC papers reviewed were duplicates between the three topic areas. Two papers were shared between climate migration and climate resilience. Asif (2019) studied out-migration from coastal villages in Cambodia, due to drought, over fishing, and sea level rise to a large city. Gueye et al. (2015) assessed climate mobility into Dakar, Touba, and the Senegalese cities network due to drought and flooding pressures. Both studies highlight rural exodus based on economic necessity that is spurred by environmental changes. The later paper also measured reversal migration due to poor city planning. The other two overlapping papers were shared between sustainability assessment and climate resilience. Lioubimtseva and da Cunha (2020) reviewed 36 SMSC climate change adaptation plans between France and the United States and found that sustainability indicators differed by country of origin. Lombardi et al. (2018) determined an Italian SMSC's urban carbon footprint in order to develop an action plan to reduce carbon emissions. These overlapping papers demonstrate the similarities between the three topic areas, like sharing similar disciplines of Environmental Sciences and Urban Planning and the overall focus on climate and the environment. As most the SMSC papers reviewed in this study did not overlap between the three topic areas, it is apparent these topic areas are highly developed within shared disciplines.

Between the three reviewed topics differences are seen in research trends. Climate-induced migration research in SMSC started a few decades before sustainability assessment and climate resilience research began. Migration theory began with Ravenstein in 1885 (Hollifield, 2020). Sustainability as a theory began in the 1970s and became more applied in the 1980s (Kidd, 1992). More recently,

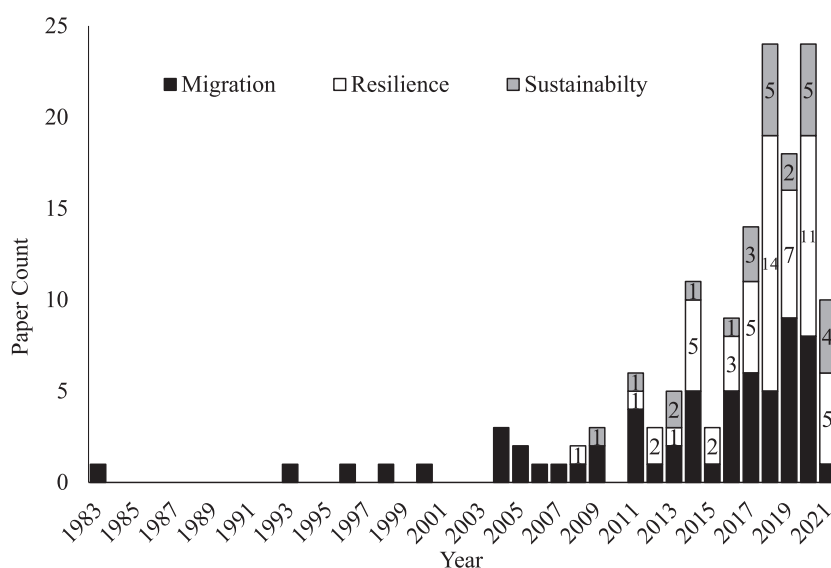


Fig. 4. Small and medium-sized cities paper count by publication year for migration, resilience, and sustainability.

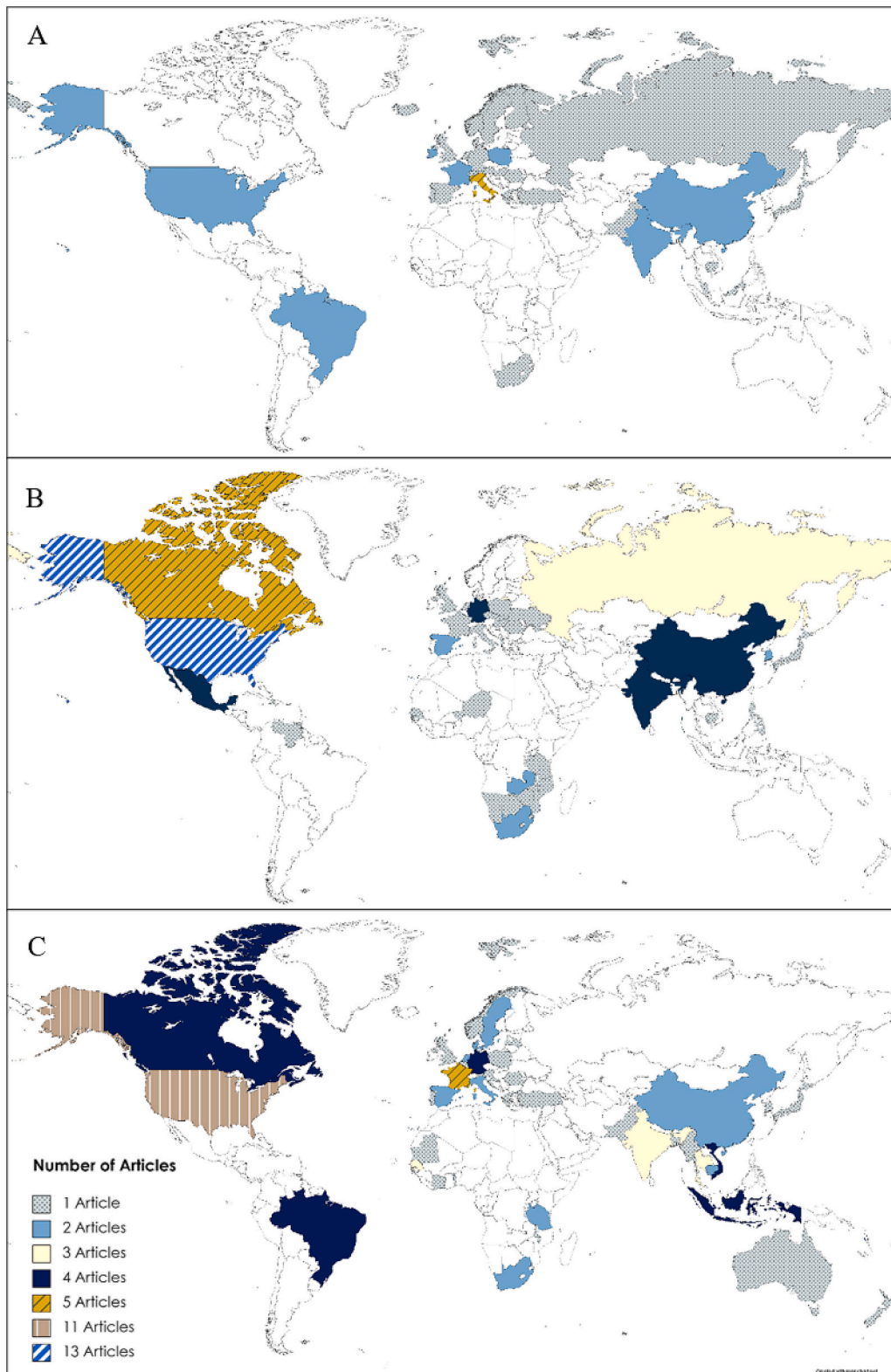


Fig. 5. Research locations of included small and medium-sized cities papers by country for A) sustainability, B) climate migration, and C) climate resilience. Results range from 0 to 13 papers per country.

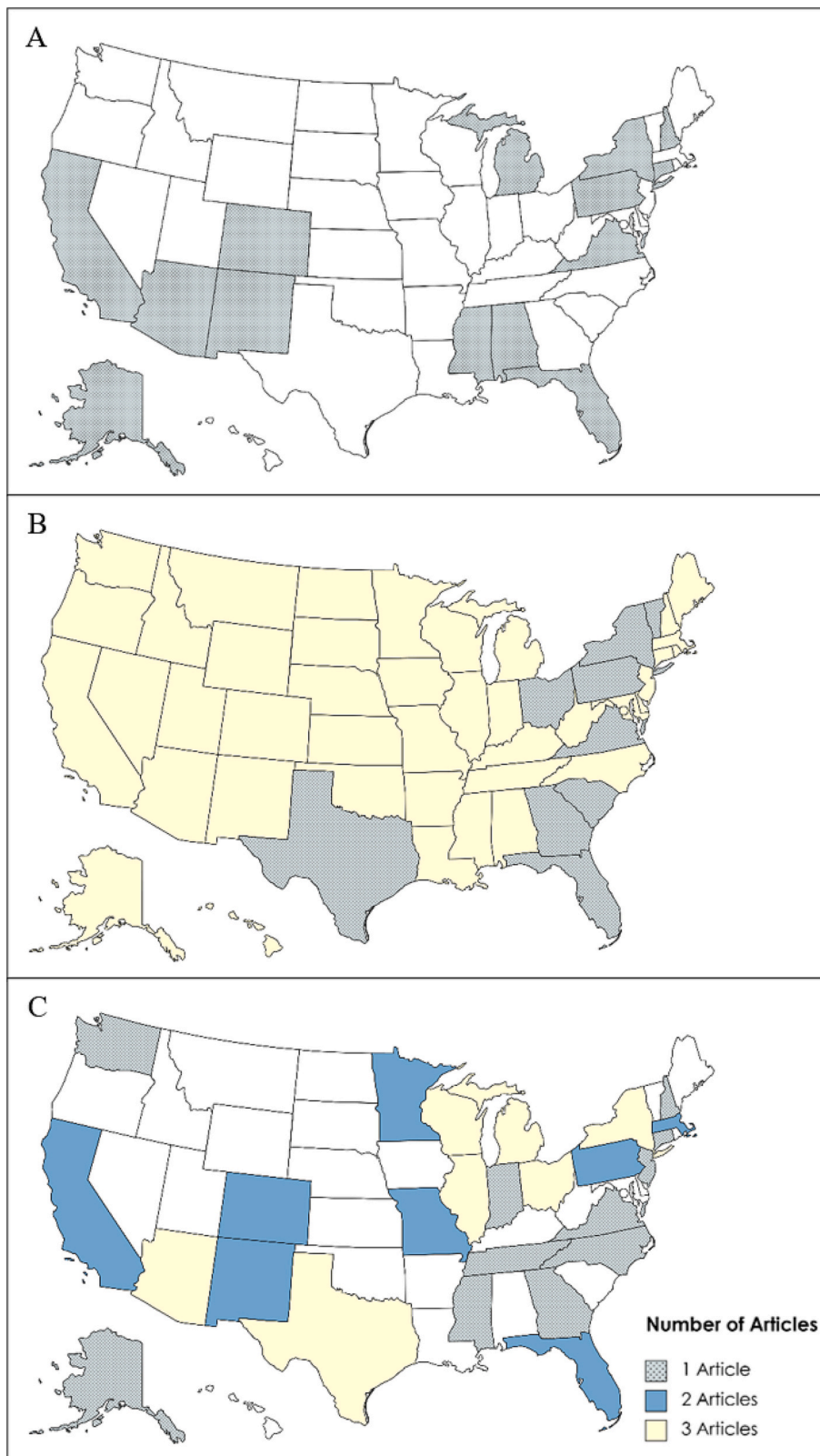


Fig. 6. Research locations within the United States of small and medium-sized cities papers for A) sustainability, B) climate migration, and C) climate resilience. Results range from 0 to 3 papers per state. Additionally, 3 climate migration topic specific papers centered on the continental US.

climate change resilience started with adaptation and vulnerability research in the late 1990s (Schoon, 2005). Location of research variability among sustainability assessment, climate migration, and climate resilience may pertain to language or political differences in how the United States addresses sustainability. Additionally, climate resilience research focuses on SMSC, while sustainability assessment and climate migration research see more comparison between city sizes. Resilience research in general is place based (Cutter et al., 2008), which may account for this disparity in approach. Topic specific research trends for each of the three areas are discussed below.

3.2. Overview of sustainability SMSC research

Academia and practitioners perceive sustainability and resilience as two distinct concepts (Meerow and Newell, 2015). However, sustainability and resilience are often conceptualized as being the same (Adger, 2003; Edwards, 2009; Farrell and Twining-Ward, 2005), with resilience as a key indicator of sustainability (Magis, 2010; Schianetz and Kavanagh, 2008; Walker et al., 2012). Sustainability is the broad social objective and resilience is the implementation strategy (Anderies et al., 2013; Fiksel, 2006). Consequently, research is intertwined, with sustainable development sometimes defined within the context of resilience, particularly in response to climate-related hazards. This interchangeability was apparent as a result within this scoping review.

Table 1 provides a breakdown of the 25 sustainability assessment papers by year and place, which include seven categories. The categories found in this review for sustainability assessment study included topics like climate adaptation plan, economic impact assessment, environmental sustainability, remote sensing usage, species sustainability, general assessment and sustainable development. The range of these categories being found in diverse disciplines (from Ecology to Geospatial Sciences) demonstrates the broad scope of sustainability studies even within the realm of sustainability assessment research studies. The main disciplinary area for most of the sustainability assessment articles is Environmental Sciences with Urban Planning coming in second.

In our results, only two of the 25 sustainability assessment papers analyzed were from the United States, but 11 studies were conducted in European countries. European nations comprise the top 17 countries evaluated under SDGs, whereas the United States, due to lack of focus on such goals, ranks 33rd globally (Sachs et al., 2021). Argumentatively, a positive association exists between the amount of sustainability assessment studies undertaken and the commitment to attaining sustainability. SMSC typically lack sufficient funds and infrastructure for sustainable projects, yet may behave sustainably due to necessity. Therefore, the absence of the word ‘sustainability’ may hinder the discovery of sustainability research in SMSC.

Multiple studies focused on conducting a region wide or country wide study to understand indicator usage for performance assessments. Danielis et al. (2017) studied sustainable urban mobility using a composite indicator based on city sizes and their performance for 116 Italian provincial towns. Rodrigues et al. (2018) used an indicator assessment for managing solid waste in a small city in the Parana state, Brazil. Other assessment studies ranged between developing dimensional indicators for assessing UN SDG 11 targets (Chan, 2020; Gubic and Baloi, 2019; Tiwari and Phillip, 2021), creating a campus sustainability assessment framework (Saadatian et al., 2013), creating a sustainable urban development framework (Nemeş, 2013), creating ranking systems to understand people’s perceptions (Tariq et al., 2021), analyzing alignment of published indicators with the smart and sustainable city approach (Machado Jr et al., 2018), and understanding development levels in a city (Zhang et al., 2019).

Sustainable development was the second largest sustainability assessment category. Kusago (2011) studied sustainable wellbeing. Kalfas et al. (2021) evaluated the relationship between studied sustainable development and ecosystem services. Dall’O’ et al. (2017)

Table 1

Categorical breakdown of sustainability assessment small and medium-sized cities papers by year, place, and count.

Discipline	Category	Year	Place	Count
Environmental Sciences, Urban Planning	Climate Adaptation Plan	2020	France and USA	1
Economics	Economic	2020	Italy	1
Environmental Sciences	Environmental Sustainability	2009, 2018	Italy, Ireland	2
Geospatial Science	Remote Sensing	2014, 2016, 2020, 2021	China, India, South Africa, USA	4
Environmental Sciences, Ecology	Species Sustainability	2020	Poland	1
Environmental Sciences, Urban Planning	Sustainability Assessment	2011, 2013, 2017, 2018, 2019, 2020, 2021	Australia, Brazil, Cambodia, China, Italy, Japan, Malaysia, Romania, Russia, Rwanda	10
Environmental Sciences, Urban Geography, Urban Planning	Sustainable Development	2017, 2018, 2021	Greece, India, Italy, Pakistan, Poland, Germany, Turkey, Netherlands, Spain, France, Belgium, Portugal, Great Britain, Norway, Austria, Cyprus, Denmark, Finland, Hungary, Iceland, Ireland, Sweden, Switzerland	6

proposed strategies to reduce climate emission. Arshad and Routray (2018) assessed Pakistan's housing plans. Zawadzka (2017) identified sustainable development strategies for European small towns via a global network. Ermolaeva et al. (2018) evaluated governance and environment in sustainable city methods. Agrawal et al. (2021), Chen (2016), Li et al. (2014), and Mudau et al. (2020) used remote sensing to analyze air pollution, land cover changes, urban expansion, and transportation in SMSC in India, USA, China, and South Africa, respectively.

Climate research and environmental sustainability are crucial topics in the field of sustainability. This review found research focused on monitoring, knowledge sharing, and cross-border comparison of climate adaptation plans (Lioubimtseva and da Cunha, 2020). An Italian study compared smart, sustainable cities to urban knowledge-based economies (Ivaldi et al., 2020). Lombardi et al. (2018), Lopucki et al. (2020), and O'Regan et al. (2009) studied air pollution, species sustainability, and environmental sustainability in SMSC.

All except one sustainability assessment paper were published in the last decade, with two thirds published in last five years. The first publication on environmental sustainability was published in Italy in 2009. The categorical focus has shifted to assessment frameworks in 2013, then to indicator evaluations in 2017 and 2018, and finally to UN SDG studies, particularly SDG 11, from 2019 to 2021 as seen in Table 1. This last shift may be related to the UN's 2030 SDG Agenda and European countries focus on these targets.

3.3. Overview of climate migration SMSC research

Migration, the Urban Informal Sector, and Earnings in the Philippines, by Hagen Koo and Peter C. Smith, was published in 1983 Koo and Smith, 1983, making it the oldest publication about migration found through the review process. A clear positive trend exists in the number of published papers after 2009. Climate migration research was concentrated primarily within North America, China, Russia, and India. This research covered categories from migratory pattern assessment to social perceptions and interactions due to migration. Most countries covered a variety of categories, however, research within China and Germany primarily focused on economic-centric labor migration. Table 2 shows the 8 main categories of research found within the 61 climate migration papers with Migratory Patterns (12), Socialization (13), and Urbanization/Urban Form (13) accounting for roughly 60% of the migration papers reviewed.

Within the broader context of climate migration SMSC research, some key disciplines dominate the literature. Studies within the disciplines of Urban Planning and Demography were prevalent, which is important to the better understanding how an inflow or outflow of people will influence the urban form of cities. Economics was another key discipline the climate migration fell within, as these studies investigate the socioeconomic influence of cities and how it may spur migration away from SMSC into larger economic capitals. An emergent discipline is the field of Sociology, with more recent studies attempting to better understand how migrants are being received in their new destination.

Migration socialization is how migrants interact and conform, how personal identity may determine migration location, and how receiving community perceptions cause barriers to new migrants (Benson and Haith, 2010). Socialization can also focus on the communities receiving new migrants and the perceptions or barriers that may be put in place toward new migrants. Papers focusing on socialization were concentrated within Russia, the United States and Canada. Bose (2014, 2021) examined immigrant settlements outside of gateway, or primary, cities looking at how resettled refugees may act to revitalize US SMSC and barriers (xenophobia, sense of place, acculturation, community) faced in these towns. Zarrugh (2008), similarly, looked at the impact of Latino migration on the demographics and culture of the SMSC of Harrisonburg, Virginia. Through decades of Latino migration, Harrisonburg has transitioned

Table 2

Categorical breakdown of climate migration small and medium-sized cities papers by year, place, and count. CONUS refers to continental United States.

Discipline	Category	Years	Place	Count
Economics, Demography	Economic/Labor Migration	1983, 1998, 2007, 2013, 2014, 2017, 2019	CONUS, Canada, Germany, Philippines, Russia, South Africa, Spain	8
Environmental Sciences	Environmental Change	2015, 2019	Cambodia, Senegal	2
Urban Geography, Urban Planning, Sociology	Governance and Policy	2009, 2014, 2017	Canada, Germany, Mexico, CONUS	3
Economics, Urban Planning, Demography	Migratory Patterns	1996, 2000, 2011, 2014, 2016, 2018, 2019, 2020	Africa, Albania, Canada, Czech Republic, China, Japan, Mexico, Niger, Poland, Ukraine, CONUS, Venezuela	12
Sociology, Urban Geography	Perceptions	2006, 2019, 2020, 2021	Hungary, Russia, CONUS	4
Sociology, Urban Geography	Socialization	2008, 2011, 2013, 2014, 2016, 2017, 2018, 2019, 2020	Canada, China, Germany, Italy, Romania, Russia, Spain, UK, CONUS	13
Economics, Demography, Urban Geography	Theory	1993, 2004, 2005, 2017, 2018, 2019	France, India, Mexico, South Korea, CONUS, World	6
Urban Geography, Urban Planning	Urbanization/Urban Form	2004, 2009, 2012, 2016, 2017, 2019, 2020, 2021	Botswana, China, Developing Countries, Eswatini, India, Latin America, Lesotho, Malawi, Mozambique, Namibia, Netherlands, Slovakia, South Africa, South Korea, Tanzania, CONUS, Zambia, Zimbabwe	13

from a 93.7% white population to having the most diverse school enrollment within the state of Virginia. Some studies looked at how an individuals' sense of place and community impacts their desire to emigrate to a larger city. Gunko and Medvedev (2018) examined the depopulation of small cities in Russia and how strong local identity leads youth to return home. Socialization studies provide insight as to how climate migration may alter the demographic and cultural landscape of SMSC.

Six of the 61 reviewed papers focused on migration theory. Prieto Curiel et al. (2018) uses gravity and scaling laws to determine if city size impacts an individual's decision to migrate, and to what city type they may emigrate. Semboloni and Leyvraz (2005) examine how migration and resource necessity result in a Zipfian distribution of population within cities. Randolph and Naik (2017) discussed the concept of 'migrant-intensity', out- versus in-migration, to understand complex migration patterns. These theory papers were also all comparative studies between SMSC and large cities, or about how migration theory can be applied to varying city types. This highlights a potential avenue for future SMSC research.

Three reviewed papers fell under the umbrella of governance and policy (Gilbert, 2009; Semple, 2017; Weck and Beißwenger, 2014). Given the time between publications, it would be noteworthy to research how international and local policies have, or will, effect migration within, and to SMSC.

Climate migration research, especially to SMSC, has many glaring gaps, such as research focusing on migration specifically to SMSC or the impacts of migration on these city types. Climate migration research was split between SMSC specific and comparison studies. Of the 61 reviewed papers, only 29 studies specifically focused on SMSC. Of these, 17 focused on the topics of urbanization and socialization. The remaining 32 reviewed papers were comparison studies to large cities or focused on migration from SMSC to large cities, or vice versa. Many of these papers focused on intra-city and intra-country labor class migration between SMSC and larger cities or focused on movement between SMSC and large cities, rather than movement into, within, or between SMSC specifically.

3.4. Overview of climate resilience SMSC research

Except for one study published in 2008, all the climate resilience reviewed papers were published in the last decade with 80% published in the last five years. Table 3 presents the 10 categories seen in the 57 climate resilience papers. Climate flood resilience, community resilience, and climate change adaptation and mitigation were the main themes researched in this topic. These SMSC climate resilience studies fell within the major disciplines of Environmental Sciences, Urban Planning and Ecology. Most the studies where published within journals focused on climate and sustainability. Only two articles were found within Health journals (Doyon et al., 2008; Lalani et al., 2021), displaying a gap in SMSC climate resilience research. The themes and trends found in the SMSC climate resilience literature are discussed here.

Over a third of the reviewed articles focused on natural hazards. Flood resilience comprised most of these papers and research locations spanned the globe. All but two of flood studies concentrated assessments within individual cities. Bilodeau et al. (2018), Kim et al. (2018), Morelli and Cunha (2021), Othmer et al. (2020), and Piketh et al. (2014) assessed infrastructure for preparedness flood planning. Bond and Barth (2020), Cissé et al. (2011) and Thuon and Cai (2019) looked at SMSC social aspects that lead to flood resilience. Beringer and Kaewsuk (2018) and Rode et al. (2018) reviewed social and infrastructure design to evaluate flooding vulnerabilities. Finch (2021) evaluated the recovery process of a city after a flood event. These various approaches provide comprehensive methods for measuring SMSC flood resilience.

Table 3

Categorical breakdown of climate resilience small and medium-sized cities papers by year, place, and count. CONUS refers to continental United States.

Discipline	Category	Years	Place	Count
Environmental Sciences, Urban Planning	Climate Change Adaptation**	2012, 2014, 2017, 2018, 2020	Canada, France, Denmark, CONUS, Bangladesh, Indonesia, Japan, India; Africa	10
Environmental Sciences	Climate Change Migration*	2015, 2019	Cambodia, Senegal	2
Environmental Sciences, Urban Planning	Climate Change Mitigation**	2013, 2014, 2017, 2018, 2019, 2020	Germany, Spain, USA, Italy, EU, France, Norway, Sweden, Turkey	9
Environmental Sciences, Urban Planning	Climate Drought Resilience	2019	Thailand	1
Environmental Sciences, Urban Planning	Climate Flood Resilience	2011, 2014, 2018, 2019, 2020, 2021	Australia, Canada, New Zealand, Thailand, South Korea, Germany, South Africa, France, Cambodia, Brazil; Africa	11
Environmental Sciences, Urban Planning	Community Resilience	2012, 2017, 2018, 2019, 2020, 2021	Canada, Myanmar, CONUS, Brazil, Indonesia, India, Japan, Pakistan, Malawi, Tanzania, Thailand, Vietnam, CONUS; Africa	10
Ecology	Ecosystem Resilience	2020	China	1
Environmental Sciences, Urban Planning	Natural Hazard Resilience	2016, 2019, 2020, 2021	Brazil, India, Vietnam, CONUS	4
Environmental Sciences, Urban Planning	Urban Heat	2008, 2015, 2016, 2017, 2019, 2021	Brazil, Canada, China, France, Netherlands, CONUS	6
Environmental Sciences, Urban Planning	Water Supply Resilience	2016, 2018	Indonesia, CONUS	3

Note: The four overlapping papers are represented for purposes of highlighting overlap within the final climate resilience paper count.

* One paper in each of these categories overlaps with sustainability.

** Papers in this category were found to overlap with the results in climate migration.

SMSC natural hazard research also focused on urban heat island (UHI) effect, heatwave research, drought, and general hazards relation to climate change. UHI intensity and heatwaves, like flooding, is an easily observable consequence of climate change, and therefore, was the second most researched SMSC natural hazard after flooding. Within this category, research focused on heat related health and mortality (Doyon et al., 2008; Vanos et al., 2015), landuse and vegetation coverage in relation to mitigation and prediction of heatwaves locations (Foissard et al., 2019; Icaza et al., 2016; Lima Alves and Lopes, 2017; Zhang et al., 2021), and comparison of urban size in relation to extreme heat (Vanos et al., 2015). Marks (2019) looked at the social and political issues that lead to drought vulnerabilities in a secondary city. Two articles (Pulliat, 2019; Rumbach, 2016) evaluated the effectiveness of existing hazard response practices. Saito et al. (2020) determined population dense areas experience the most flood and landslide disasters. Villarreal and Meyer (2020) assessed women's limitations post-disaster. While specific climate related hazard research in SMSC was found to cover several hazard types, insufficiencies can be seen in research related to hazards beyond flooding resilience. Additionally, little research has been conducted in the United States, central and south America, central Africa, and parts of Asia.

Climate change adaptation, mitigation, and community resilience categories comprised half of the papers. Climate change adaptation research focused on assessing adaptive and social capacity (Drolet and Sampson, 2017; McEvoy et al., 2014; Radhakrishnan et al., 2017; Wisner et al., 2015) and reviewing adaptation planning and methods (Hamin et al., 2014; Lioubimtseva and da Cunha, 2020; Nugraha and Lassa, 2018; Pathirana et al., 2018; Setyono et al., 2018). Water supply resilience is a form of climate change adaptation, but it is also considered sustainable infrastructure. Therefore, it was highlighted separately. Water conservation in the form of an incentives program (O'Donnell and Berrens, 2018), rainwater harvesting (Prihanto et al., 2018), and city water supply vulnerabilities (Rushforth and Ruddell, 2016) were the researched themes. Climate change mitigation research centered on renewable energy (Biernacki et al., 2018; Melica et al., 2018; Pitt and Bassett, 2013; Ramshani et al., 2020), household and urban carbon footprint measurements and reductions (Lombardi et al., 2018; Sköld et al., 2018), and transportation (Francisco Coloma et al., 2019; Javid et al., 2014) and waste management strategies (Kayakutlu et al., 2017) to reduce greenhouse gas emissions. Community resilience research centered on surveys and interviews to assess climate resilience and adaptive capacity (De Lima et al., 2020; Hussain et al., 2018; Kalafatis, 2020; Kareem et al., 2020; Koch et al., 2017; Lalani et al., 2021; Martin et al., 2019; Pasquini, 2020; Prabhakar et al., 2012). Locational gaps exist in these categories of research. Climate adaptation and community resilience research was located more throughout African and Asian countries. Climate mitigation research was conducted within Europe and the United States.

4. Discussions and conclusions

This scoping review provided an overview of SMSC research themes and trends specifically within three topics: sustainability assessment, climate migration, and climate resilience. The utilization of three search engines (WOS, APS, and Google Search) resulted in finding 6493 SMSC publications published since 1901, including the 25 sustainability, 61 migration, and 57 climate resiliency papers analyzed in this study. The assessment found global locational gaps and an increase on SMSC research in the past decade. The most SMSC research was conducted in the United States, and climate migration and resilience specific research does as well. Other regions of significant research occurred within China, Germany, India, Russia, and Canada.

SMSC sustainability assessment research is more centralized across Europe and mostly focused on sustainable development. Most of these studies were comparisons between SMSC and large cities. Additionally, there are fewer independent studies in SMSC, which could be due to lack of infrastructure, funding, and importance given to SMSC. Greater emphasis on research is need beyond European countries to encourage sustainable practices and ways to measure success in SMSC. With lack of global representation of studies, a larger understanding of regional trends and disparities is impossible to quantify.

For migration studies, there is a clear lack of SMSC specific studies. Much of the literature found surrounding this topic were generally comparisons between SMSC and large or megacities. Moreover, there are gaps in the research by category as well. There were only three studies on the governance and policy of migration. Governance and policy largely dictate migratory flows patterns across the world. Furthermore, these policies can also shift locals' perceptions on migration, and again, impact where an individual may be able to; or desire to move. This review highlights a clear underrepresentation of the role of SMSC in the global migration system and how these city types may face climate migration. Such a large deficit in papers focusing on environmental change and migration is concerning, as many SMSC may be the first stop for migrants or 'climate refugees' in the future.

Conversely to sustainability and migration studies, most climate resilience SMSC studies centered on individual cities versus the comparison of SMSC to large cities. Comparison studies between and within city type could highlight specific climate hazard adaptation and mitigation strategies that are effective by city type. Comparison studies that focus on specific hazards could also be useful in understanding difference in management strategies need in SMSC versus large cities to contend with vulnerability and risk.

While over half of the climate resilience studies focused on climate change adaptation, mitigation, and community resilience, locational gaps exist globally in these three categories of research. Climate adaptation and community resilience research is located more heavily in African and Asian countries and climate mitigation research is located within Europe and the United States.

While specific climate related hazard research in SMSC was found to cover several hazard types, insufficiencies can be seen in research related to hazards beyond flooding resilience. Further research by hazard type needs to be conducted in the United States, central and south America, central Africa, and parts of Asia. Drought research is sparse in SMSC. Additionally, no SMSC research was found relating to compounding natural hazards or cascading effect of multiple climatic hazards.

Specific disciplines were underrepresented within all topic areas. Agriculture, health, social, and cultural considerations are important in the discussions of sustainability assessment, climate-related migration, and climate resilience. Agricultural research was not seen SMSC in any of the three topics, not even in relation to food sustainability or climate impacts to food resilience. The idea of people moving due to employment concerns within the agricultural field due to climatic changes is an important topic that needs

discussed while looking at SMSC.

Sustainability assessment, climate migration, and climate resilience research in SMSC could benefit from the inclusion of more qualitative or human-centric disciplines, like Health and Epidemiology fields. With climate change caused temperature increases, malnutrition, injury from heatwaves and drought, infectious disease vectors and cardiorespiratory morbidity is anticipated to increase (Kurane, 2010). How might more people in SMSC impact the amount of health resources available? How could climate-induced migration spur transmission of disease in the future? These are a couple of the many questions regarding SMSC in relation to these increases that remain unanswered.

Studies within the Cultural Geography and modern Anthropology fields are needed to investigate the impacts of physical relocation on a culture or community, as well as, cultural responses to natural hazards in SMSC. What physical aspects of a culture may be left behind due to relocation? What aspects of culture or community may be given up to be adopted into a larger, urban system? How do SMSC with diverse populations approach climate resilience and sustainability in equitable ways?

The results of this study largely focused on the identification of the gaps (contextual, spatial, and temporal) in the SMSC studies. Future examinations need to focus on filling spatial gaps to gain a better knowledge of expansion and infrastructure variabilities with SMSC that are necessary to resist climate change hazards and build sustainable cities.

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Kristin Youngquist: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Visualization, Project administration, Writing – original draft, Writing – review & editing. **Megha Shrestha:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Brandon Ryan:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Chandana Mitra:** Conceptualization, Supervision, Project administration, Writing – review & editing.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Co-author serves as associate editor of Urban Climate - C.M.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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