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Extreme Heat in Urban Areas of Vietnam: A Systematic Review

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Extreme Heat in Urban Areas of Vietnam: A Systematic Review

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Abstract
This study provides a systematic review of scientific and grey literature, in both english and vietnamese, on extreme heat in Vietnam's urban areas. We assess the current state of knowledge on this issue, the role of urban heat islands, impacts and vulnerabilities. Local anthropogenic factors, including rapid urbanization, inadequate infrastructure, and high population density are identified as key contributors to worsening heat extremes. The study also evaluates current adaptation and mitigation strategies, such as green infrastructure, early warning systems, and public awareness programs, highlighting major gaps in research, policy implementation, and public awareness, particularly in secondary cities and among vulnerable populations, where adaptation efforts remain insufficient. We conclude with public policy recommendations to address the growing challenges of extreme heat in Vietnam's rapidly urbanizing cities, ensuring sustainable urban development and improved quality of life.

Keywords
Extreme Heat, Urban Heat Island, Climate Change, Urban Areas, Vietnam, Health, Vulnerability, Adaptation, Mitigation, Hanoi, Ho Chi Minh City.

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Résumé
Cette étude fournit une revue systématique de la littérature scientifique et littérature grise, en anglais et vietnamien, sur les chaleurs extrêmes en zone urbaine au Vietnam. Nous évaluons l'état actuel des connaissances sur cette problématique, le rôle des îlots de chaleur urbains, les impacts et les vulnérabilités. Les facteurs anthropiques locaux, notamment l'urbanisation rapide, l'inadéquation des infrastructures et la forte densité de population, sont identifiés comme des facteurs clés contribuant à l'aggravation des chaleurs extrêmes. L'étude évalue également les stratégies actuelles d'adaptation et d'atténuation, telles que les infrastructures vertes, les systèmes d'alerte précoce et les programmes de sensibilisation du public, mettant ainsi en lumière des lacunes majeures dans la recherche, la mise en œuvre des politiques et la sensibilisation du public, en particulier dans les villes secondaires et parmi les populations vulnérables, où les efforts d'adaptation restent insuffisants. Nous concluons avec des recommandations de politiques publiques visant à relever les défis croissants posés par les chaleurs extrêmes dans les villes vietnamiennes en plein essor, afin de garantir un développement urbain durable et une meilleure qualité de vie.

Mots-clés
Chaleur extreme, îlot de chaleur urbain, changement climatique, zones urbaines, Vietnam, santé, vulnérabilité, adaptation, atténuation, Hanoi, Ho Chi Minh Ville.

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Introduction

Background on urban climate

Urban climate refers to the surface climate in a city, which differs from the surrounding suburban and rural areas due to anthropogenic activities and land surface modifications **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**. Urban climates are characterized by higher surface temperatures (up to several degrees Celsius at night), reduced wind speeds, and lower relative humidity compared to surrounding regions. This localized warming, known as the Urban Heat Island (UHI) effect, arises from the accumulation of heat in urban infrastructure and weakened natural cooling processes **Erreur ! Source du renvoi introuvable. Erreur ! Source du renvoi introuvable.**.

Empirical evidence shows that global research on urban climates has evolved through three distinct phases: (i) prior to 1990, studies on urban climate were limited; (ii) between 1990 and 2010, the volume of research increased approximately threefold; and (iii) since 2015, the annual number of publications has tripled compared to 2010 **Erreur ! Source du renvoi introuvable.**. Initially, the research was largely conducted by meteorologists and environmental scientists, but the scope has since expanded to include interdisciplinary studies on urban planning, green infrastructure, and climate resilience. After 2010, studies addressed issues such as the spatial distribution of green spaces, housing, energy, and building engineering. Interdisciplinary research on technical solutions for thermal insulation (for both heat and cold), resistance to strong winds, urban flooding, urban space design, and housing design has been rapidly applied in practice in many countries **Erreur ! Source du renvoi introuvable.**.

The World Meteorological Organization (WMO) has identified the increasing impacts of natural disasters and the accelerated pace of urbanization as major climate challenges for urban areas worldwide **Erreur ! Source du renvoi introuvable.**. Addressing these challenges is critical for achieving multiple United Nations Sustainable Development Goals (SDGs), including goals related to climate action, sustainable cities, and public health. Among the 17 SDGs, urban climate resilience is linked to Goals 6, 7, 11, 12, 13, 14, and 15 **Erreur ! Source du renvoi introuvable.**. In the context of climate change, studying and clarifying the relationship between climate and urban areas would provide a scientific basis for urban planning and the development of green, low-emission, smart, and climate-resilient cities. With the following objectives: (i) create a more comfortable and favorable living environment for people; (ii) enhance resilience to natural disasters and climate change, hence

reducing the risks of adverse impacts and disease outbreaks **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**; (iii) reduce greenhouse gas emissions **Erreur ! Source du renvoi introuvable.**.

Drivers of extreme heat in urban areas

The development of extreme heat in urban areas results from the interaction of global climate drivers and local anthropogenic factors. At the global scale, greenhouse gas (GHG) emissions from human activities contribute to long-term global warming **Erreur ! Source du renvoi introuvable.**. This global warming trend interacts with natural climate variability at the regional scale and combine with localized human drivers to create distinct urban climate conditions and intensify urban climate risks **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**.

Four main local factors (Figure 1) contribute to increased temperatures in urban areas [159]:

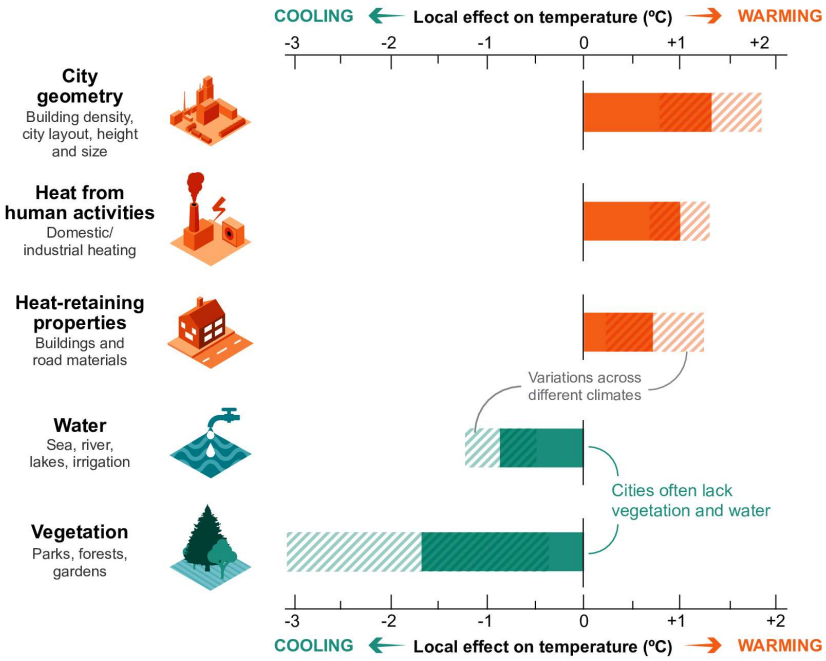
i) **Urban geometry.** Tall and close buildings absorb and store heat and also reduce natural ventilation, trapping heat in urban canyons.
ii) **Heat release from human activities.** Anthropogenic heat emissions from air conditioning systems, industrial activities, and transportation, together with air pollution, contribute to amplifying the UHI effect and disturb the energy and water balance in urban environments **Erreur ! Source du renvoi introuvable.**.
iii) **Heat-retaining properties of materials.** The physical properties of materials commonly used in urban construction — such as concrete, asphalt, and bricks — significantly alter the thermal and radiative balance compared to natural surfaces, thereby intensifying the UHI effect **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**. These materials typically have higher heat capacity and thermal conductivity, along with lower reflectivity (albedo) and emissivity, resulting in increased heat absorption during the day and prolonged heat release at night.
iv) **The lack of vegetation and water bodies,** which could counterbalance these heating factors, limits natural cooling processes.

All these factors act on sensible and latent heat fluxes in the city and play a critical role in shaping the urban thermal environment, intensifying localized heat accumulation. Finally, the expansion of impervious surfaces further exacerbates these effects by reducing water infiltration and evapotranspiration, which limits the natural cooling of surfaces and increases surface runoff and urban flooding risks **Erreur ! Source du renvoi**

introuvable.Erreur ! Source du renvoi introuvable..

While UHI is a well-documented phenomenon, the magnitude and spatial distribution of urban heat exposure vary depending on the city's land use patterns, construction materials, energy consumption, and urban design, but also on the background climate.

Figure 1. Efficiency of the various factors at warming up or cooling down neighbourhoods of urban areas.



Note: The hatched areas on the bars show how the strength of the warming or cooling effects of each factor varies depending on the local climate. For example, vegetation has a stronger cooling effect in temperate and warm climates. Source: IPCC (2021), FAQ 10.2, Figure 1.

Urban heat challenges in Vietnam

According to the 6th Assessment Report of the Intergovernmental Panel on Climate Change [159], the global average surface temperature has risen by approximately 1.1°C over 2011-2020 compared to the pre-industrial era, and is projected to further increase by 1.5°C to 4.5 °C by the end of the 21st century, depending on global greenhouse gas emission scenarios **Erreur ! Source du renvoi introuvable.**. The 2024 update of key indicators of the state of the climate system shows that for 2015-2024 global warming level reached

1.24°C [1.11-1.35°C] compared to the preindustrial [175]. Without changes, the 2°C threshold could be reached by mid-century, and exceeded in the second half of the century [176].

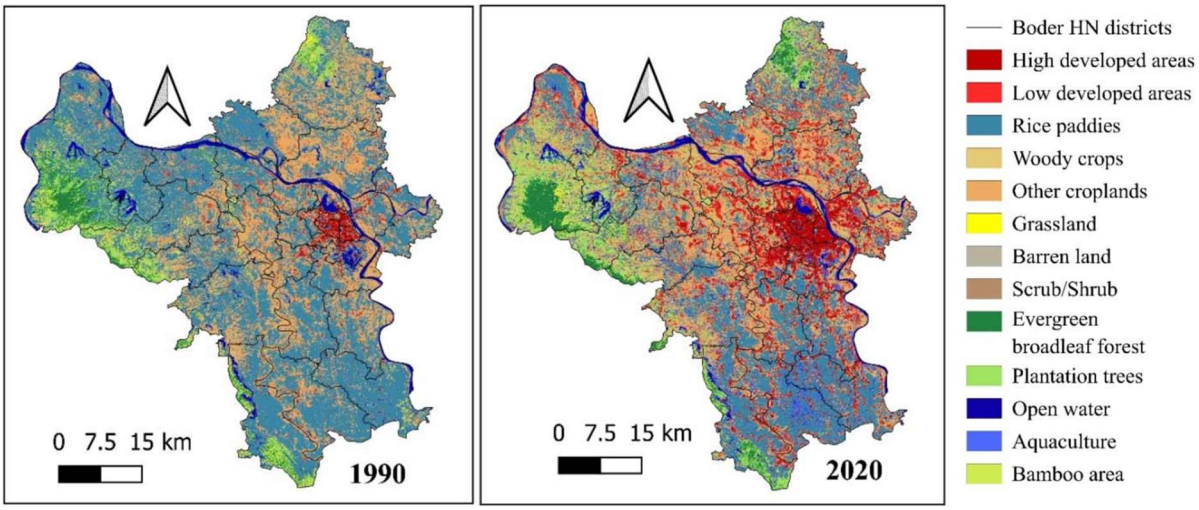
The synergy between increasing hot extremes driven by global warming and the UHI effect poses significant risks to urban areas in Vietnam. Major cities, such as Hanoi and Ho Chi Minh City, are experiencing more frequent and intense heatwaves, with record-breaking temperatures observed in recent years. For instance, during the June 2017 heatwave, Ha Dong station in Hanoi recorded a maximum temperature of 42.5°C, the highest in the city's history **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**. Similarly, in April 2019, Northern Vietnam experienced unprecedented heat, with temperatures reaching 41.1°C in Hoa Binh City (Hoa Binh Province, surpassing the previous record of 40.5°C), 43.4°C in Huong Khe (Ha Tinh Province), 43.0°C in Tuyen Hoa (Quang Binh Province, surpassing the previous record of 41.4°C), and 38.9°C at Ha Dong station (Hanoi, surpassing the previous record of 38.5°C) **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**. In May 2023, Hanoi faced another severe heatwave, with temperatures exceeding 41.0°C (41.0°C and 41.3°C recorded at Lang and Ha Dong stations, respectively, which was the highest May temperatures on record) **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**. While these figures are based on standard meteorological shelters, they likely underestimate actual surface heat stress in urban areas. Indeed, empirical observations and remote sensing data consistently show that surface temperatures on urban infrastructure (e.g., roads, rooftops) often exceed air temperature by 10°C or more under direct sunlight — further intensifying human exposure to extreme heat.

In Vietnam, rapid and often unplanned urbanization over the last decades has increased the extent of impervious surfaces and reduced vegetation cover, especially in major cities such as Hanoi and Ho Chi Minh City. The comparison of land use types in Hanoi between 1990 and 2020 (Figure 2) reveals a sharp decline in rice paddy areas, from 53% to 30% of the total surface, while residential land increased from about 3% to 17% [163]. Similarly, impervious surfaces in Ho Chi Minh City increased by about 57% between 2002 and 2022 (Figure 3), and are projected to nearly double by 2032 compared to 2022 [164]. This evolution is primarily driven by construction expansion and infrastructure projects **Erreur ! Source du renvoi introuvable.**.

Moreover, UHI is often exacerbated by inefficient energy use, limited green spaces, and poor building design. Urban development in Vietnam has traditionally

prioritized maximizing land use and built-up density, while heat mitigation considerations have remained limited in construction practices and urban planning. Many urban areas in Vietnam lack climate-sensitive planning regulations, and national building codes currently emphasize structural safety over thermal comfort or heat mitigation **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**. As cities continue to densify, the prioritization of high-rise buildings and paved surfaces — without sufficient integration of vegetation or cooling infrastructure — creates a feedback loop that amplifies both temperature and energy demand. Hence, transformations in land use reflect the intensifying pressures of urbanization and are strongly associated with increased surface temperatures and UHI formation.

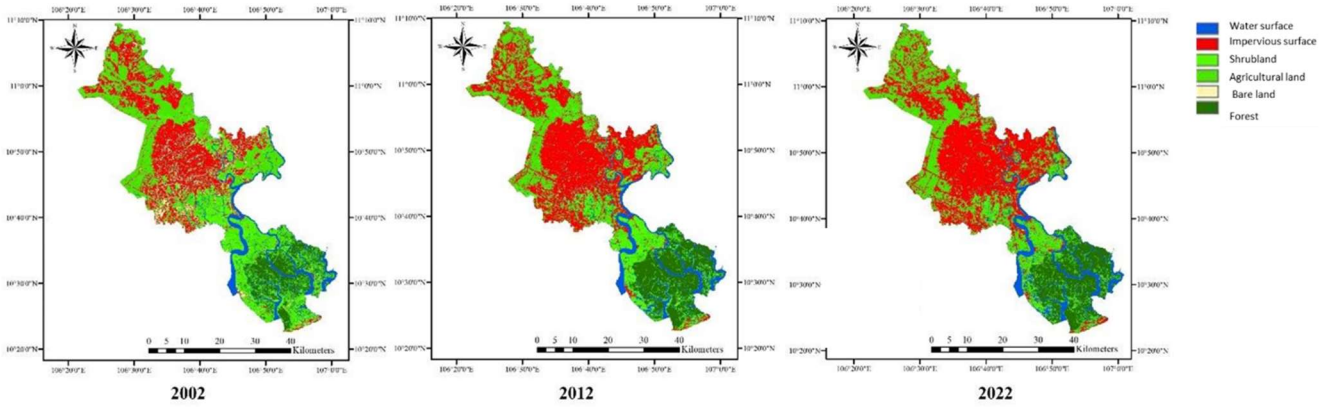
Figure 2. Evolution of land use in Hanoi between 1990 and 2020.



Source: Modified from Tuan Tran Nguyen (2024) [163].

Figure 3. Land use evolution in Ho Chi Minh City from 2002 to 2022.

Source: Tung et al., (2023) [164]



Another key challenge is the limited inclusion of urban-specific metrics in national climate planning. While Vietnam has developed and regularly updated national climate change scenarios (e.g., MONRE, 2021) **Erreur ! Source du renvoi introuvable.**, these often do not disaggregate data by urban versus rural settings. Urban microclimates are still poorly characterized and important indicators such as Heat Index (HI) or Wet-Bulb Globe Temperature (WBGT), and urban-specific projections of extreme heat are generally absent. This limits the ability of city governments and sectoral agencies to assess exposure, plan responses, or prioritize interventions for heat resilience.

As highlighted in the review of Woillez (2024) [150] (see references therein), extreme heat already has significant negative impacts in Vietnam. In particular, several studies reveal a positive correlation between heatwaves and public health issues, including increased hospital admissions and a higher incidence of heat-related illnesses **Erreur ! Source du renvoi introuvable.**. This underscores the urgent need to understand and mitigate impacts of extreme urban heat in the context of climate change.

Objectives of the study

Vietnam's rapidly expanding cities are at the frontline of climate change. The convergence of UHI effects, rising background temperatures, poor urban ventilation, and limited adaptive capacity poses an increasingly urgent threat to public health, urban infrastructure, and social equity. Addressing these challenges requires enhanced monitoring, data disaggregation, localized urban climate scenarios, and the mainstreaming of heat mitigation into all levels of urban planning and policy.

In Vietnam, research on urban climate, particularly extreme heat events, has gained attention over the past two

decades, primarily using remote sensing and GIS methodologies. However, significant gaps remain in understanding the localized impacts of extreme heat and the effectiveness of adaptation measures **Erreur ! Source du renvoi introuvable.**. Existing studies, while valuable, lack comprehensive evaluations to guide policy implementation and urban planning.

Nonetheless, research efforts have significantly contributed to the development of legal frameworks and policy mechanisms aimed at mitigating the adverse impacts of urban heat and enhancing urban resilience. Vietnam has begun integrating urban climate considerations into national and local planning frameworks. Government initiatives such as the National Climate Change Adaptation Plan (2021–2030, updated in 2024) **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**, the National Climate Change Strategy to 2050 **Erreur ! Source du renvoi introuvable.**, and the Urban and Rural System Master Plan (2021–2030) **Erreur ! Source du renvoi introuvable.**, all include elements targeting extreme heat, green infrastructure, and smart urban development. The Ministry of Construction and Ministry of Health have also issued action plans and technical guidelines aimed at promoting climate-resilient cities **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**. However, while policy frameworks are evolving, many implementation gaps remain.

In this context, this study aims to address these gaps by conducting a thorough review of scientific literature and grey sources in both English and Vietnamese in order to:

- Assess the current state of knowledge on extreme heat in urban areas and related impacts and vulnerability in Vietnam across disciplines, including meteorology, public health, urban planning, and environmental governance.
- Review current adaptation and mitigation strategies, including legal frameworks, green infrastructure efforts, early warning systems, and public awareness campaigns.
- Assess the level of awareness of population and decision makers of the risks posed by extreme heat.

By synthesizing current research and identifying critical knowledge gaps, this review aims to inform policy decisions and support the development of effective strategies to mitigate the impacts of extreme heat in Vietnam's rapidly urbanizing cities. Based on the findings of the review, we provide recommendations for strengthening urban resilience to extreme heat, with a focus on interdisciplinary research, data-driven planning, and policy integration.

The methodology is presented in Section 1 and the results in Section 2. We discuss the findings in Section 3, and present the main conclusions and recommendations in Section 4.

1. Methodology

1.1. Systematic literature review

To conduct this study, we organized a systematic search for relevant literature. The selection process followed PRISMA guidelines, ensuring transparency in document screening. To capture a broad scope of evidence, we collected documents from three main sources of evidence:

(i) peer-reviewed scientific articles (both English and Vietnamese);
(ii) policy documents, legal frameworks, and strategic reports from central and local governmental agencies;
(iii) institutional reports and grey literature related to urban heat adaptation and mitigation.

Collected documents were categorized based on thematic relevance, covering legal frameworks, policy reports, meteorological studies, and public health assessments related to extreme heat in urban Vietnam. A PRISMA flowchart (Figure 4) was developed to illustrate the document selection process and the reasons for exclusion, ensuring the reproducibility and transparency of the review. The selection process followed three stages: 1) identification and collection; 2) screening and inclusion.

1.1.1. Step 1: Identification and collection

For peer-reviewed scientific articles and institutional reports published in academic or professional outlets, we performed database searches in PubMed, Web of Science, Embase, CINAHL, and Google Scholar. Search queries were applied to the titles, abstracts, and keywords, using a combination of key terms and Boolean operators. The search terms include: “extreme urban heat”, “urban heat island”, “urban areas”, “heat risk assessment”, “urban vulnerability”, “population exposure”, “adaptation strategies”, “heatwave impacts”, “heat stress”, “city”, “urban area”, “urban climate”, “public health”, “Hanoi”, “Ho Chi Minh City”,

and “high temperature”. To ensure comprehensive coverage, the identification of Vietnamese-language studies involved a structured keyword search using Vietnamese equivalents of key terms, complemented by manual screening of domestic academic journals and institutional or provincial repositories to ensure comprehensive coverage. The search was restricted to publications between January 2008 and February 2025. This timeframe was selected to reflect the period of active climate policy implementation and research following the launch of Vietnam’s National Target Program to Respond to Climate Change (NTP-RCC).

Legal documents, policy mechanisms, institutional frameworks, strategies, plans, programs, and strategic reports/documents, official materials were not collected through academic databases but retrieved through manual searches from the official websites and repositories of governmental bodies, as well as directly from internal archives where applicable. The main governmental sources included the Ministry of Natural Resources and Environment (MONRE), the Ministry of Construction (MOC), the Ministry of Health (MOH), the Viet Nam Meteorological and Hydrological Administration (VNMHA), and the National Centre for Hydro-Meteorological Forecasting (NCHMF). Data from local authorities and previous studies conducted by the Viet Nam Institute of Meteorology, Hydrology, and Climate Change (IMHEN) were also included. These materials encompassed documents, reports on extreme heat and heatwaves, and records of high-temperature events in urban areas, etc.

All collected documents (full papers) were stored and managed using Microsoft Excel, with metadata fields including title, keywords, abstract, publication year, issues addressed, methods, and key findings to facilitate data organization and retrieval. The Covidence platform was used separately for English and Vietnamese articles. This platform facilitates the systematic review process by managing and tracking article screening, ensuring consistency and transparency across both language groups.

To facilitate thematic analysis, the collected documents were categorized into three main groups, then divided into subgroups (as shown in Figure 4):

- ***Legal Documents***

The group of legal documents, policy mechanisms, strategies, plans, and strategic reports/documents, as well as strategic or official reports from institutional bodies, are collectively referred to as Legal Documents related to Extreme Urban (Heat – LD_EUH) in the forthcoming sections. LD_EUH includes documents directly referencing the keywords “extreme urban heat” and “urban heat island”. We categorized them into three main subgroups:

i) Legal documents, including laws, circulars, decrees, national technical regulations (QCVN), Vietnamese standards (TCVN), and guidance documents;
ii) Policy mechanisms, strategies, plans, and urban planning, encompassing policy frameworks, strategic plans, and urban development guidelines;
iii) Strategic reports/documents from central to local agencies, including official reports and other documentation produced by government bodies at both central and local levels.

For the category *strategic reports/documents*, further subgroups were created based on thematic relevance: related to climate change and hydrometeorology, construction sector, and health sector.

- ***Scientific articles and books in Vietnamese and English***

For the analysis, we separated the scientific literature in Vietnamese and the literature in English. The documents in each category were then classified into five thematic groups:

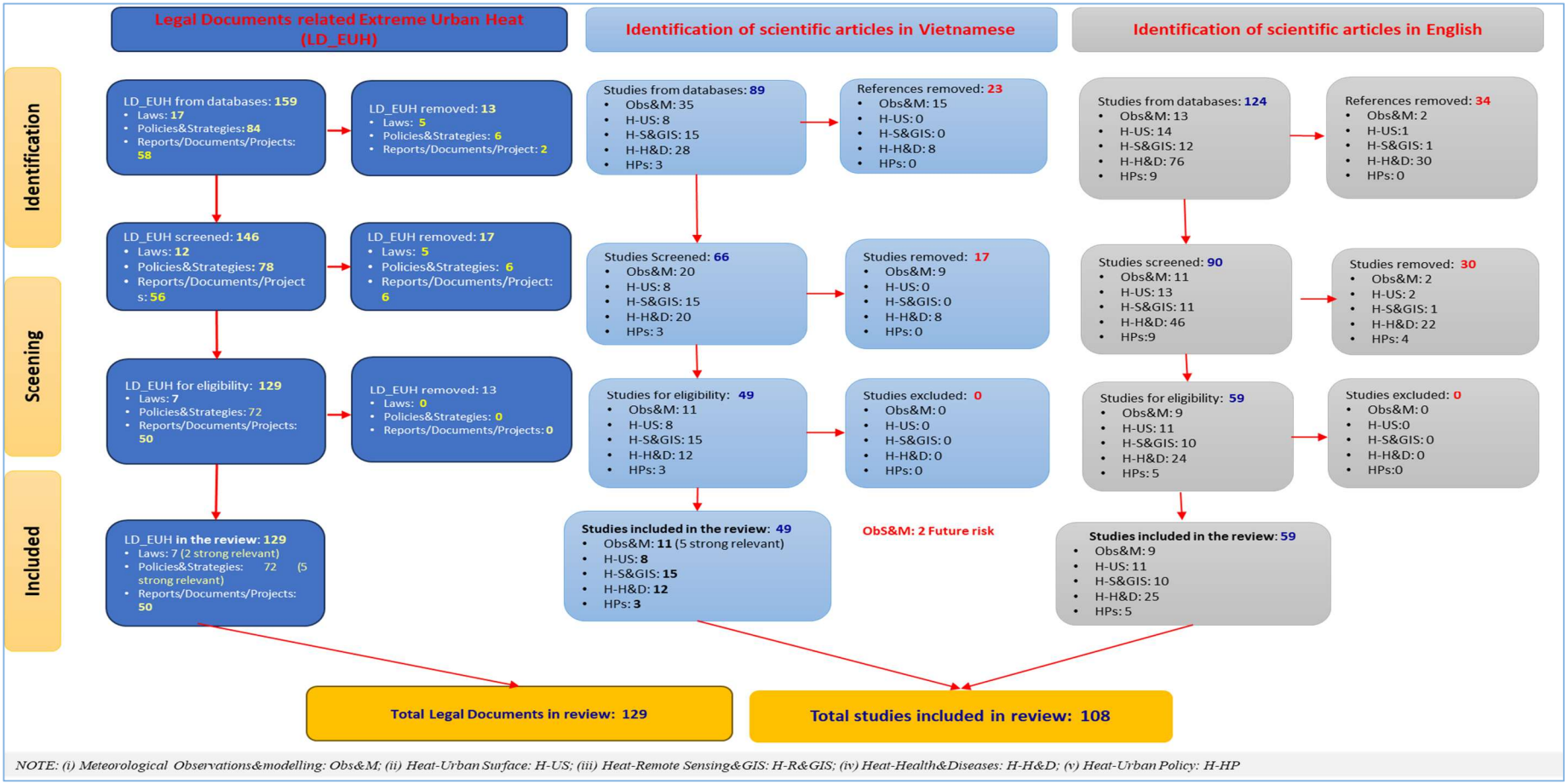
i) **Meteorological Observation & Modeling** (Obs&M), including studies based on meteorological observation data from hydrometeorological stations and numerical modeling, typically conducted by meteorologists;
i) **Heat - Urban Surface** (H-US), covering research on local factors such as housing, green spaces, parks, lakes, urban planning and their interactions with urban climate and heatwaves. These studies are usually conducted by meteorologists and construction experts;
ii) **Heat – Remote Sensing & GIS** (H-R&GIS), comprising studies using remote sensing data and GIS technology to investigate urban climate and heatwaves, typically conducted by meteorologists, environmental scientists, and geographers;
iii) **Heat-Health & Diseases** (H-H&D), encompassing studies on public health and diseases related to urban climate and heatwaves. Such research is typically conducted by health and public health experts, often in collaboration with meteorologists, geographers, and environmental scientists;
iv) **Heat-Policies** (H&P), including reviews and policy analyses on responses to heatwaves and high temperatures in urban areas in Vietnam.

1.1.2. Step 2: screening and inclusion

In the screening stage, titles and abstracts (or executive summaries for policy/legal documents) were first reviewed for relevance. Full-text reviews were then conducted to assess alignment with the research focus. For Vietnamese-language studies, only those with explicit reference to urban settings — such as city-level temperature trends, urban heat

islands, or heat-related vulnerability — were retained. Broader studies without disaggregated urban data were excluded.

Figure 4. Flowchart of selection of legal documents and scientific articles.



Source: Authors's own elaboration.

During the screening process, documents were included for a full-text review if they met at least one of the following criteria:

(i) addressed extreme heat, heatwaves, or urban heat island (UHI) effects;
(ii) focused on urban areas in Vietnam, unless explicitly linked to urban heat or heat stress;
(iii) discussed relevant aspects such as exposure, vulnerability, health or economic impacts, urban anthropogenic drivers, adaptation/mitigation strategies, or policies;
(iv) were full-text accessible in scientific, policy, or technical formats.

We excluded irrelevant documents, such as:

- studies focused exclusively on indoor thermal environments;
- documents addressing climate hazards other than extreme heat, such as floods, heavy rainfall, tropical storms, or typhoons, unless they explicitly addressed their interaction with urban heat or heat stress;
- laboratory-based studies where temperature variables were artificially controlled and did not reflect real-world urban climate dynamics;
- non-research content such as editorials, comments, letters to the editor, opinion pieces, and introductions;
- documents without full-text access;
- documents that were not focused on urban settings, including those addressing rural or regional contexts without urban relevance;
- duplicates and outdated documents.

1.2. Data collection from Media sources

To examine political and community engagement with heatwaves and climate extremes in urban Vietnam, we completed our review of the LD_EUH documents by a systematic media analysis using web data scraping tools. We used the methods outlined in the Lancet Countdown 2021 [167] for tracking down the progress of two heat-health indicators in cities. A predefined set of keywords related to heatwaves and urban environments was utilized to identify relevant media publications. These keywords included both English and Vietnamese terms, such as: “heatwave”, “extreme heat”, “urban heat”, “urban heat island”, “high temperature”, “climate change and health”, “urban climate risks”, “heat-related illness”, “heat stress”, “heatwave early warning”, “Vietnam urban heat”, as well as “nắng nóng đô thị”, “nắng nóng cực đoan”, “sóng nhiệt”, “biến đổi khí hậu và sức khỏe”, “ứng phó nắng nóng”, “bệnh liên

quan đến nắng nóng", "cảnh báo sớm sóng nhiệt". Only media sources containing these search terms were included in the analysis to reduce irrelevant content and ensure thematic consistency. This methodology enabled the capture of a comprehensive range of public discourse and institutional responses to urban heat stress.

1.3. Information retrieval, analysis and synthesis

This section describes the process of retrieving information from the selected documents, as well as the subsequent analysis and synthesis of the extracted data and critical assessments. Relevant information was synthesized using a mixed-methods approach combining qualitative and quantitative analyses.

1.3.1. General approach

Descriptive analyses were conducted to examine trends and distributions within the included studies. The results of this analysis were visualized through charts and maps to facilitate the identification of patterns. In addition, a narrative synthesis method was applied to qualitatively analyze the data [160]. The narrative synthesis followed a three-step approach. First, a preliminary synthesis was developed by grouping studies according to thematic areas, summarizing study characteristics and identifying research topics. Second, relationships within the data were explored by analyzing the consistency and differences in findings across studies and investigating potential factors that may explain contradictory findings. Finally, the reliability of the synthesis was assessed by evaluating the strengths and limitations of the evidence base.

The quality of the included studies was evaluated using a framework based on the Mixed Methods Appraisal Tool (MMAT), which allows for the assessment of qualitative, quantitative, and mixed-methods studies [154]. The assessment of the included articles was conducted systematically and verified to ensure consistency and accuracy.

1.3.2. Specificity for policy documents

Policy documents were systematically reviewed to compile a comprehensive inventory of regulations and guidelines addressing urban heatwaves and high temperatures. This review included an assessment of key strategies and action plans, as well as expert consultations to identify barriers and propose actionable recommendations. Experts from the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Agriculture and Rural Development (MARD) – now the Ministry of Agriculture and Environment (MAE) – with domain-specific knowledge on urban climate and climate change adaptation were engaged to identify barriers to effective policy execution and to propose actionable

recommendations for improving the governance and implementation of heatwave-related policies. This multi-method approach facilitated a comprehensive analysis of media narratives and formal policy frameworks, offering a holistic understanding of urban heat resilience in Vietnam.

2. Results

2.1. Overview of legal documents and scientific articles

The collection and analysis of 372 documents, comprising full texts in both Vietnamese and English, provide a comprehensive foundation for understanding the current state of research and policy frameworks related to extreme urban heat in Vietnam. As detailed in section 1.1, this dataset is divided into three primary groups: Legal Documents related to Extreme Urban Heat (LD_EUH), Vietnamese-language scientific articles, and English-language scientific articles, reflecting the interdisciplinary approach required to address urban heatwaves challenges.

2.1.1. Legal documents in Vietnamese (LD_EUH)

A total of 159 documents related to legal frameworks, policy mechanisms, strategies, plans, and institutional reports from central to local levels were collected and 146 entered the screening phase. This dataset includes:

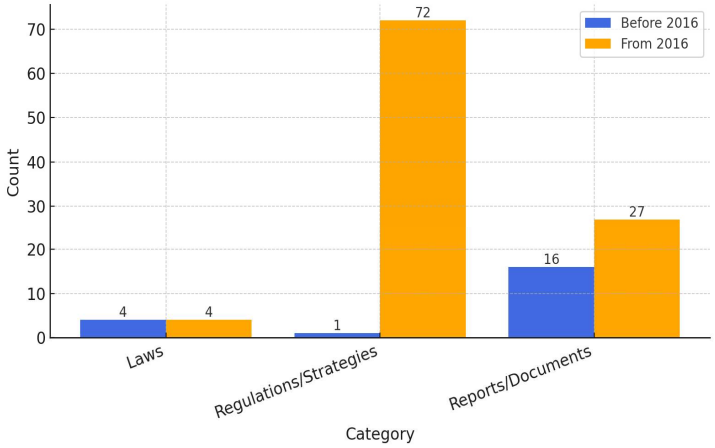
- 7 laws directly related to climate adaptation and urban heat mitigation [1][2][3][4][5][6][7], but only 2 laws explicitly mention or enable action related to urban heat risk;
- 9 key policy documents [9] [10] [11] [12] [13] [14] [15] [16] [17], including the “National Climate Change Adaptation Plan for 2021–2030" and the Action Plan of the Construction Sector to Respond to Climate Change (2022–2030);
- 63 climate change action plans for the period 2021-2030, with a vision to 2050 issued by all provinces and cities in Vietnam [8] – while comprehensive, these plans mainly address general climate change issues and most do not detail urban heat mitigation or adaptation strategies;
- 14 annual hydrometeorological condition reports from the VNMHA (from 2011 to 2024) [28]; 14 annual climate condition reports from IMHEN (from 2011 to 2024) [30];
- 14 reports related to hydrometeorology and climate change [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31];
- 7 reports related to construction [32] [33] [34] [35] [36] [37] [38];
- 3 reports related to healthcare [39] [40] [41].

Most of these documents have been officially applied to support state management and climate governance activities. Their inclusion reflects both their technical relevance and their operational role in Vietnam’s institutional response to urban climate risks. Notably, one

ongoing project led by the Ministry of Health (MOH) is developing a national technical report on the health impacts of climate change. While the report addresses multiple climate hazards, it includes a dedicated analytical section on extreme heat stress in urban populations, supported by preliminary climate-health modeling. This section is directly relevant to our review and offers important insights into emerging adaptation planning in Vietnam's health sector. The report for the MOH project is still under implementation and is expected to be completed by 2027 [41].

There is a substantial increase regulation and strategic documents as well as in official reports/documents after 2016 (Figure 5). This trend aligns with Vietnam's commitment to addressing climate change, particularly following its participation in the Paris Agreement, with contributions from the 63 climate change action plans of all provinces/cities.

Figure 5. Total number of legal documents (LD_EUH) issued before and after 2016, by category.



Source: Authors' own elaboration.

The number of policy and strategic documents rose from 16 before 2016 to 72 after 2016, reflecting growing institutional attention to climate adaptation. However, it is important to emphasize that urban extreme heat remains a marginal focus within these strategies. Most documents focus broadly on climate change or disaster risk reduction, without specific provisions on extreme heat in urban contexts. The number of reports and technical documents also increased from 16 (before 2016) to 27 (after 2016) — a 68.75% growth — signaling a stronger focus on scientific assessments and practical tools. Yet, only a limited subset addresses urban climate change in detail or includes projections of heat indices such as Heat Index (HI) or Wet-Bulb Globe Temperature (WBGT).

Despite this institutional progress, Vietnam's legal framework for extreme urban heat remains fragmented and limited in scope. The total number of national laws remained

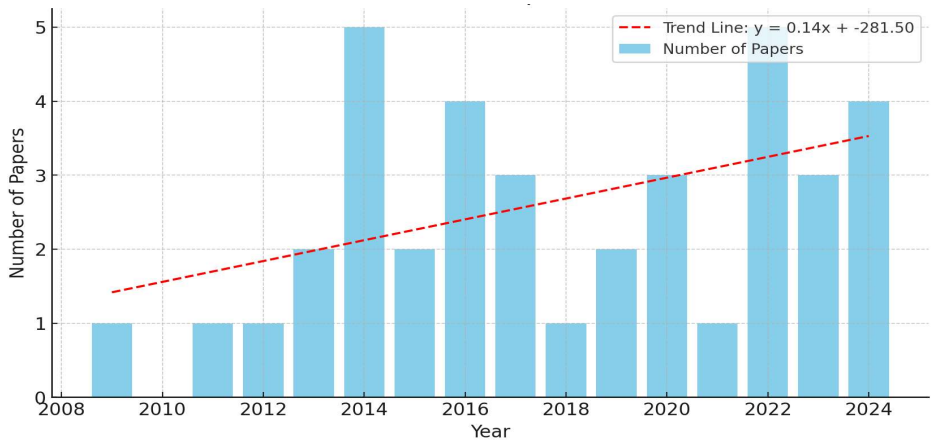
unchanged (4 laws before and after 2016), and no major legal reform has been introduced that specifically addresses urban heat mitigation or mandates actionable heat-resilience measures. This highlights a policy gap between climate adaptation rhetoric and concrete legal provisions targeting extreme heat in urban areas.

2.1.2. Scientific publications in Vietnamese

We collected 89 Vietnamese-language scientific articles, of which 49 were selected for inclusion based on their relevance to the topic of urban extreme heat in Vietnam. These studies either explicitly focused on urban areas or included disaggregated urban-level data and analysis.

Geographically, the distribution of city-specific studies is as follows: 17 studies focused on Hanoi; 7 studies focused on Ho Chi Minh City; 25 studies analyzed heat-related phenomena in other cities, including Thừa Thiên Huế, Thanh Hóa, Vinh (Nghệ An), Thái Nguyên, and Bắc Ninh. Additionally, several studies examined urban heat dynamics at a regional level, such as across the Mekong Delta, the Central Coast, or the Red River Delta, incorporating urban heat indicators applicable to multiple cities within those regions. This distribution underscores that while Vietnam's two largest urban centers — Hanoi and Ho Chi Minh City — receive the most research attention, empirical studies on smaller and mid-sized cities are emerging, though still limited in number.

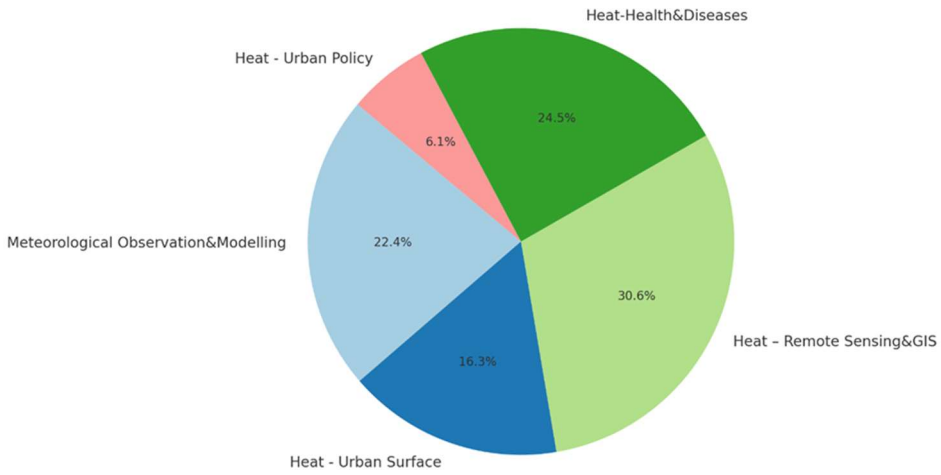
Figure 6. Evolution of the total number of scientific publications in Vietnamese investigating urban heat-related issues in Vietnam, from 2008 to 2024.



Source: Authors' own elaboration.

The increasing number of scientific articles addressing urban heatwaves and extreme heat in Vietnam in recent years (Figure 6) underscores the growing recognition of this critical issue within the academic and research community. This trend reflects the escalating concerns about the impacts of climate change and urbanization on urban thermal environments in Vietnam and indicates a policy-driven push for more scientific investigation and institutional engagement on urban heat issues. Despite the increasing trend, the number of papers fluctuates significantly annually, with low outputs (1 paper/year) during 2008–2012 and in 2018 and 2021.

Figure 7. Percentage distribution of scientific publication in Vietnamese by topics.



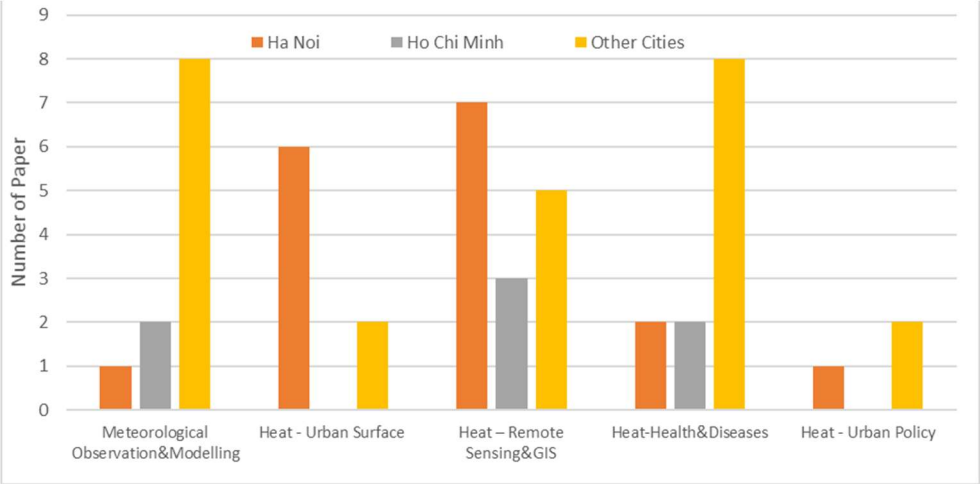
Note: Total number of articles: 49. Source: Authors' own elaboration.

The distribution of articles by topic (Figure 7) highlights the diverse focus areas within the field. Notably, the H-R&GIS topic accounts for the largest proportion (30.6%), indicating a strong emphasis on leveraging advanced geospatial technologies to study urban heat dynamics. The prominence of this category suggests the importance of advanced data collection and spatial analysis in understanding urban thermal environments and their spatial variability. This is followed by H-H&D at 24.5%, reflecting substantial research interest in the public health implications of urban heat, including the effects of elevated temperatures on human morbidity and mortality. The focus on this area underscores the increasing concern regarding the health risks associated with UHIs and the necessity for interdisciplinary approaches to mitigate health-related impacts. The Obs&M and H-US topics represent 22.4% and 16.3% of the articles, respectively, demonstrating a balanced interest in both observational data and the role of urban surface characteristics in heatwave formation. However, the H-UP (Heat-Urban Policies) category constitutes only 6.1% of the articles. This indicates a limited research focus on policy-driven solutions despite their crucial role in addressing urban heat challenges. The relatively low representation suggests

a relative gap in policy-oriented research, which is critical for translating scientific findings into actionable strategies, highlighting the need for increased collaboration between researchers and policymakers to translate scientific findings into actionable urban heat mitigation policies.

As mentioned above, the research is geographically concentrated primarily in Hanoi (17 articles) and Ho Chi Minh City (7 articles), highlighting a disproportionate focus on Vietnam's two largest cities (Figure 8). This disparity may reflect differences in research capacity, funding availability, or the perceived urgency of addressing heat-related challenges in these two megacities. Hanoi has a strong emphasis on urban surface and remote sensing & GIS related heat studies, while "Other cities" show a pronounced focus on meteorological modelling and health-related heat impacts. Ho Chi Minh City consistently has fewer contributions across all topics. This regional also imbalance suggests a critical research gap in Ho Chi Minh city and other urban areas, which are increasingly vulnerable to the impacts of extreme heat but remain underrepresented in the literature.

Figure 8. Scientific publications in Vietnamese by city and topic.



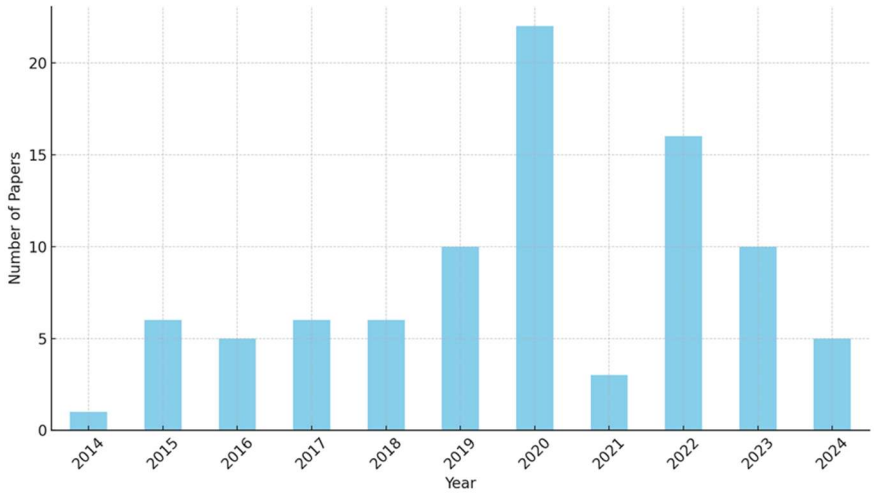
Source: Authors' own elaboration.

In general, while the increasing volume of research on urban heatwaves in Vietnam is encouraging, the findings highlight the need for a more balanced distribution of research topics and geographic focus. Greater emphasis on policy-oriented studies (heat-related policies) and expanded research efforts in Ho Chi Minh City could enhance the comprehensiveness and applicability of scientific findings to address urban heat challenges across Vietnam.

2.1.3. Scientific publications in English

A total of 123 English-language scientific articles were collected, of which 59 were deemed relevant to the study. The number of English-language articles, as illustrated in Figure 9, shows that urban heatwaves in Vietnam have gained attention in international journals. However there are important annual fluctuations, with more than 20 articles in 2020 but only 5 articles in 2024, and no clear sustained trend on the topic over the past decade.

Figure 9. Total number of scientific publications on urban-heat related issues in Vietnam, in English, from 2014 to 2024.



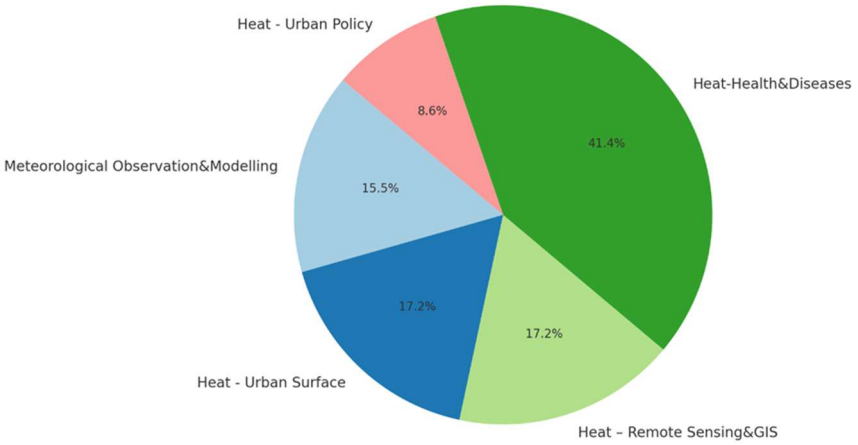
Source: Authors' own elaboration.

Similar to the Vietnamese corpus, these studies encompass five major thematic areas, with a notable emphasis on public health impacts (Figure 10):

- Meteorological Observation & Modeling (Obs&M) – 15.3%,
- Heat - Urban Surface (H-US) – 17%,
- Heat – Remote Sensing & GIS (H-R&GIS) – 16.9%,
- Heat-Health & Diseases (H-H&D) – 41%,
- Heat-Urban Policies (H-UP) – 8.6%,

The relatively balanced distribution of articles across the Obs&M, H-US, and H-R&GIS topics demonstrates a multidisciplinary approach to understanding urban heat dynamics. However, the H-UP category remains underrepresented, indicating a gap in policy-oriented research that could bridge scientific findings with actionable strategies.

Figure 10. Percentage distribution of scientific publications in English, by topics.



Note: Total number of articles: 59. Source: Authors' own elaboration.

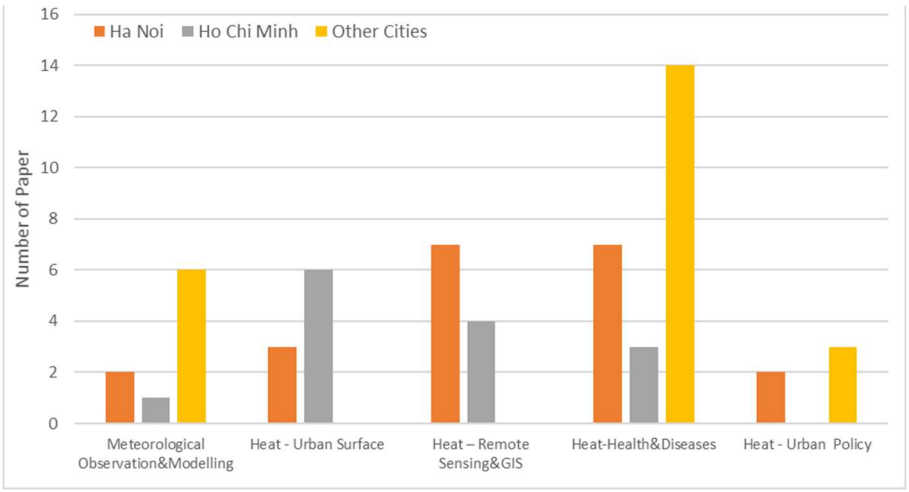
Geographically, the distribution of studies across cities (Figure 11) reveals that while Hanoi and Ho Chi Minh City are prominent research foci, a substantial proportion of studies (44.5%) are conducted in other cities or address general trends across Vietnam. This broader geographic coverage is particularly evident in the H-H&D category, where 19 out of 24 articles focus on other cities, with a notable concentration in the Mekong Delta region. This regional focus likely reflects the vulnerability of the Mekong Delta to climate extremes and its significance as a hotspot for heat-related health studies.

In contrast, research on Obs&M and H-R&GIS topics is more concentrated in Hanoi and Ho Chi Minh City, likely due to the availability of meteorological infrastructure and data in these megacities. The limited number of studies on H-US and H-UP topics in Ho Chi Minh City, compared to Hanoi, suggests potential gaps in research capacity or focus in the southern metropolis.

In general, the increasing volume of English-language research on urban heatwaves in Vietnam is encouraging; the findings highlight the need for a more balanced distribution of research topics and geographic focus. Greater emphasis on policy-oriented studies (H-UP) and expanded research efforts in underrepresented regions, such as Ho Chi Minh City and other urban areas, could enhance the comprehensiveness and applicability of scientific findings. Additionally, the strong focus on health impacts (H-H&D) underscores the urgency of addressing the public health dimensions of urban heat, particularly in vulnerable regions like the Mekong Delta. The geographical concentration of studies in Hanoi and Ho Chi Minh City overlooks the needs of other urban areas, and the limited attention to policy-oriented

research (6.1% in Vietnamese and 8.6% in English) constrains the development of holistic adaptation strategies.

Figure 11. Scientific publications in English, by city and topic.



Source: Authors' own elaboration.

2.2. Meteorological observations and modeling studies (Obs&M)

The analysis of 20 Obs&M studies (11 in Vietnamese and 9 in English) highlights a focus on quantifying extreme heat events. However, only half of these studies specifically address urban heat, with the remainder examining broader regional scales. Although all included studies provided relevant data on urban heat, the limited number of studies with a dedicated urban-scale focus constrains the development of localized adaptation strategies that are crucial to strengthen urban heat resilience in Vietnam's cities.

Geographically, 10 articles focused on urban areas are unevenly distributed, with 3 studies conducted in Hanoi, 3 in Ho Chi Minh City, and 4 in other cities. This distribution suggests that while some attention has been given to Vietnam's two largest megacities, research in other urban areas remains limited. Furthermore, the majority of these studies have concentrated on calculating and analyzing extreme urban heat [42][46][47][48][52][92][93][94][98]. Only two studies investigated future risks of extreme urban heat under climate change scenarios: one in Ho Chi Minh City [102], and another in Hanoi, which assessed the impacts of both global warming and land use changes projected under the Hanoi Master Plan 2030 [108]. One more study investigating the annual average temperature for Ho Chi Minh City, with a warning about extreme heat [91].

The two studies that address future risks of extreme heat under climate change at the national level [49][50] provide a broader perspective but do not offer the granularity needed for localized urban planning and adaptation strategies. This underscores the importance of developing city-specific climate change scenarios and risk assessments, particularly for rapidly urbanizing areas like Ho Chi Minh City.

2.3. Heat-Urban surface studies (H-US)

The analysis of 18 studies classified in the Heat - Urban Surface (H-US) category (8 in Vietnamese and 10 in English) provides valuable insights into the relationship between urban development and extreme urban heat in Vietnam's two largest megacities, Hanoi and Ho Chi Minh City. These studies collectively highlight the significant role of urbanization and surface changes in exacerbating extreme urban heat and urban heat island (UHI) effects, while also identifying potential mitigation strategies.

The geographic focus of these studies is heavily concentrated on Hanoi and Ho Chi Minh City, with most Vietnamese-language studies conducted in Hanoi and a majority of English-language studies focusing on Ho Chi Minh City. This reflects the prominence of these cities as research hubs and their status as rapidly urbanizing areas facing significant heat-related challenges. Among the studies, 8 specifically address urban heat islands (UHI), while 15 focus on extreme urban heat, demonstrating a strong emphasis on understanding the drivers and impacts of heat extremes in urban environments.

A notable contribution of this research topic is the assessment of future urban climate risks based on the master plans of Hanoi and Ho Chi Minh City [56][106][109][110]. These studies provide critical insights into the potential impacts of urban expansion and climate change on extreme heat, offering valuable information for policymakers to integrate into urban planning processes. Particularly noteworthy are the studies by Doan Q.V. and colleagues at the University of Tsukuba, which used a high-resolution regional climate model (WRF) to evaluate the combined effects of urbanization and global warming on Ho Chi Minh City's urban climate [101][102][103][104]. Their findings indicate that urbanization contributes significantly to increased urban temperature. By 2050, average monthly temperatures are projected to increase by 1.6-1.8°C under RCP4.5 scenario and by 2.0-2.2°C under RCP8.5 scenario, with future urbanization accounting for 10-30% and 10-20% of the total rise respectively. Furthermore, these studies explored mitigation strategies such as green roofs and thermal insulation. Their findings demonstrate that while such nature-based and technological solutions can contribute to reducing the UHI effect, their outdoor cooling impacts remain relatively limited in scale. For example, green roofs were estimated to reduce nighttime urban temperatures by approximately 0.25°C [101]. These results suggest

that such strategies, although beneficial, may only partially mitigate the magnitude of urban heat increases and should be integrated as part of a broader set of urban adaptation measures.

Studies using remote sensing and GIS technologies have clearly demonstrated the role of impervious surfaces, residential areas, and commercial buildings in elevating urban temperatures, while highlighting the cooling effects of green spaces such as parks and lakes [61] [62] [63] [64] [65] [66] [68] [69] [70] [72] [73] [74] [75] [111] [112] [113] [114] [115] [116] [117] [119] [120].

2.4. Heat-Remote sensing & GIS studies (H-RS&GIS)

The analysis of 25 scientific articles classified in the Heat - Remote Sensing & GIS (H-RS&GIS) category (15 in Vietnamese and 10 in English) highlights the critical role of advanced geospatial technologies in understanding the relationship between urban heatwaves, high temperatures, and urban surface development. This research direction has provided valuable tools and methodologies for extracting temperature data, mapping extreme urban heat, and evaluating the impacts of surface changes on urban heat islands (UHI).

Again, the geographic focus of these studies is predominantly on Vietnam's two largest megacities, Hanoi and Ho Chi Minh City, with 14 studies conducted in Hanoi and 7 in Ho Chi Minh City. This concentration reflects the availability of remote sensing data and the significant urbanization pressures in these cities, which exacerbate extreme heat and UHI effects. Among the studies, 12 focus on urban heat islands (mostly in English), while 13 address extreme urban heat, demonstrating a balanced emphasis on both phenomena.

A key contribution of this research direction is the development of technologies to extract temperature data from remote sensing information and create detailed maps of extreme urban heat. These tools have enabled researchers to identify spatial patterns of heat distribution within cities, revealing significant temperature variations. For instance, studies have shown that during typical heatwaves, the land surface temperature (LTS) difference between the hottest and coolest areas within Hanoi's inner city can reach up to 13°C [72]. Such findings underscore the localized nature of extreme heat and the importance of targeted interventions to mitigate its impacts.

Additionally, recent research has explored the potential of remote sensing for real-time monitoring of extreme urban heat and urban heat islands [67]. Although these studies have not yet implemented operational real-time monitoring systems, they highlight important technological pathways for improving data availability to support timely responses by urban planners and policymakers. .

However, the heavy focus on Hanoi and Ho Chi Minh City leaves other urban areas in Vietnam underrepresented in this research topic. Expanding the geographic scope to include secondary cities and rapidly urbanizing regions would provide a more comprehensive understanding of extreme heat dynamics across the country. Furthermore, while the studies have effectively mapped and monitored extreme heat, there is a need for more research on the socio-economic and health impacts of these phenomena, as well as the effectiveness of mitigation strategies.

2.5. Heat-Health and disease studies (H-H&D)

The reviewed literature highlights that extreme urban heat poses serious public health risks, particularly for vulnerable groups such as the elderly, children, people with pre-existing conditions, and outdoor workers. Studies consistently demonstrate that heat-related illnesses and mortality are strongly associated with high ambient temperatures in urban environments, where the heat island effect exacerbates exposure risks.

High temperatures in Vietnam already have diverse and far-reaching consequences of extreme heat on public health, particularly in urban areas, as highlighted in the review of Woillez (2024) (see references therein), which underscores the need for targeted interventions to mitigate these impacts. In particular, high temperature lead to increased hospitalizations for mental disorders, respiratory disease among young children and heat-related illness among outdoor workers in Hanoi. In Ho Chi Minh City, high temperatures are correlated with increased hospitalizations for cardiovascular diseases, as well as with increases in heat-related mortality risk. However, the positive correlation for cardiovascular, respiratory and mental diseases is not always statistically significant in other cities or Vietnamese regions, highlighting the need for more research to better understand health impact of extreme heat depending on the socio-economic situation of a city or a region.

In this study, the analysis of 36 scientific articles in the Heat-Health & Diseases (H-H&D) category (12 in Vietnamese and 24 in English) provides critical insights into the health impacts of extreme urban heat in Vietnam. These studies collectively highlight the significant and multifaceted risks posed by rising temperatures and heatwaves, particularly in urban areas.

The studies are broadly categorized into two sub-topics: (i) those addressing climate/urban climate-sensitive infectious diseases and extreme climate events in relation to health and diseases (in Vietnamese: [76][77][78][79][80][83][84][85][86] [87]; and in English: [121][126][130][133][134][135][136][139]), and (ii) those directly focusing on extreme urban heat-sensitive infectious diseases and the health impacts of extreme urban heat [122] [123] [124]

[126] [127] [128] [129] [131] [137] [138] [140] [143] [145] [146], with one study specifically examining urban heat islands (UHI) and their health implications [125]. This dual focus reflects the complex interplay between climate change, urbanization, and public health in Vietnam.

A key finding from these studies is the J-shaped relationship between temperatures and all-cause mortality, observed in two single-city studies [123] [124]. These studies indicate that high temperatures with a short lag (0–3 days) significantly increase the risk of all-cause mortality, with a threshold of approximately 29°C. This underscores the acute health risks posed by extreme heat, particularly during heatwaves. In contrast, studies on temperature-hospitalization relationships in multiple provinces/cities predominantly report linear effects, with every 1°C increase in average temperature raising the risk of all-cause hospitalizations by 1.1%–1.3% [125] [137]. Heatwaves were found to have a more pronounced impact on hospitalizations in northern Vietnam compared to the south (5.4% vs. 1.3%), likely due to differences in climate adaptation capacity and infrastructure [137].

The health impacts of extreme heat are particularly severe for vulnerable populations, including the elderly, children [121] [127] [129] [131] [138] [146], and outdoor workers [128]. Prolonged exposure to extreme heat has been linked to increased hospital admissions for cardiovascular and respiratory diseases, mental health disorders, and heat-related illnesses [121] [122] [123] [124] [125] [127] [128] [129] [131] [137] [138] [140] [143]. These risks are exacerbated by factors such as poor urban planning, high population density, and limited access to green spaces, which amplify the urban heat island (UHI) effect [125] [134].

In addition to these direct health impacts, extreme heat also plays a significant role in driving the dynamics of climate-sensitive infectious diseases, particularly dengue fever, in Vietnam. While extreme heat is often studied alongside other environmental and climatic factors, its impact on disease dynamics is consistently evident across multiple studies. Research on dengue fever outbreaks and forecasting demonstrates a clear correlation between high temperatures and increased dengue incidence, particularly during the rainy season and in regions with warm climates year-round. Urban areas, which experience higher temperatures due to the UHI effect, are particularly vulnerable to dengue outbreaks compared to rural areas. The evidence consistently shows that for every 1°C increase in temperature, dengue incidence rises by approximately 5% (range: 3–7.4%), a much higher sensitivity than the 0.4–2.5% increase reported for other infectious diseases [76][77][79][80][83][84][87][126] [135] [136][146]. This underscores the sensitivity of dengue transmission to temperature variations and highlights the need for targeted public health interventions to mitigate the impacts of extreme heat on disease dynamics. The combination of higher temperatures, increased population density, and inadequate urban planning creates an environment conducive to the proliferation of dengue vectors, such as

Aedes aegypti mosquitoes. Furthermore, the seasonal nature of dengue outbreaks, which peak during the rainy season, suggests that interventions should be tailored to address both temperature and precipitation patterns.

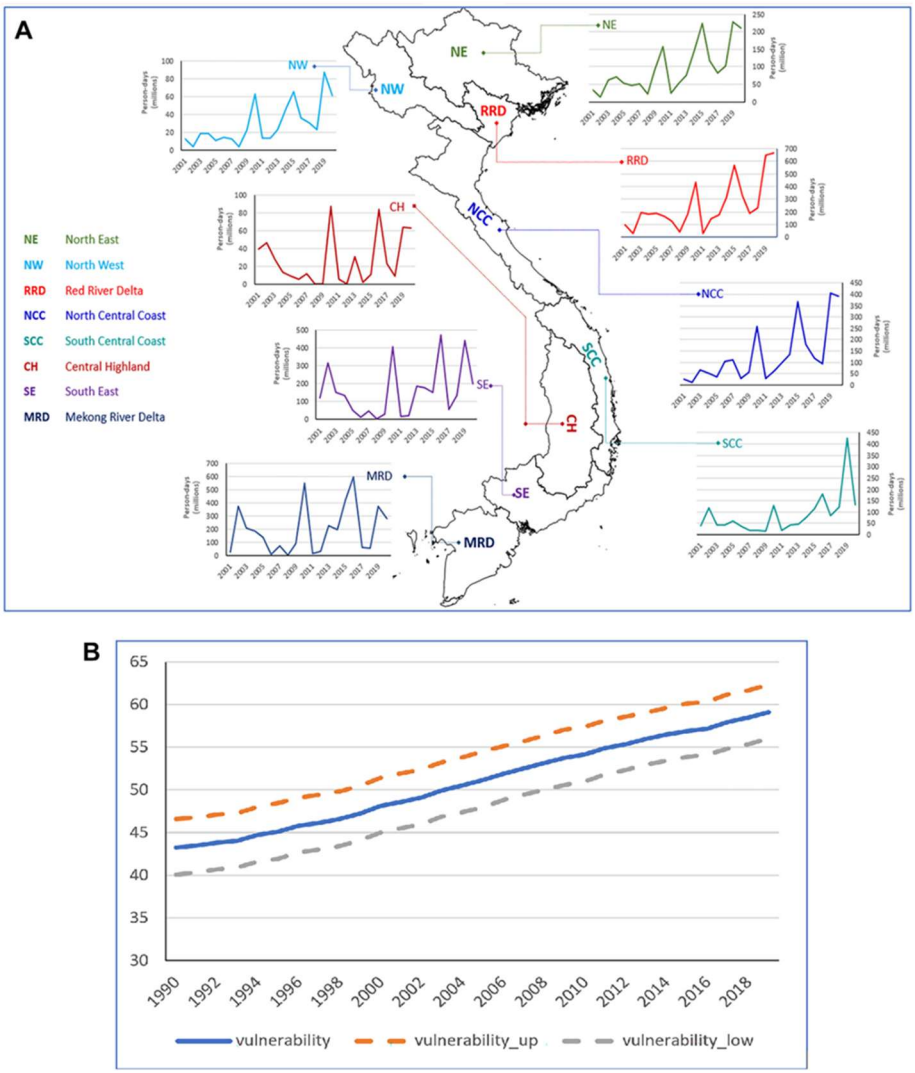
2.6. Issues of population exposure, impacts and vulnerability

This section provides a multi-dimensional framing of population vulnerability beyond individual-level health outcomes — incorporating spatial, socio-economic, and future risk dimensions that are essential to understanding urban heat impacts. It highlights the complexity of population-level vulnerability to heat, driven by both biophysical exposure and social determinants, and complements more detailed medical and modeling discussions presented in earlier sections.

The findings highlight the profound and multifaceted impacts of climate change and extreme urban heat on public health in Vietnam, particularly in the context of rapid urbanization and population growth. As analyzed in the Introduction, climate change is expected to accelerate in the 21st century [18][19][20][22], resulting in more frequent and severe heatwaves. These heatwaves, exacerbated by the UHI effect, pose significant risks to urban populations by increasing both daytime and nighttime temperatures, which generate cumulative thermal stress on the human body and elevate the risks of heat-related illness and mortality [171].

Tran et al. (2023) [134] conducted a comprehensive review of climate change and health in Vietnam. In addition to synthesizing existing studies, the research team also conducted supplementary analyses to quantify the health risks associated with high temperatures. Their findings provide further insights into heatwave exposure and vulnerability in Vietnam. The study revealed a steady increase in heatwave exposure person-days across all regions, with the Red River Delta experiencing the highest rise (29 million person-days per year) and the Northwest region recording the lowest increase (9 million person-days per year). Nationally, heatwave exposure increased by 200 million person-days from 2001 to 2020 (Figure 12A). The Heat Exposure Vulnerability Index (HEVI), which incorporates factors such as the elderly population, disease prevalence, and urbanization rates, shows an upward trend in Vietnam from 1990 to 2020, significantly exceeding global and WHO regional averages (Figure 12B) [134].

Figure 12. Exposure of the Vietnamese population to heatwaves.

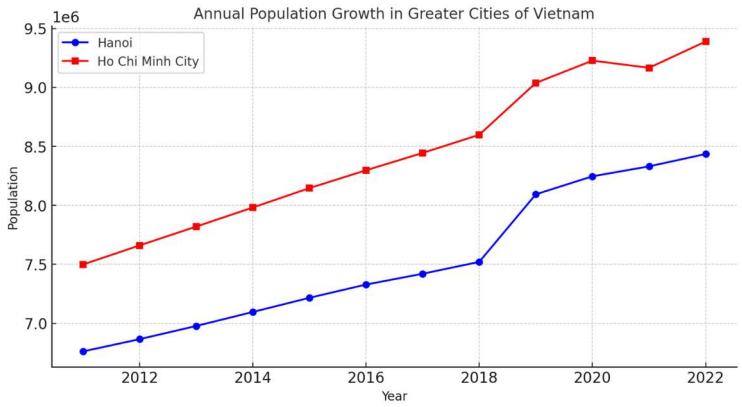


Notes: A) Exposure of populations to heatwaves (in person-days/year) across 8 ecological regions of Vietnam. B) Heat exposure vulnerability index for the Vietnamese population over 1990-2018. Source: Tran et al. (2023) [134].

Projections under climate change scenarios (RCP4.5 and RCP8.5) indicate that heat-related excess mortality in Vietnam could increase by 3–26% by the end of the century (2090–2099), depending on the climate scenario and assuming no adaptation or population changes [155]. Another study finds that heat-related excess mortality in Vietnam could rise by 10.34% per degree of regional warming [161]. Additionally, hospital admissions in the Mekong river delta could increase by 10,000 cases by 2100 in the most severely affected province [81]. These projections underscore the urgent need for targeted public health interventions and climate adaptation strategies.

The increasing exposure of Vietnam's urban populations to extreme heat will be further exacerbated by demographic growth and urban expansion. Between 2011 and 2022, Hanoi's population increased from 6.76 million to 8.43 million, while Ho Chi Minh City's population grew from 7.49 million to 9.39 million (Figure 13). Projections from the "Master Plan for Urban and Rural Systems for the Period 2021–2030, with a Vision to 2050" indicate that this trend will continue, with Hanoi's population expected to reach 10.2 million and Ho Chi Minh City's population projected to hit 12 million by 2030 **Erreur ! Source du renvoi introuvable.**. This rapid urbanization, coupled with an annual population growth rate of 3.37–4.13% during the 2025–2030 period, will place additional pressure on urban infrastructure, housing, and public health systems.

Figure 13. Evolution of the population (in million of inhabitants) in Ha Noi and Ho Chi Minh city.



Source: Authors' own elaboration, based on the population data from the General Statistics Office of Vietnam (GSO, 2025)

The implications of this population growth are profound. As urban areas expand, the replacement of natural surfaces with impervious materials will likely intensify the UHI effect, further increasing temperatures and exacerbating heat-related risks. The lack of adequate green infrastructure and cooling services in low-income neighborhoods will disproportionately affect vulnerable populations (elderly [137] [140], children [138] [82][131] [129], and outdoor workers [128]), leading to greater health disparities. High temperatures are associated with increased risks of respiratory and cardiovascular diseases, infectious diseases, kidney diseases, and mental health disorders [122][127][137][140] (see section 2.5). Factors such as population density, poverty rates, access to clean water and sanitation, and household income further influence the relationship between temperature and health, with southern provinces being more susceptible to heatwave impacts than northern regions [143].

From an economic perspective, exposure to extreme heat not only drives increasing healthcare costs due to higher hospitalization rates but also reduces labor productivity, especially in sectors such as construction and agriculture [173]. These economic impacts will strain both households and the broader economy. Additionally, they are compounded by social vulnerabilities, as low-income populations often reside in poorly ventilated, densely populated areas with limited access to cooling services **Erreur ! Source du renvoi introuvable.**. The combination of socio-economic, geographic, and health factors — such as an aging population, high prevalence of chronic diseases, and proximity to industrial zones — further exacerbates vulnerability to heat-related health issues **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**.

To mitigate these challenges, it is essential to integrate climate resilience into urban planning and development. Expanding green infrastructure, such as parks, green roofs, and tree-lined streets, can reduce heat absorption and improve air quality. Enhancing community awareness and preparedness for extreme weather events, along with implementing early warning systems, can help reduce population exposure and vulnerability. Furthermore, ensuring equitable access to resources, such as affordable housing with proper ventilation and cooling systems, must be prioritized to protect the most vulnerable populations.

2.7. Policy and community preparedness for extreme heat events

This section examines Vietnam's preparedness to address the growing risks of extreme heat through national and local policies, community engagement, and institutional responses. It highlights the evolution of legal frameworks and public awareness campaigns, identifies critical gaps, and emphasizes the need for a more integrated and strategic approach to extreme heat adaptation.

2.7.1. Awareness of populations

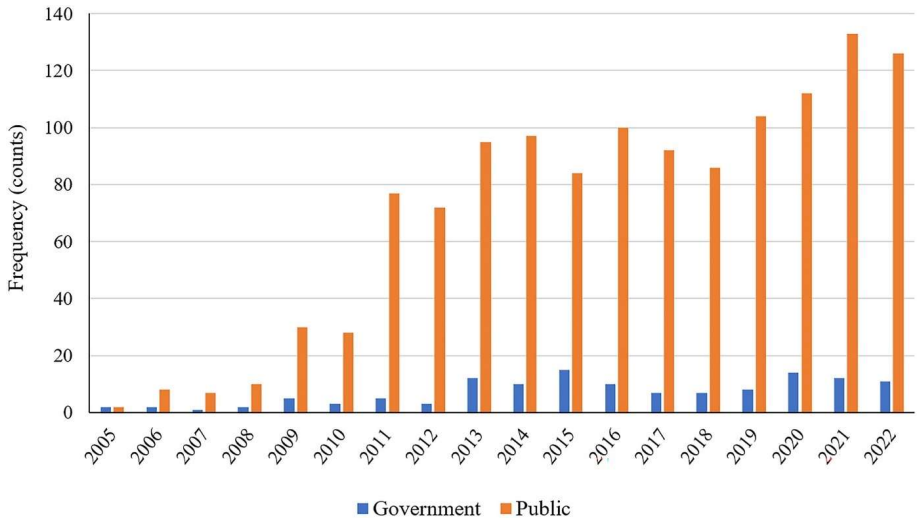
The findings highlight the critical role of awareness and communication in addressing the impacts of climate change, particularly extreme weather events, on vulnerable populations in Vietnam. Several studies have examined awareness and communication efforts targeting outdoor workers, slum dwellers, children, farmers, and other vulnerable groups [23][128][132][141]. While healthcare professionals demonstrate a high level of awareness about climate change adaptation, the general public remains inadequately prepared to respond to the adverse effects of extreme weather. This gap underscores the need for more

effective communication and education initiatives to enhance public understanding and preparedness.

Research by Lohrey et al. [128] emphasizes the strong demand for communication and education to raise awareness and improve responses to climate change impacts, particularly weather-related illnesses. Similarly, a survey by IMHEN and CARE (2021) revealed that many farmers struggle to read and understand hydrometeorological bulletins, highlighting the need for training and capacity-building to enable proactive responses to natural disasters [31]. These findings suggest that while there is a growing recognition of the importance of climate information, significant barriers remain in translating this knowledge into actionable responses.

The analysis by Tran et al. (2023) [134] of media coverage on the impacts of climate change on human health provides further insights into the role of communication in raising awareness. The study identified a total of 1,392 articles from 2005 to 2022, with 90.7% coming from public media and the remainder from government sources. Figure 14 illustrates a significant increase in coverage from 2008 (12 articles) to 2011 (82 articles), followed by relative stability with some annual fluctuations [134]. Notably, while government articles remained limited, public media coverage steadily increased, reflecting a growing public interest in climate change and its health impacts.

Figure 14. Frequency of media coverage on climate change and health covered in public media in Vietnam.



Source: Tran et al. (2023) [134]

Despite the increase in media coverage, the low number of government articles suggests a need for more proactive engagement from official sources to ensure accurate and consistent messaging. Public media, while valuable, may not always provide the depth or reliability required for effective climate communication. Strengthening collaboration between government agencies, media outlets, and community organizations could enhance the quality and reach of climate-related information.

From 2019 to 2024, the German Red Cross (GRC) collaborated with the Vietnam Red Cross Society (VRCS) to implement the "Forecast-Based Financing for Heatwaves" project. The GRC, in coordination with the Hanoi Red Cross and district-level Red Cross branches in Hanoi, conducted training sessions and disseminated information on heatwaves and their impacts on communities in various districts. They also deployed a heatwave early warning and forecasting system and established cooling shelters and water distribution points to help residents cope with extreme heat in eight districts of Hanoi (Figure 15). Through these activities, the GRC found that a lack of awareness about preventive measures can lead to a failure to take protective health actions during periods of high temperatures. For example, many residents living in areas lacking infrastructure such as shaded areas, cooling systems, or green spaces are more vulnerable to severe impacts during prolonged heatwaves. Additionally, the lack of information and effective communication campaigns contributes to this gap in awareness [23].

Figure 15. Red Cross members and volunteers during a heatwave in Hanoi (2020).



Note: Red Cross members and volunteers learn about the process of supporting heatwave prevention and response (left) and a cooling shelter providing water to residents during a heatwave in Hanoi in 2020 (right). Source: German Red Cross (2023).

In general, urban communities, particularly vulnerable groups such as the elderly, children, and outdoor workers, may not be fully aware of the impacts of extreme heat. This could be due to the lack of systematic training programs and knowledge dissemination to the community. Training programs are often conducted independently or in isolation as part of

project activities. In practice, when searching online using keywords such as "community awareness of heatwaves," "urban heatwaves," or "heatwave training," the results primarily consist of weather bulletins from meteorological agencies about heatwaves and information on heat-related diseases. However, training programs and materials on this issue remain very limited.

2.7.2. Awareness of decision makers

The efforts led by the MONRE, the Ministry of Construction (MOC), and other relevant agencies demonstrate a proactive approach to addressing climate change and its impacts, particularly in the context of urban heatwaves and high temperatures. MONRE's development and periodic updates of climate change scenarios in 2009 [18], 2012 [19], 2016 [20], and 2021 [22] provide a critical foundation for understanding and responding to climate risks. These scenarios, along with the compilation and assessment of climate risks and policy mechanisms for adaptation [22], offer valuable insights for policymakers and local authorities in planning and implementing climate resilience strategies.

The annual updates of heatwave and high-temperature datasets by the VNMHA [28] and the IMHEN [30] ensure that decision-makers have access to the latest information for risk analysis and response planning. The implementation of tools to support data provision and climate risk analysis [24][26][29], as well as the development of localized research reports on urban climate [26][27], further enhance the capacity to address climate challenges at both national and local levels. The NCHMF's bulletins on the impacts of weather on public health and urban heatwaves [29], along with IMHEN's pilot seasonal bulletins forecasting climate impacts on public health [25], represent important steps toward integrating climate information into public health planning and response.

However, these efforts remain at an early stage in terms of addressing urban heat in detail. Most reports do not include detailed projections of extreme temperature indices such as the Heat Index (HI) or Wet-Bulb Globe Temperature (WBGT). Urban heat exposure is often not consistently modeled or visualized, and detailed projections for urban microclimates are largely absent. Even in the most recent national climate change scenario released by the Ministry of Natural Resources and Environment (MONRE, 2021), urban climate change manifestations and urban-specific climate change scenarios are not yet addressed. Since 2023, IMHEN has been conducting assessments of urban climate and developing urban climate change scenarios, which are expected to be published in the next update of the national climate change scenarios planned for release at the end of 2025. Most reports address national or provincial levels, and urban heat exposure is not consistently modeled or visualized. This highlights a critical gap in current institutional assessments and the urgent

need for more detailed, urban-focused, and health-relevant climate metrics to inform urban planning and heat-health adaptation.

In the construction sector, the MOC has made significant contributions to climate-resilient urban planning. The development of indicators for climate-resilient urban areas [32], the establishment of a natural database (including heatwave data) [35], and the creation of a framework for urban-climate atlas development [33] provide essential tools for urban planners and policymakers. Additionally, the issuance of guidelines for energy efficiency in buildings [33] and the provision of a scientific basis for urban planning and development [38] underscore the importance of integrating climate resilience into infrastructure and urban design. However, the issue of UHI remains poorly integrated in in urban planning tools and infrastructure guidelines.

In the health sector, studies and reports on climate-sensitive infectious diseases [40][39], assessments of climate impacts on health and disease [39], and tools for dengue fever forecasting [41] highlight the growing recognition of the linkages between climate change and public health. These efforts are critical for developing targeted interventions to mitigate the health risks associated with extreme heat and other climate-related hazards.

Despite these efforts, as highlighted in Section 2.1, only a very small number of legal documents and national-level policies explicitly address extreme heat or urban heat islands. Most adaptation plans and technical guidelines focus on broader climate change risks without specifically targeting urban heat risk management. This indicates that while awareness among decision makers is improving, the legal and policy framework addressing extreme heat in urban areas remains fragmented and underdeveloped.

2.7.3. Current adaptation and mitigation strategies

The integration of high temperatures and heatwaves into Vietnam's legal documents and policy mechanisms reflects a growing recognition of the challenges posed by extreme heat in urban areas. However, the analysis reveals significant gaps and limitations in the current framework, highlighting the need for more comprehensive and targeted approaches to address these issues.

While legal documents related to urban development, hydrometeorology, and climate change mention heatwaves, their coverage remains limited. For instance, only two national building codes (issued in 2009 [2] and 2021 [6]) by the Ministry of Construction include specific data on high temperatures and heatwaves. These codes primarily focus on resilience to strong winds, earthquakes, and urban flooding, with minimal attention to heatwave

mitigation. This underscores the need for updated regulations and guidelines that explicitly address the design and implementation of construction projects to withstand extreme heat.

At the national level, the Prime Minister's issuance of the National Climate Change Adaptation Plan (2020 [11], updated in 2024 [17]) and the National Climate Change Strategy to 2050 (2022 [15]) represents significant progress. These plans and strategies include tasks and projects related to urban heatwaves and high temperatures, such as developing climate-resilient urban infrastructure and establishing disaster early warning systems. For instance, the National Adaptation Plan (NAP, 2024) includes a set of adaptation solutions for the urban and construction sectors. These include the development and retrofitting of infrastructure in urban areas, industrial zones, and coastal resettlement sites, with an emphasis on climate-resilient design and materials. Notably, the plan outlines tasks related to green infrastructure, heat-reflective building materials, and spatial planning strategies to mitigate urban heat island effects and the intensification of extreme heat events [17]. Similarly, the National Climate Change Strategy to 2050 [15] identifies reducing greenhouse gas emissions and mitigating urban heat islands as priority objectives. These policies reflect a shift toward more comprehensive urban climate adaptation, encompassing both biophysical risks (e.g., heatwaves) and social vulnerabilities.

However, the implementation of these initiatives remains uneven. For example, the Ministry of Construction's projects on urban development in response to climate change [9][12] have made strides in creating urban-climate atlases and integrating climate change considerations into urban planning. Yet, the urban-climate atlas has only been piloted in Ca Mau City [37], limiting its broader applicability. Preliminary assessments indicate that the pilot atlas includes general climate vulnerability maps but currently does not integrate mapped UHI layers or data-driven simulations of UHI intensity, which are essential for urban heat risk analysis and adaptation planning [37]. This highlights the need for scaling up successful pilot projects and ensuring that critical inputs, such as databases and urban-climate atlases, are developed for all urban areas. The Ministry of Health's "Climate Change Response Plan for the Health Sector for 2019–2030, with a Vision to 2050" [10] addresses the health impacts of climate change through programs focused on community awareness, early warning systems, and regional response models. However, the lack of systematic implementation of these measures, particularly in vulnerable regions like the Mekong Delta, remains a challenge. In addition, we identified a lack of mandated thresholds or early warning protocols for extreme urban heat, unlike existing systems for floods and typhoons.

Current adaptation and mitigation strategies, such as green infrastructure development, improved building and urban design, and heat action plans, have shown promise but face significant barriers. Significant challenges and risks arise from Vietnam's urbanization

trends, as outlined in the "Master Plan for Urban and Rural Systems for the Period 2021–2030, with a Vision to 2050". By 2030, the urbanization rate is expected to exceed 50%, reaching 70% by 2050, with the total number of urban areas nationwide projected to range from 1,000 to 1,200 **Erreur ! Source du renvoi introuvable.**. While the plan aims to allocate 16–26% of urban land for transportation and achieve 8–10 m² of green space per capita[1], the pressures of population growth and construction density may hinder these goals. Green infrastructure initiatives, while effective in mitigating UHI effects, are often deprioritized in high-density urban planning, despite the fact that these are the very areas most exposed to extreme heat risks due to impervious surface concentration and limited vegetation cover. In addition, the conversion of agricultural and natural land into residential and industrial areas not only exacerbates the UHI effect but also leads to biodiversity loss, land degradation, and increased environmental pollution.

Similarly, climate-responsive building designs and reflective surfaces are inconsistently implemented due to regulatory gaps and financial constraints. Heat action plans and early warning systems, though piloted in some areas, require stronger inter-agency coordination and technological advancements to enhance their coverage and effectiveness.

Nguyen et al. (2022) [89] identify several shortcomings in Vietnam's approach to urban climate challenges, including a lack of fundamental scientific research on urban climate, insufficient development of urban climate risk databases, and the absence of systematic implementation of climate change adaptation measures. Additionally, legal documents do not fully address urban climate extremes, and nature-based solutions have not been adequately considered.

[1] To meet this target of 8–10 m² of green space per capita by 2050, Vietnam would need approximately 560 to 700 km² of urban green space, i.e. around 4–6% of the projected total urban land area — a relatively modest ratio compared to international benchmarks. WHO for instance recommended the availability of a minimum of 9 m² of green space per individual with an ideal value of 50 m² per capita (cited in [177]).

3. Discussion

Our review reveals substantial progress in terms of policy recognition, scientific research, and pilot initiatives for coping with extreme heat in urban areas. However, the analysis also exposes critical limitations that must be addressed to enhance Vietnam's urban resilience to extreme heat in the context of climate change and rapid urbanization.

First, while urban heat has become an increasingly acknowledged issue in national and local strategies, most legal and planning documents remain general in scope and do not provide specific mechanisms or enforceable targets for heat risk mitigation. The absence of mandated indicators — such as minimum green space ratios, ventilation corridors, reflective surface standards, or localized UHI intensity thresholds — illustrates a disconnect between scientific evidence and operational policy tools. The review highlights that foundational efforts exist in the form of strategic plans and pilot projects, but these have not yet been translated into comprehensive or enforceable implementation pathways.

Second, the institutional landscape remains fragmented. Although sectoral strategies by the Ministry of Construction (MOC), Ministry of Health (MOH), and the newly merged Ministry of Agriculture and Environment (MAE) each acknowledge the issue of urban heat to some extent, there is no cross-sectoral coordination mechanism dedicated to urban heat governance. The lack of institutional integration significantly hampers the scaling of effective adaptation and mitigation measures. For example, climate-health research and early warning systems remain loosely linked with urban planning processes. Likewise, the potential for integrating high-resolution urban climate modeling into urban development planning remains underutilized.

Third, existing research tends to concentrate on Hanoi and Ho Chi Minh City, with limited attention to secondary cities where urbanization is accelerating. Although progress has been made in using remote sensing and GIS technologies to monitor UHI effects and surface changes, these efforts are often project-based and disconnected from long-term urban climate monitoring systems. There is a pressing need to expand the spatial and temporal scope of urban heat studies, including the assessment of socio-economic vulnerabilities and the health impacts of extreme heat in underrepresented regions.

Fourth, the analysis reveals a gap between awareness and action. While awareness among decision makers is improving, practical tools and institutional mandates remain insufficient to support the implementation of heat-resilient urban planning. Community awareness, although increasing through NGO and Red Cross initiatives, remains low among the general population, particularly among vulnerable groups such as the elderly, children, and informal

sector workers. Awareness-raising campaigns are not yet institutionalized or consistently implemented at scale.

Finally, although the Government of Vietnam has articulated a long-term vision for climate-resilient urban development through the "Master Plan for Urban and Rural Systems" and related strategies, operationalization remains weak. Projects such as the urban-climate atlas piloted in Ca Mau City or heatwave early warning systems in Hanoi demonstrate potential, but these need to be institutionalized, expanded, and supported through sustained investment and inter-agency collaboration.

It is important to note that this review, while comprehensive in its scope, remains primarily descriptive in nature due to the fragmented and heterogeneous characteristics of the existing literature. The integration across domains — such as meteorological science, health impacts, and policy instruments — remains limited, in part reflecting the siloed nature of current research efforts in Vietnam. Furthermore, secondary cities remain underrepresented in both scientific and policy analyses. These limitations underscore the need for future research to adopt more integrative, multi-sectoral approaches and to broaden geographical coverage, particularly to rapidly urbanizing mid-sized cities across the country.

4. Conclusions

4.1. Summary of the findings

This comprehensive review highlights the growing challenges posed by extreme heat in urban areas of Vietnam, particularly in the context of rapid urbanization and anthropogenic climate change. The findings underscore the urgent need for integrated strategies to mitigate the impacts of extreme heat, which are exacerbated by UHI effect and local anthropogenic factors such as inadequate infrastructure and high population density. Cities like Hanoi and Ho Chi Minh City are experiencing more frequent and intense heatwaves, with significant implications for public health, economic productivity, and urban sustainability.

Despite recent policy advancements and a growing body of research, Vietnam's current urban heat mitigation and adaptation strategies remain fragmented, and institutional responses lack the operational depth required for long-term resilience. A major gap persists in the legal and regulatory frameworks, which do not yet establish enforceable standards or measurable adaptation targets for urban heat. In practice, urban planning decisions often lack tools or guidelines to systematically evaluate or mitigate UHI impacts.

From a research perspective, the review identifies key contributions and gaps across major themes. Remote sensing and GIS applications (H-RS&GIS) have successfully mapped urban heat in major cities, yet research coverage in secondary cities remains limited. Integration with health and socio-economic indicators is needed to support policy decisions. Urban surface and design studies (H-US) reveal that mitigation strategies such as green roofs and reflective materials have localized cooling benefits, but their effectiveness is insufficient to counter projected climate warming. These measures must be part of broader urban planning and adaptation efforts. Health-related studies (H-H&D) consistently show strong links between extreme heat and increased morbidity, particularly among vulnerable groups.

As mentioned in Section 3, despite the strengths of our review in consolidating diverse sources of evidence and identifying critical knowledge and policy gaps, it remains primarily descriptive in nature. This reflects both the fragmented state of the existing literature and the time constraints of the study. The integration of findings across thematic domains (e.g., meteorology, health, and urban policy) remains limited. Additionally, the review is geographically skewed toward Hanoi and Ho Chi Minh City, with insufficient representation of secondary and emerging urban centers where heat risks are also intensifying. Therefore, future research should move toward more integrative, cross-sectoral analyses that link climatic, socio-economic, and health dimensions of extreme heat. Expanded spatial

coverage, including longitudinal studies in secondary cities, is essential for capturing diverse vulnerability patterns and for informing place-based adaptation strategies.

The review also underscores the need for interdisciplinary and systems-based approaches. While foundational efforts have been initiated — such as pilot urban-climate atlases, health bulletins, and heat early warning systems — these remain geographically limited and lack cross-sectoral scalability. Fragmentation between ministries, particularly the newly established Ministry of Agriculture and Environment (MAE), Ministry of Construction (MOC), and Ministry of Health (MOH), with no dedicated national mechanism or task force focusing on urban heat governance, continues to hinder coordinated responses. Current policies and action plans fall short of operationalizing urban heat adaptation through measurable targets, enforcement mechanisms, and integrated multi-sectoral implementation.

4.2. Recommendations

Addressing extreme urban heat in Vietnam requires not only technical solutions but also institutional innovation, governance reforms, and sustained public engagement. By strengthening coordination, mainstreaming urban climate data into policy, increasing awareness among both decision-makers and the public and centering adaptation efforts on the most vulnerable, Vietnam can move from fragmented pilot initiatives to a comprehensive national strategy for urban heat resilience.

In the light of these findings, to enhance Vietnam's capacity to adapt to and mitigate the impacts of extreme heat in urban areas, we propose the following integrated set of policy recommendations:

4.2.1. Institutions and governance

- **Institutionalize cross-sectoral coordination.** Establish a national task force on urban heat resilience to ensure coordination between MAE, MOC, MOH and other relevant stakeholders. This body should define responsibilities, align strategies, and facilitate the mainstreaming of heat adaptation measures into planning, health, and infrastructure development, with the support of meteorological agencies.

- **Integrate urban Heat mitigation into legal and regulatory frameworks.** Revise national and local urban planning laws to mandate UHI mitigation strategies such as cool pavements, reflective surfaces, urban shading, ventilation corridors, heat-resilient building materials and green space expansion. Update building codes to include design guidelines that promote thermal comfort and reduce indoor heat

stress. Ensure operationalization through clear guidelines, enforcement mechanisms, and measurable indicators for urban heat mitigation – such as minimum green space ratios, reflective surface standards, or localized UHI intensity thresholds.

4.2.2. Monitoring and risk mapping

- **Strengthen urban climate monitoring and data systems.** Establish a comprehensive urban climate monitoring network by expanding the number of automatic weather stations in urban heat-prone zones. Integrate meteorological, remote sensing, and GIS data with health and socio-economic indicators, particularly in high-density areas. This will support the devlopement of early warningtargeted interventions and real-time heat-health alerts, especially in high-density neighborhoods.

- **Develop urban-climate atlas including assessment of heat exposure**. Based on the pilot project of the Ca Mau urban-climate atlas, MOC should prioritize development and nationwide implementation of the urban-climate atlas, in collaboration with MAE, to integrate high-resolution climate projections that account for global warming and localized urbanization trends. This will provide essential input for urban planning, smart and green city development, and climate-adaptive public health and sectoral strategies.

- **Map vulnerable areas.** Vulnerability corresponds to the susceptibility of people, infrastructure, economy, or ecosystems to be negatively affected by heat. Vulnerability mapping, encompassing both communities and infrastructure, combined with heat exposure mapping is crucial to identify priority areas for targeted heat adaptation or mitigation strategies.

4.2.3. UHI mitigation

- **Expand green infrastructure and nature-based solutions.** Allocate a minimum percentage of urban land for green space, particularly in heat-vulnerable areas. Promote the development of pocket parks, urban forests, green roofs, and green corridors. Prioritize nature-based solutions in climate adaptation and city master plans.

- **Support public-private investment in climate-smart technologies** such as cool pavements, smart ventilation systems, and passive cooling architecture alongside nature-based solutions to manage rising temperatures.

4.2.4. Mitigation of heat-related impacts

- **Expand heat early warning systems.** Deploy early warning systems to trigger public health responses before and during heatwaves. Early warning systems should take into account not only air temperature but also air humidity through the use of heat-stress indices such as the Heat Index or WBGT. Use multi-platform messaging tailored to vulnerable groups, including the elderly, low-income households, and outdoor workers.

- **Embed heat risks in public health strategies.** Develop heat-health action plans at national and local levels. Train healthcare workers to identify and respond to heat-related illnesses. Ensure hospitals have protocols for managing high-temperature events.

- **Develop public services to cope with extreme heat,** such as access to clean water, shaded areas and cooling centers.

- **Enhance public awareness and community engagement.** Design targeted communication campaigns and training programs to raise awareness about heat risks, behavioral responses, and available public services. These efforts should be accessible, inclusive, and adapted to the needs of vulnerable groups.

4.2.5. International Collaboration and Climate Finance.

- **Engage in global initiatives** such as the Extreme Heat Resilience Alliance[2] and the Cool Coalition[3] to exchange best practices and access technical and financial support. Aligning with global standards will help accelerate national progress on climate adaptation and urban heat governance.

- **Leverage international climate finance** for infrastructure upgrades, capacity building, and public health system resilience.

[2] https://onebillionresilient.org/project/extreme-heat-resilience-alliance/
[3] https://coolcoalition.org/

4.2.6. Research

- Promote interdisciplinary and transdisciplinary research and innovation. Support collaboration between urban climatologists, planners, public health professionals, and social scientists.
- Foster innovation in modeling urban microclimates, evaluating mitigation measures, and designing tools for integrated heat risk assessment.
- Fund policy-oriented research programs to integrate remote sensing and climate models into national urban planning processes.
- In order to operationalize urban heat resilience, foster collaboration between researchers and policymakers to translate scientific findings into actionable policies, enforceable urban planning standards, and inclusive governance mechanisms at both national and local levels.

Together, the above recommendations provide a roadmap for Vietnam to strengthen its climate resilience framework and reduce the health, social, and economic impacts of extreme urban heat. It has to be noticed that while some actions (e.g., early warning systems, public awareness campaigns) can be implemented relatively quickly, others (e.g., revising legal frameworks, expanding green infrastructure) inherently require more time and institutional commitment. More targeted studies and context-specific research are necessary to translate the above strategic directions into detailed, prioritized implementation plans for specific cities and regions in Vietnam.

4.3. Additional perspectives

Beyond extreme heat, it is important to acknowledge that Vietnamese cities are increasingly affected by other climate-related extremes such as heavy rainfall, urban flooding, and severe wind events. Recent disasters, including Typhoon Yagi (2024) and record-breaking rainfall episodes in 2025 that caused widespread inundation in northern and central urban areas (e.g., Hue province), underscore the multi-hazard vulnerability of cities in Vietnam. Urban areas are complex systems, highly sensitive not only to temperature extremes but also to hydrometeorological hazards. Furthermore, current urban design regulations (e.g., wind and drainage standards based on 1–20 year return periods) may not sufficiently reflect emerging risks. In addition to climate adaptation, cities are also major greenhouse gas emission sources and must be included in national mitigation strategies. These observations reinforce the need for further research on compound climate risks in urban areas, improved risk-based planning standards, and integrated urban climate resilience pathways.

Hence, as cities become increasingly exposed to climate risks under future climate change scenarios, there is a growing need to develop urban-specific climate projections that capture localized extremes such as heat, flooding, and wind hazards. The integration of such urban climate scenarios into development planning and infrastructure design is essential to ensure that cities are equipped with actionable and context-relevant information for climate resilience. Vietnam's upcoming national climate scenarios (2025) offer a timely opportunity to incorporate downscaled projections tailored to urban environments, thereby supporting science-based urban planning and risk governance.

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List of acronyms and abbreviations

COP26	Conference of the Parties 26
GIS	Geographic Information System
GRC	German Red Cross
HEVI	Heat Exposure Vulnerability Index
H-H&D	Heat - Health and Diseases
H-RS&GIS	Heat - Remote Sensing and Geographic Information System
H-UP	Heat - Urban Policies
H-US	Heat - Urban Surface
IMHEN	Viet Nam Institute of Meteorology, Hydrology, and Climate Change
IPCC	Intergovernmental Panel on Climate Change
LD_EUH	Legal Documents related to Extreme Urban Heat
MAE	Ministry of Agriculture and Environment
MARD	Ministry of Agriculture and Rural Development
MOC	Ministry of Construction
MOH	Ministry of Health
MONRE	Ministry of Natural Resources and Environment
NAP	National Adaptation Plan
NCHMF	National Center for Hydro-Meteorological Forecasting
Obs&M	Meteorological Observation and Modeling
QCVN	Vietnamese Technical Regulations
RCP	Representative Concentration Pathway
SDGs	Sustainable Development Goals

TCVN	Vietnamese Standards
UHI	Urban Heat Island
UNDP	United Nations Development Programme
VNMHA	Vietnam Meteorological and Hydrological Administration
VRCS	Vietnam Red Cross Society
WHO	World Health Organization
WMO	World Meteorological Organization

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