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Review

Climate Risk Mitigation and Adaptation Concerns in Urban Areas: A Systematic Review of the Impact of IPCC Assessment Reports

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Abstract: Urban areas continue to be the center of action for many countries due to their contribution to economic development. Many urban areas, through the urbanization process, have become vulnerable to climate risk, thereby making risk mitigation and adaptation essential components in urban planning. The study assessed the impacts of IPCC Assessment Reports (ARs) on academic research on risk mitigation and adaptation concerns in urban areas. The study systematically reviewed literature through searches of the Web of Science and Scopus databases; 852 papers were retrieved and 370 were deemed eligible. The results showed that the East Asia and Pacific, and Europe and Central Asia regions were most interested in IPCC ARs, while Sub-Saharan Africa showed little interest. Several urban concerns, including socio-economic, air quality, extreme temperature, sea level rise/flooding, health, and water supply/drought, were identified. Additionally, studies on negative health outcomes due to extreme temperatures and air pollution did not appear in the first four IPCC ARs. However, significant studies appeared after the launch of the AR5. Here, we must state that climate-related problems of urbanization were known and discussed in scientific papers well before the formation of the IPCC. For instance, the works of Clarke on urban structure and heat mortality and Oke on climatic impacts of urbanization. Though the IPCC ARs show impact, their emphasis on combined mitigation and adaptation policies is limited. This study advocates more combined risk mitigation and adaptation policies in urban areas for increased resilience to climate risk.

Keywords: urban areas; climate change; mitigation; adaptation; risk; IPCC

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1. Introduction

Urban areas have long been the preferred place for human settlement [1]. This is due to the benefits and functions that serve and enable culture, learning, information, and industry [2,3]. Urban centers or cities in general go beyond human and resource concentration. People continue to settle in urban centers, and today, about half (54%) of the world's population lives in urban areas [4,5]. This is projected to increase to about 70% by the middle of the century [4]. Urban centers are articulate and facilitate greater functions of socio-economic activities that attract a lot of people [6].

The increasing concentration of people in urban areas has resulted in the transformation of agricultural lands into residential and industrial purposes [7,8]. There is, thus, unequal development of trade, housing, and tourism [9,10]. People's willingness to live in urban areas has resulted in migration and the continuous expansion of urban areas [5,11–13].

Through urbanization, many urban areas of the world have experienced massive growth with respect to population and economic development [13,14]. Urbanization is, thus, considered an essential process that offers numerous opportunities and serves as a catalyst for economic growth in urban areas [14]. Despite the numerous opportunities associated with urbanization, it results in some negative impacts and has received criticism in many studies (e.g., Wang et al. [15], Zhang et al. [16]). As people continue to live in urban centers, urban spaces expand, resulting in many socio-economic and environmental problems [15,17].

As urban areas continue to battle with the problems of urbanization, they are also challenged by the negative impacts of climate change [18,19]. This has made many urban areas of the world vulnerable [18,20,21]. For example, rising climate risks and atmospheric pollution negatively affect urban areas and increase urban vulnerabilities [22,23]. While several threats arise from the climate–atmosphere interactions, it is crucial to stress the negative impacts posed to human health, especially considering the critical role of health in socio-economic transformation [24]. Several studies have stressed the negative human health impacts and related vulnerabilities. For instance, Knol et al. [25] reported a medium to high relationship among short-term ultrafine particle exposure, mortality and morbidity, and increased cardiac and lung disease in Europe. Baccini et al. [26] highlighted the dire effects of increasing summer temperatures on people's health in fifteen European cities. Kan et al. [22] informed us about the mounting effects of extreme weather events and air pollution on mortality, infectious diseases, and water quality in China. Petkova et al. [27] also highlighted how heat-related death (deaths per one thousand population) increased in Philadelphia, New York City, and Boston between 1985–2006. Additionally, Lehtomäki et al. [28] showed that the death rate caused by particulate matter ($PM_{2.5}$) and ozone (O_3) was highest in Denmark and lowest in Iceland among the Nordic countries. Similarly, Peters and Schneider [29] explained how the combined consequences of heat, air pollution, age, and socio-economic and health conditions cause cardiovascular diseases and the need to consider disease prevention. The rise in the negative impacts of climate change and the potential health effects and vulnerabilities, especially in urban areas, needs attention [30–32]. Attention in this regard is on the right path considering the already existing negative impacts associated with the urbanization process and climate change [15].

Recent climate change is highly attributed to anthropogenic activities, and this makes population growth in urban areas a factor of global warming [14,33]. The numerous problems and vulnerabilities associated with the urbanization process place urban areas at the center of climate adaptation and mitigation [18,34]. Massive efforts have been made by urban areas and cities in general to mitigate and adapt to climate change [35,36]. As reported by Mi et al. [34], many of the world's urbanized areas have agreed on protocols that address climate change and push for urban actions that reduce greenhouse gas emissions and climate risks. Urban areas and cities' mitigation and adaptation actions to climate risks are, thus, essential towards the reduction of vulnerabilities [37].

Several studies have revealed the complementary and interrelated nature of adaptation and mitigation [38,39]. As reiterated by Landauer et al. [38], whereas adaptation reduces urban areas' sensitivity to climate risks, mitigation lessens their exposure. Conversely, Jones et al. [40] indicated differing views on the interrelatedness of adaptation and mitigation and, thus, suggested their separate treatment, especially considering the diversity of urban scale and policy design. Notwithstanding, adaptation and mitigation policies are essential to the continuous development of urban areas, and their combination offers enormous benefits, increases synergies, and minimizes conflicts [41]. As emphasized by Grafakos et al. [42], urban areas and cities recently have given attention to both adaptation and mitigation policies in planning. Several research studies (e.g., Seto et al. [13], de Oliveira and Doll [43], Gao et al. [44]) have stressed the co-benefits of adaptation and mitigation plans for urban areas.

Climate risks in urban areas were initially given less attention by climate change researchers and institutions as much attention was given to ecosystems and agriculture [45].

However, in recent times, urban areas have become the center of climate risk mitigation and adaptation, considering the socio-economic and human health vulnerabilities [13,18,34,35]. With urbanization and population growth recognized as a greater driver of global warming [14,33], it is imperative to understand how urban areas and urbanization have been treated by the climate change community, especially by the Intergovernmental Panel on Climate Change (IPCC) in their Assessment Reports (henceforth ARs).

The IPCC, established in 1988 under the auspices of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), is responsible for providing consistent scientific assessment on climate change, its consequences and potential future hazards, as well as adaptation and mitigation options (https://www.ipcc.ch/ accessed on 2 January 2022). The IPCC has delivered six ARs since 1988: the First (FAR) in 1990, which stressed the essence of climate change as a challenge with global effects and the need for world collaboration; the Second (SAR) in 1995, delivered essential materials for policymakers close to the approval of the 1997 Kyoto Protocol; the Third (TAR) in 2001, also drew attention to the impacts of climate change and the need for adaptation; the Fourth (AR4) in 2007, further based on the approval of the Kyoto Protocol and aimed at limiting warming at 2 °C above the late 19th century temperatures, and the Fifth (AR5) completed between 2013 and 2014, offered scientific contributions to the Paris Agreement. The Sixth (AR6), which is the current report, is expected to be completed by the second half of 2022 (although some sections are already released) and seeks to deliver three special reports: Global Warming of 1.5 °C (SR1.5), Special Report on Climate Change and Land (SRCCL), and Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) (https://www.ipcc.ch/about/history/ accessed on 2 January 2022).

As policymakers, academic and scientific communities, and other stakeholders await the release of the full and complete AR6, it is worthwhile to understand the impact of the first five ARs on academic concerns. With urban areas at the forefront of climate change adaptation and mitigation [13,18,34], and urbanization regarded as a major contributor to global warming [14,33], it is critical to comprehend the implications of IPCC ARs on the issue of climate risk mitigation and adaptation in urban areas. It is interesting to note that amongst the five IPCC ARs, only the AR5 dedicated a chapter to urbanization (captured under chapter 8: Urban Areas) [46]. The AR6 also recognizes climate-related problems of urbanization. It is, thus, important to understand how research advances after the delivery of each of the IPCC's ARs. The geographical distribution and prominence of this research and the main topics reached will help understand which regions of the world are represented and cared for by IPCC ARs.

Although there exist several research studies on urbanization [33,47–49], especially on urbanized areas [14,50,51], there exists a dearth of information about how it is represented and treated after the release of each of the IPCC's ARs. Again, there is a dearth of information on how IPCC ARs impact climate risk mitigation and adaptation concerns in urban areas. A comprehensive systematic review of literature, looking at how urban areas and urbanization have been treated before and after the release of each of the IPCC's ARs is, therefore, necessary. This will help to understand the impact of IPCC ARs on climate risk mitigation and adaptation in urban areas. Such an understanding will be helpful in advising future academic research and development projects. In this regard, this study presents results of a systematic review undertaken to extract and synthesize existing knowledge on the number and type of papers 5 years before and 5 years after each of the IPCC's five ARs, their geographical distribution and prominence, and the main topics reached by placing emphasis on climate risk mitigation and adaptation in urban areas in each of these ARs. Following this, the key question that drives this review is: What impacts have IPCC ARs had on academic research on risk mitigation and adaptation concerns in urban areas?

2. Materials and Methods

This section describes the approach that was utilized to extract relevant papers that aided the understanding of the impacts of IPCC's ARs on academic research on risk mitigation and adaptation concerns in urban areas. This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) procedures [52]. The PRISMA procedure guides systematic reviews of the scientific literature to ensure that a clear research question and inclusion and exclusion criteria for studies are defined [53].

2.1. Resources and Search Procedure

The study systematically searched for documents that showed evidence of how IPCC's ARs have impacted academic research on climate risk mitigation and adaptation concerns in urban areas. The search process was conducted on 14 January 2022, in the Web of Science (WoS) and Scopus databases. The WoS, established by Clarivate Analytics, is a strong database containing more than 33,000 journals and covering more than 256 disciplines such as social sciences, environmental studies, interdisciplinary, development, and planning, among others [54,55]. Thus, WoS has more than a century of comprehensive backfile and citation data [54,55]. The Scopus database also contains more than 22,800 journals with peer-reviewed literature from five thousand publishers globally. Scopus is considered one of the largest abstract and citation databases, and has varied subject areas such as social sciences, environmental sciences, and agriculture, among others [55].

After several tests and deliberations on keywords, the authors established a range of terminologies associated with the concepts of climate change, urbanization, and risk mitigation and adaptation (Table 1). To understand the impact of IPCC ARs, the terms "ipcc" and "intergovernmental panel on climate change" were included.

Table 1. Keywords used in the document search. Note: the asterisk (*) function of truncation was used where applicable to ensure variant endings of keywords.

Climate Change	Urbanization	Risk Mitigation and Adaptation	IPCC Reports
climate change	cities	adapt *	ipcc
global warming	city	mitigate *	intergovernmental panel on climate change
greenhouse	Urban *	polic *	
CO_2			

Keywords were blended with Boolean operators (e.g., OR, AND) to find relevant concepts about climate change, urbanization, and risk mitigation and adaptation. The usage of the Boolean operator "AND" indicates that the review included studies that were based on these concepts. The full search plan with strings and Boolean operators for each database is presented in Supplementary Materials Table S1.

2.2. Eligibility and Exclusion Criteria

The literature search was restricted to research articles, books, book chapters, conferences, and conference proceedings. While many systematic review studies employ only the English language, our study expanded to include Portuguese and Spanish in addition to the English language. Publication years between January 1985 and December 2021 were deemed eligible. This was done to place the study findings in the context of current research and to conform to the IPCC's FAR published in 1990 [56]. The study excluded document types such as reviews, editorials, comments, and letters. Again, the study excluded papers that failed to treat all the three topics of interest (i.e., climate change, urbanization, and risk mitigation and adaptation). Additionally, the study excluded documents that were not related to the subject and those without direct access. The present study accepts that the exclusion of other document types might have led to the missing of vital information. However, the study believes the literature sample is broad enough to obtain a fair representation of the present literature. We must state that our study is limited to academic concerns.

2.3. Search and Selection Process

Searches from both WoS and Scopus produced 411 and 441 documents, respectively. We must state that the document search from WoS was conducted in the Web of Science Core Collection. Resulting literature citations were imported to the EndNote reference management software for organization of references (https://endnote.com/ accessed on 2 January 2022). At this stage, authors first eliminated duplicate records, a total of 268. After this, 584 documents were exported to Microsoft Excel where authors independently screened the documents to check for their eligibility. Through an independent review, the authors employed selection criteria to titles and abstract. The authors first selected a large array of articles based on titles and abstracts. From this point, the criteria were restricted to incorporate only studies that centered on climate risk mitigation and adaptation in urban areas. The study established its exclusion criteria on the proof of inclusion of climate change, urbanization, and risk mitigation and adaptation. Therefore, only studies that tackled these elements were included in this review. During this process, authors met regularly to resolve and discuss all conflicting issues with respect to the selected articles for review. In the instances where it was difficult for authors to reach a consensus on a selected document, a third researcher was contacted. The final stage of this process resulted in a total of 370 documents (Figure 1).

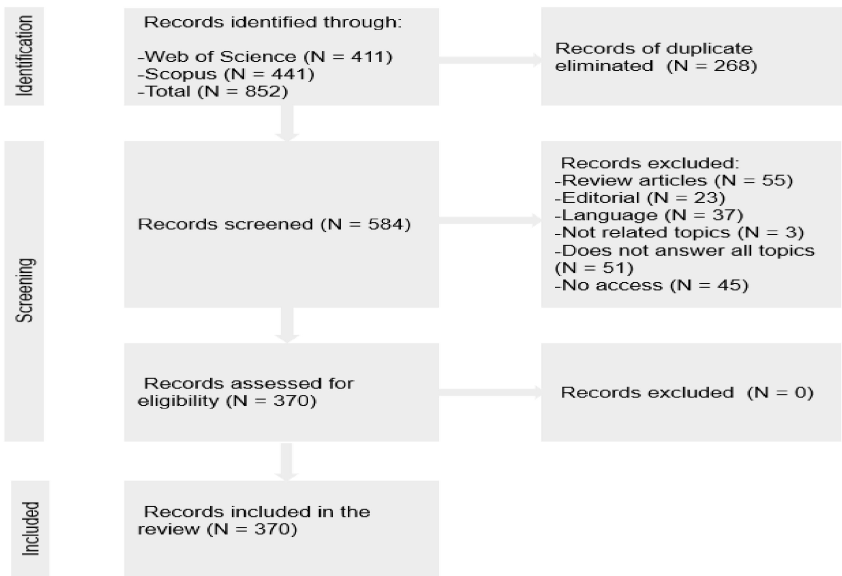

Figure 1. Flow diagram of the search and selection process of documents. Note: N indicates number of records.

2.4. Data Extraction and Analysis

Here, the data extraction procedure used by Madureira and Monteiro [57] was followed. In this regard, the authors first extracted publication characteristics such as title of the study, authors, and year of publication. Additionally, the study area, geographical distribution, and prominence were examined and extracted from each document. Additionally, the number and type of papers 5 years before and 5 years after each of the IPCC's AR were analyzed. Moreover, the topics and concerns raised in each of these documents were also extracted and analyzed. At the end of this process, documents were grouped into recurring topics, which enabled comparison across studies. Inductive qualitative analysis was used to identify the main topics covered in the IPCC ARs.

3. Results

3.1. Trends in Publication, Study Locations, Regional Groupings, and Spatial Dimension

Figure 2a–d shows the number of studies published by year, their locations, regional groupings, and the spatial dimensions applied. From Figure 2a, the majority (51) of the studies were published in the year 2019 and the least (0) in the years (e.g., 1985–1989) among others. From Figure 2a, it can be said that the IPCC paid little or no attention to climate-related urbanization problems in the earlier ARs, even though these issues were well known and discussed in scientific papers. The variations in studies between periods AR4, AR5, and AR6 could be attributed to the introduction and recognition of climate-related urbanization problems in AR5. For instance, the AR4 did not highlight the urbanization problems, and this could be a reason for the low number of studies as compared to the AR5 and AR6. FAR, as shown in Figure 2a, refers to the First Assessment Report of the IPCC which was released in 1990. The FAR stressed the essence of climate change as a challenge with global effects and the need for world collaboration. SAR is the Second Assessment Report released in 1995. Here, the IPCC delivered essential materials for policymakers close to the approval of the 1997 Kyoto Protocol. The Third Assessment Report (TAR) was launched in 2001 and in this report, the IPCC underlined the impacts of climate change and the need for adaptation. The Fourth Assessment Report (AR4), which was released in 2007, emphasized the approval from the Kyoto Protocol and aimed at limiting warming at 2 °C. Between 2013 and 2014, the Fifth Assessment Report (AR5) was also released and presented scientific contributions to the Paris Agreement. The Sixth Assessment Report (AR6), which is the current IPCC report and is expected to be completed by the second half of 2022, will seek to provide three special reports: Global Warming of 1.5 °C (SR1.5), Special Report on Climate Change and Land (SRCCL), and Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) (https://www.ipcc.ch/about/history/ accessed on 2 January 2022).

In Figure 2b, most (74) of the studies were undertaken in China, the U.S.A (50), and the least (1) were undertaken in countries such as Barbados, Algeria, and Madagascar, among others. The diversities in study locations reveal the wide-ranging regional groupings as shown in Figure 2c. Here, the majority (134) of the studies were in the East Asia and the Pacific region, followed by Europe and Central Asia (89) with the least (15) in Sub-Saharan Africa. Here, the study adapted the regional groupings of the World Bank (https://www.worldbank.org/en/about/unit accessed on 2 January 2022). In furtherance to this, a greater part (188) of the studies were conducted at the local scale, followed by national (103), and the least (6) being without scale (Figure 2d). It must be noted that local scale in this review indicates studies undertaken in specific urban areas of a country. The national scale consists of two or more cities/countries. International scale comprises two or more countries whereas global scale contains studies that were general in nature with no interest in a specific city or country but have their outcome applicable to the global sense. Studies without scale were those that did not indicate any specific scale of applicability. These studies occurred due to the document types (e.g., books and book chapters) used in the review. A summary of all the studies (370) used in the review is displayed in Supplementary Materials Table S2.

3.2. Number of Studies 5 Years before and 5 Years after the Release of Each of the IPCC ARs

Figure 3 shows the number of studies 5 years before and 5 years after the release of each of the IPCC ARs. On the FAR, the 5 years before begins from 1985–1989 and the 5 years after, which included the actual year of release (1990), starts from 1990–1994. That of the SAR in 1995 starts from 1990–1994 (5 years before) and 1995–1999 (5 years after), in that order. From Figure 3, 5 years before and 5 years after the release of the FAR (in 1990) produced (0 study) and (1), respectively. Following this and in a consistent manner, 5 years before and 5 years after the release of the SAR (in 1995) produced (1) and (0), respectively. Likewise, TAR (in 2001) recorded (0) and (6), correspondingly. It is interesting to note that more studies were produced towards the release of the AR4 (in 2007). For instance, 5 years before and 5 years after the release of the AR4 produced (7) and (60), in that order while 5 years before and 5 years after the release of the AR5 (in 2014) recorded (77) and (156), respectively. The AR6 has produced a total of 120 studies even though it has not been fully launched. This analysis gives an idea of the research behavior of the studies that follow the IPCC ARs. It also helps to understand why the IPCC paid little attention to climate-related urbanization problems, despite the fact the issues were known and discussed in scientific papers.

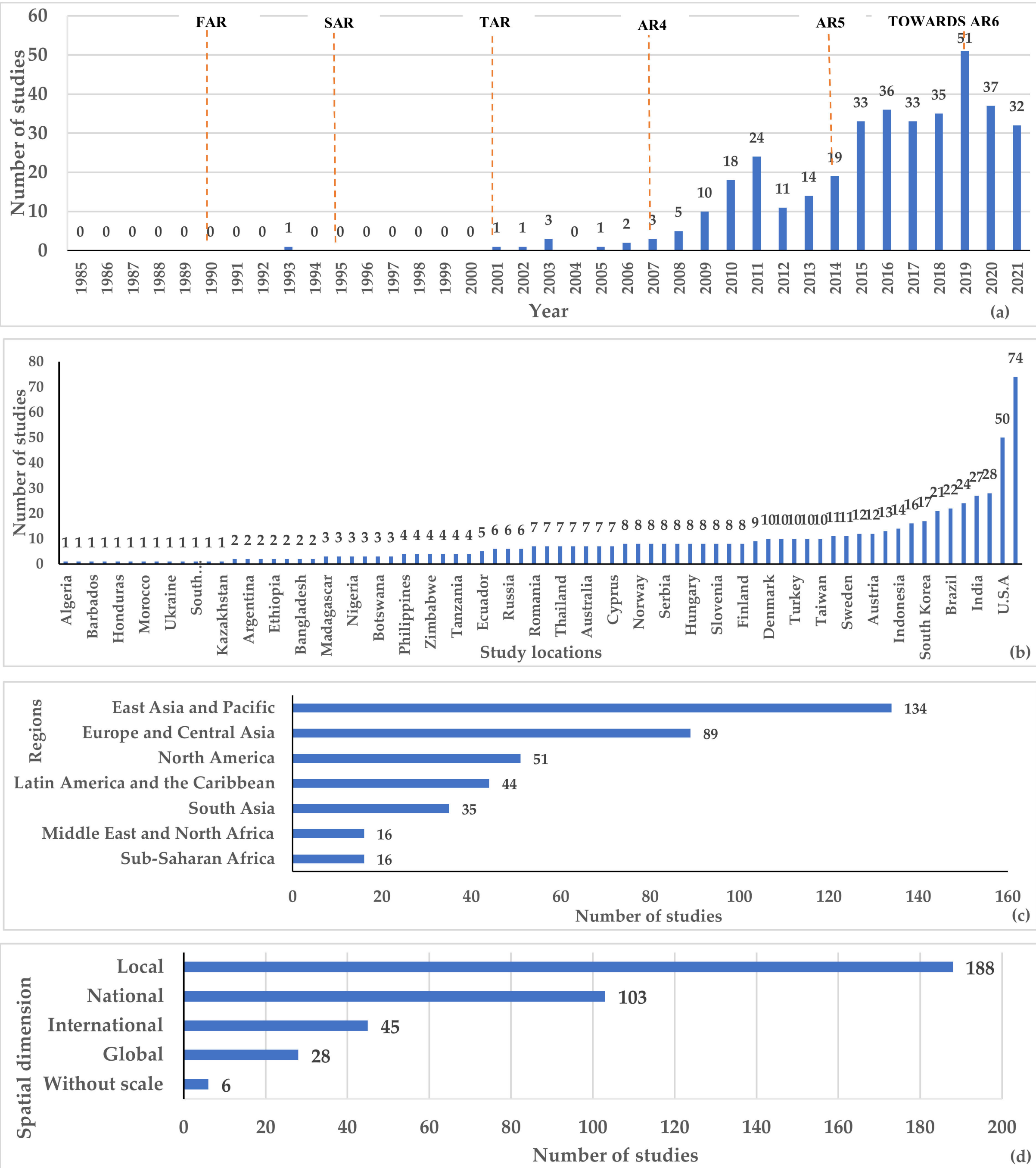

Figure 2. Study characteristics based on number of publications by year (**a**), study locations (**b**), regional distribution (**c**), and spatial dimension (**d**) of the literature used in the review.

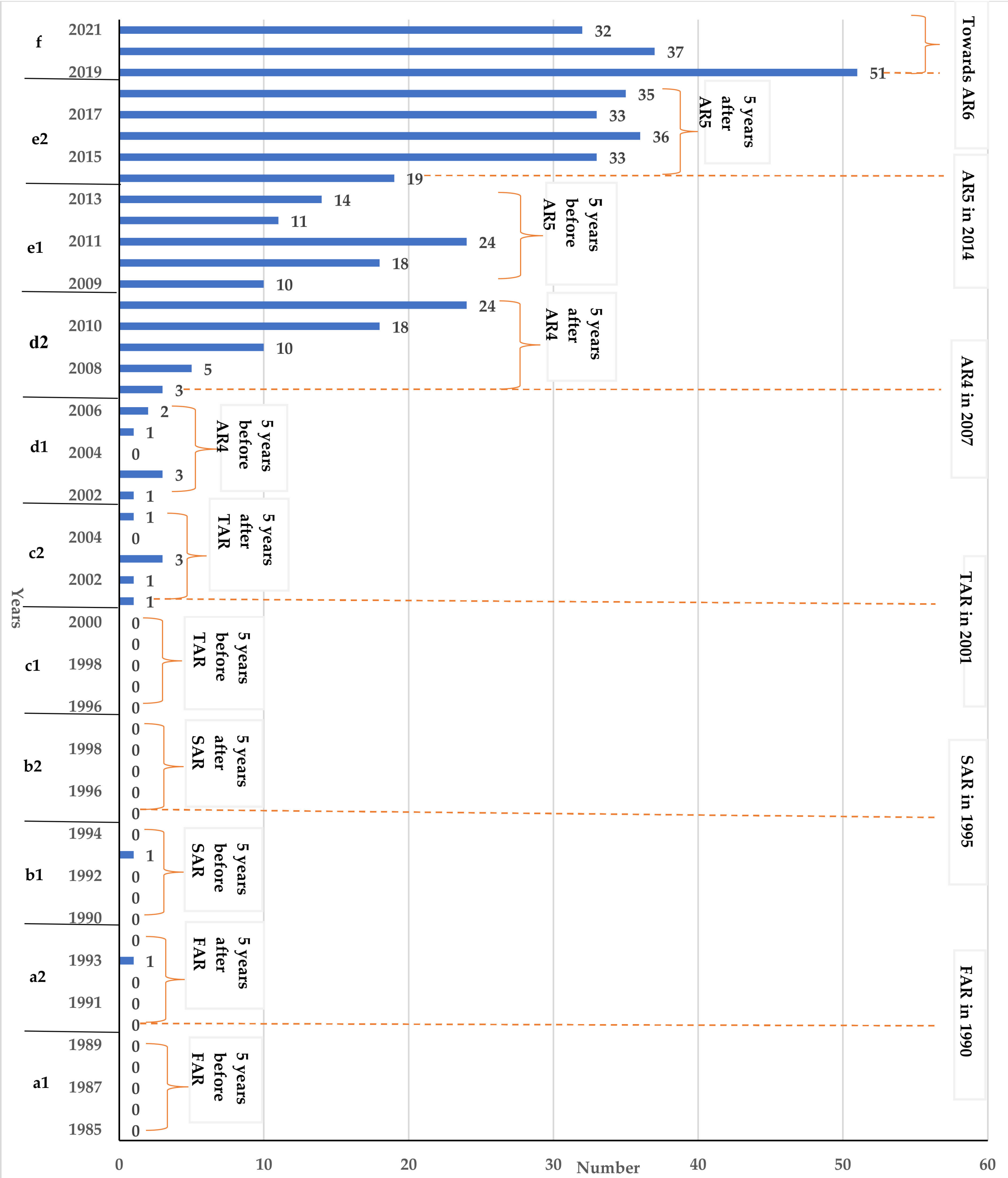

Figure 3. Number of studies 5 years before and 5 years after the release of FAR (**a1**,**a2**), SAR (**b1**,**b2**), TAR (**c1**,**c2**), AR4 (**d1**,**d2**), AR5 (**e1**,**e2**), and towards AR6 (**f**). Note: The 5 years after analysis include the year of release of the IPCC ARs.

3.3. Data Sources, Approaches to Data, and Methods

The study considered the data sources, approaches to data analysis, and methodologies utilized in the studies problematizing the subject in question. From Figure 4a, the majority (70%) of data were obtained from secondary sources and the least (5%) from both primary and secondary sources. Here, secondary sources were those studies where researchers employed already collected data. For instance, from government departments, nongovernmental organizations, etc. Primary sources reveal studies where researchers utilized their own data, either through field surveys, experiments, or interviews, among others. In Figure 4b, a greater proportion (80%) of the studies used quantitative approach to data analysis while the qualitative approach was the least utilized (2%). In furtherance to this, most of the studies (28%) in Figure 4c used a model as the methodology, followed by the IPCC methodology (23%), while the life cycle assessment methodology, and machine learning/algorithms, among others, were the least (1%) methodology utilized. Additionally, in Figure 4d, the majority (24%) of the data type employed were from weather/climate and health data, followed by emission/activity/energy consumption (21%), while field data was the minimum (1%). The results presented here reflect the complex nature of climate-related problems of urbanization. For improved risk mitigation and adaptation plans to these problems, researchers employ diverse data sources and techniques in their analyses to understand the present and potential climate dynamics in urban areas.

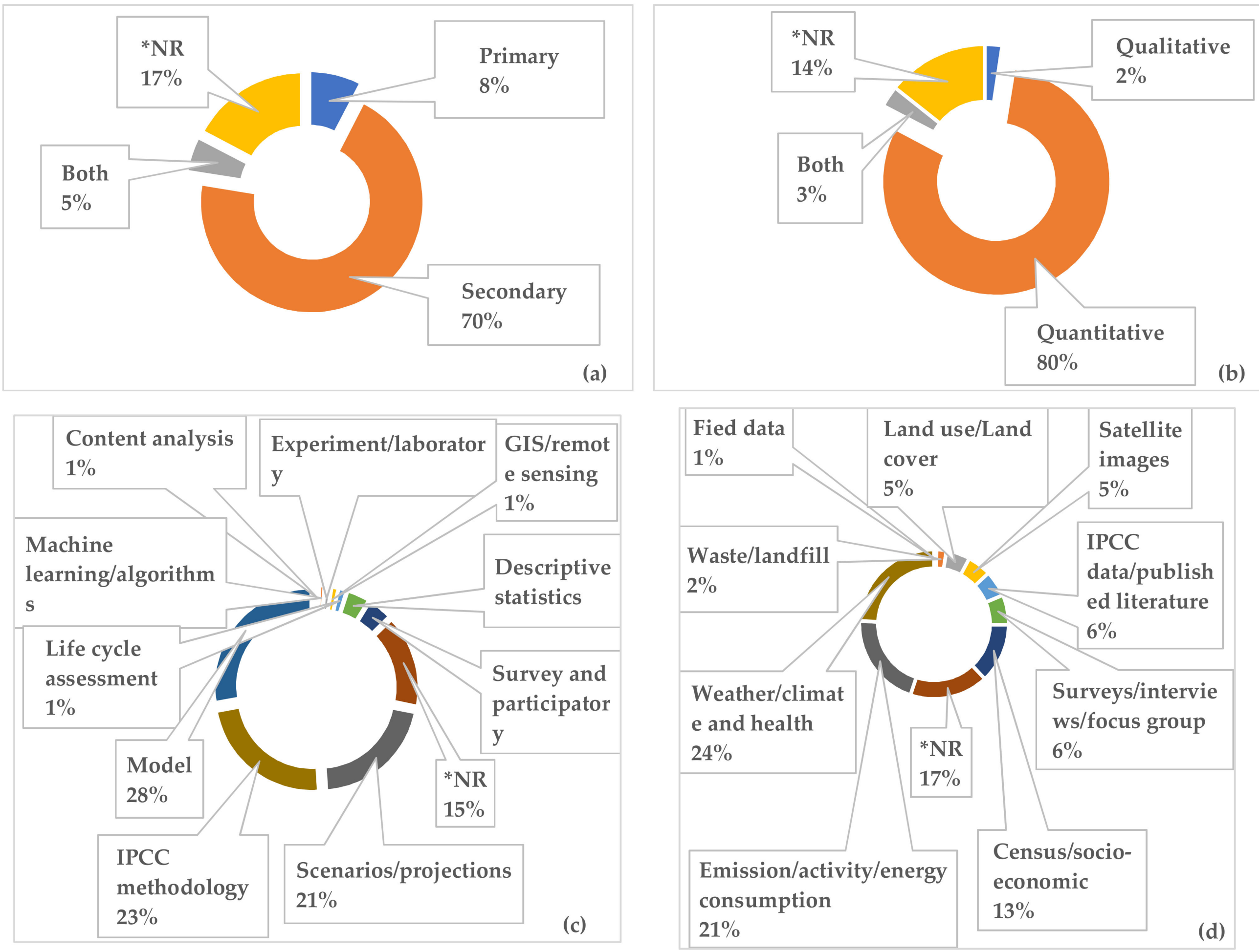

Figure 4. Data sources (**a**), approach to data analysis (**b**), methodology (**c**), and data types (**d**) of the literature used in the review. Note: *NR indicates studies that did not report any data source, approach to data analysis, methodology, and data type.

3.4. Study Focus, Outcome, and Main Concerns

Figure 5a–c reveals the focus, outcome, and main concerns addressed by researchers following the release of each of the IPCC ARs and taking into consideration the concerns of risk mitigation and adaptation in urban areas. In Figure 5a, a greater proportion (53%) of research studies concentrated on risk mitigation measures, followed by adaptation (42%), while few studies (5%) placed emphasis on both risk mitigation and adaptation. Here, topics that focused on reducing the impact of climate change or reducing greenhouse gas emissions in a particular urban area were defined as “risk mitigation”. Those that focused on adjusting to present and potential impacts of climate change in a particular urban area were classified as "adaptation". Studies that employed both of the aforesaid were categorized as both (mitigation and adaptation). Again, in Figure 5b, outcomes from most research studies (98%) were general recommendations rather than specific evidence (2%) of risk mitigation and adaptation measures in urban areas. A general recommendation is used here to denote research studies that did not indicate any individual mitigation or adaptation measure in the area of application but made an overall conclusion of the need for such measures in the respective urban areas of application. Specific evidence is also used to signify research studies that show proof of the existence or new application of mitigation and adaptation measures in their study in the respective area of application. Additionally, socio-economic issues were the most (50%) concerns raised, followed by air quality (17%), while health (5%) and water supply/drought (5%) were the minimum concern highlighted (Figure 5c).

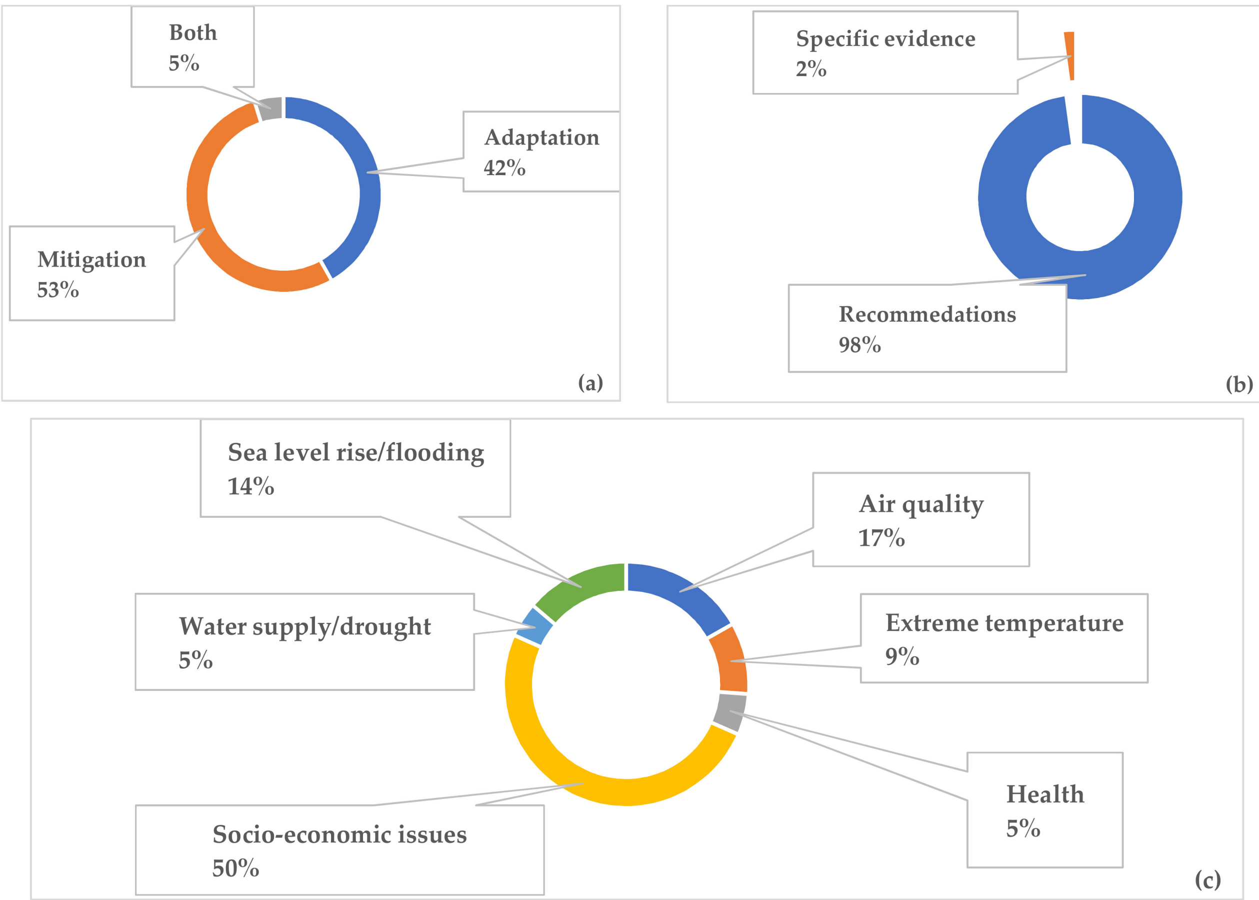

Figure 5. Study focus (**a**), outcome (**b**), and main concerns (**c**) raised in the literature used in the review.

4. Systematic Review: Qualitative Synthesis of Literature

The studies presenting the impacts of IPCC ARs on academic research on risk mitigation and adaptation in urban areas raised several concerns, including socio-economic, air quality, sea level/flooding, extreme temperature, health, and water supply/drought.

4.1. Socio-Economic

The studies revealing the socio-economic impacts of climate issues in urban areas showed varied outcomes. Most studies raised problems relating to climate impacts on agriculture, food security, poverty, and the adaptive capacity of urban areas. For instance, Salleh [58] stressed the impacts of climate change on agriculture and urban commerce in

Malaysia and the developing countries of Southeast Asia, and its effects on poverty and food security. Salleh [58] suggested the need for better adaptation plans to prevent national and international conflicts in the region. Similarly, Ruiz-Alvarez et al. [59] underlined the variations in monthly and annual precipitation and their negative effects on agriculture in Aguascalientes, Mexico. To better adapt to this situation, Ruiz-Alvarez et al. [59] advocated the need to store water during high humid precipitation months for use in the dry season. Likewise, Singh et al. [60] stated that decreased freshwater access will have a surging effect on worldwide food security, livelihood, and widespread migration. Singh et al. [60] recommended increased measures for water preservation and wastewater recycling for improved adaptation. On the contrary, Ye et al. [61] projected an increase in food crop yield from 2030−2050 in China and indicated an increase in food supply in China. Nonetheless, Ye et al. [61] warned of the growing Chinese population as a counter-element to the projected increase in food supply and called for significant policy alternatives to address this issue. Again, Zhao et al. [62] found low and high adaptive capacity to climate problems in the inland and eastern coastal urban agglomerations, respectively, in China. Zhao et al. [62] proposed both adaptation and mitigation measures such as the expansion of infrastructure and funding for improved adaptive capacity in the underdeveloped regions and the regular monitoring of climate change impacts in the developed areas of China. Additionally, Wilder et al. [63] noted that climate change adaptation at international (U.S.A.–Mexico) borders is conservatively seen as difficult, despite the possible improved resilience in regionalization of adaptive responses. The researchers suggested specific adaptation plans such as improved social learning and co-creation of climate knowledge [63]. Additionally, Khan et al. [64] reported the vulnerable conditions of farmers in urban Punjab, Pakistan. To adapt to this situation, Khan et al. [64] suggested the enabling of climate-smart adaptation initiatives for urban farmers through the execution of useful policies and investment strategies.

Other studies emphasized the concerns about the impact of urbanization, urban housing, and city planning. Norman [65] saw the challenges associated with urbanization in Australia and proposed seven principles (see Norman [65] for more details), that should support intergovernmental accord on urban coastal planning. Moreover, Xie et al. [66] emphasized that the Shanghai metropolitan areas in China have the highest rates of increase in annual and seasonal average surface air temperature, ranging from 0.23 °C to 0.50 °C per decade due to urbanization. Likewise, Marelle et al. [67] stressed that urbanization increased the frequency and intensity of extreme urban precipitation in the megacities of Paris, Tokyo, Shanghai, and New York. To mitigate this, Marelle et al. [67] advocated the recognition of urbanization effects in urban planning assessments to make cities more resilient to extreme precipitation. In furtherance to this, Wilkinson [68] found changes in environmental building elements in Melbourne, Australia, and emphasized the need for policymakers to monitor building owners' integration of environmental elements into their stock to enhance sustainability. Moreover, Rosatto et al. [69] informed us about the usefulness of green roofs in regulating the thermal change of buildings in the autonomous city of Buenos Aires, Argentina, and specifically advocated for their use in controlling thermal change of buildings. Equally, Kousis et al. [70] established the potency of resin-based pavement binder made with waste bio-oils in urban noise reduction and explicitly suggested its global exploration in the urban pavement market.

4.2. Air Quality

The studies on air quality reflecting the impacts of IPCC ARs on the concerns of risk mitigation and adaptation in urban areas focused on pollution from both outdoor and indoor sources in cities. For instance, Garg et al. [71] found the electric power generation division of India to be the highest contributor of sulfur dioxide (SO_2) emissions, while the power and transport divisions likewise lead in nitrogen oxide (NO_x) emissions. Garg et al. [71] suggested mitigation elasticity to officials for efficient mitigation in India. Sthel et al. [72], in their laboratory experiment, found that ethanol production in Brazil generates pollutant gases like N_2O, SO_2, and NO_x, and advised better mitigation measures in that regard. Again, Campbell et al. [73], in their analysis on the impacts of transport sector emissions on future U.S. air quality under climate change reported widespread decreases in future concentrations of NO_X, SO_2, volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH_3), and particulate matter with a diameter of microns (µm) less than or equal to 2.5 ($PM_{2.5}$) due to decreasing on-road vehicle emissions in urban areas. Notwithstanding, Campbell et al. [73] indicated an increase in 8 h ozone (O_3) in the U.S.A. and advised on the appropriate mitigation measures. Additionally, at the European level, San José et al. [74] found that by the year 2100, O_3 concentrations will decrease over most parts of Europe due to changes in temperature and precipitation, except Greece, Bulgaria, and Romania, and in the city of Milan, Italy, and advised on the need for the right mitigation measures. Moreover, Xie et al. [75] established that biogenic VOC and soil NO_X emissions over the Yangtze River Delta (YRD) area of China in 2008 were 657 Gigagrams (Gg) of carbon and 19.1 Gg of nitrogen, correspondingly. Xie et al. [75] indicated a potential increase in these emissions by 25% and 11.5% in 2050, in that order. In the same study, the researchers found an increase in surface O_3 of 5 to 15 parts per billion (ppb) in the northern areas and a decrease of −5 to −15 ppb in the southern areas of the YRD. Similarly, Lam [76] highlighted the potential increase in $P.M_{2.5}$ and O_3 in the Pearl River Delta region of China in 2050 under the representative concentration pathway (RCP 8.5). In their analysis on the impact of urban growth on air quality in Indian cities, Misra et al. [77] found that above the central portion of a city, concentrations of $PM_{2.5}$ emissions are mostly contributed by residential areas, brick kilns, and industries.

4.3. Sea Level Rise/Flooding

Several other studies confirmed sea level rise and flood risks in urban areas. On sea level rise, Bhuiyan and Dutta [78] informed us about increased salinity intrusion into the Gorai River in Bangladesh and advocated for the appropriate adaptation plans. Wong et al. [79] stressed that regionally, megacities in Africa, South, Southeast, and East Asia, and the Small Island States have the highest vulnerabilities to sea level rise, which requires adaptation. Wang et al. [80] revealed the potential impacts of rising tides on residential buildings in Australia and informed the need for adaptation. In Abadie's analysis of sea level damage risk in the world's 120 major coastal megacities, the researcher reported potential greater damage for Guangzhou, China and New Orleans, U.S.A., and emphasized the need for potential huge adaptation assets in these countries [81]. Additionally, Mycoo et al. [82] emphasized the vulnerable state of Greater Bridgetown, Barbados, due to sea level rise and revealed the significance of human adaptation and the safety of precious coastal assets.

On flood risk, Moeslund et al. [83] talked about the possible flooding in Aarhus, Denmark, in the event of extreme weather phenomena and suggested the incorporation of appropriate flood models equally to those in their study on potential city planning. Mortsch [84] revealed the flooding challenges in downtown London, Ontario, Canada, and recommended increased adaptation in that regard. Le Cozannet et al. [85] reported the probabilistic marine flooding in the urban Mediterranean basin in Lyon, France, and recommended the consideration of a change-centered global sensitivity analysis of potential marine flooding. Additionally, Cheng et al. [86] showed the effectiveness of the detention of increasing flood hazards in the Charles River watershed in Boston, U.S.A., and suggested the importance of creating more detention areas integrated with soil preservation in watershed development. Further, Samu and Kentel [87] stated that the greater part of Zimbabwe has low to medium (2.3% likelihood) flood incidence and highlighted the need for the execution of proper mitigation measures. Martínez-Gomariz et al. [88] highlighted the effects of pluvial flood risk in Badalona, Spain, and stressed the need for a comprehensive adaptation plan. Moreover, Abadie et al. [89] analyzed potential coastal flood risk damage in 136 cities and found the highest potential damage in Guangzhou, China; Mumbai, India, and New Orleans, U.S.A. Abadie et al. [89] recommended the need to encompass the likelihood of high-end scenarios into coastal urban adaptation development for potential sea level rise and flood risk.

4.4. Extreme Temperatures

In extreme temperatures, many studies emphasize heat stress and thermal comfort. For instance, Lee and Levermore [90] reported an increase in mean surface temperature and its effect on heat and cold in the cities of Seoul and Ulsan, South Korea, and indicated the need for improved mitigation. Similarly, O'Neill et al. [91] stressed the excessive heat events in 285 communities in the U.S.A. Although mitigation measures are in place, O'Neill et al. [91] suggested the need for more collaboration and economic resources to assist widespread mitigation actions. Again, Adachi et al. [92] revealed the present and potential increased urban heat island (UHI) in Tokyo, Japan, and called for increased mitigation measures against UHI for the city. Additionally, Tromeur et al. [93] described the energy needs for residential buildings and comfort (heat) in 10 French cities and indicated their susceptibility. For improved mitigation, Tromeur et al. [93] suggested the need for city managers to think about green space spots, push polluting actions beyond the city, and lower car traffic for riders. McPhee et al. [94] informed us about the potential heat events in Santiago, Chile, due to increasing temperatures and decreasing precipitation and recommended the need for effective adaptation plans. Additionally, Shevchenko et al. [95] underlined the heat wave episodes in Lugansk and Henichesk, Ukraine, and highlighted the need for adaptation. Further, Cinar [96] revealed the increased UHI in Fethiye, Turkey, due to a rise in night-time temperatures. The researcher suggested the need to consider street alignment of buildings and the dimensions of public and green areas in city management and design [96]. Hamdi et al. [97] found no significant change and increased warming in annual mean UHI intensity and nocturnal UHI, respectively, in the cities of Brussels (Belgium) and Paris (France), and advised appropriate adaptation plans. In furtherance to this, Alves et al. [98] showed the residential thermal discomfort situation in São Paulo, Brazil, and recommended an improved adaptation plan in that regard. Equally, Invidiata and Ghisi [99] indicated the potential increase in residential energy demand of buildings in the cities of Curitiba, Florianópolis, and Belém, Brazil, and recommended the utilization of passive design plans in buildings. Li et al. [100] emphasized the potential for higher temperatures and severe heat waves in Toronto, Ontario, Canada, and showed how their study can help policymakers realize potential temperature changes in Ontario. In proposing specific mitigation measures against heat due to increasing urban temperatures in Bari, Italy, Lassandro et al. [101] specifically suggested the use of green roofs, water jects, and cooling resources. Furthermore, Kotharkar et al. [102] discovered significant variation in temperature regime and heat stress within Nagpur, India, and demonstrated how their research can provide heat response planning and mitigation plans to the area.

4.5. Health

Several studies stressed the negative health impacts (mortality, morbidity, and general human health) in urban areas due to increasing temperatures and air pollution. For instance, Knol et al. [25] reported that 14 European technocrats ranked a medium-to-high association between increased short-term ultrafine particle exposure and mortality, and morbidity for cardiac and lung diseases. The researchers recommended the need to consider ultrafine particles in potential health risk assessment [25]. Muthers et al. [103] informed us about the potential rise in heat-associated mortality of about 129% in the city of Vienna, Austria, if no adaptation plan is taken. In the analysis of the effect of heat on mortality in 15 European cities, Baccini et al. [26] found that heat-related mortality for summer went from zero (0) in Dublin, Ireland to 423 in Paris, France. Baccini et al. [26] further indicated the potential increase in summer temperatures and their effect on the health of the people in Europe, and emphasized the need for improved mitigation. Similarly, Ostro et al. [104] reported increased premature deaths in California, U.S.A., and recommended the increased use of air conditioners as a mitigation measure for heat risk. Likewise, Petkova et al. [27] showed that heat-associated mortality per thousand population increased in Philadelphia, New York City, and Boston, respectively, from 1985 to 2006. Petkova et al. [27] highlighted the significant contributions of their study in developing measures that can reduce potential heat effects. Again, Kim et al. [105] revealed the projected increased mortalities in Seoul, Daegu, Gwangju, Busan, Incheon, and Daejeon, South Korea, and stressed effective measures that can cause significant health improvement and decrease heat-associated mortality. Additionally, Rasmussen et al. [106] highlighted the increased ragweed species in the European countries of Denmark, France, Germany, and Russia by the year 2100, and showed how this intersects with heavily inhabited cities like Paris and St. Petersburg. Rasmussen et al. [106] suggested the need for preventive measures to limit ragweed seed spread and the application of inter-country management measures for increased mitigation of potential health risk. Chen et al. [107] further informed us about the potential increase in surface O_3 and associated mortality in China and underlined the need for mitigation measures. Additionally, Estoque et al. [108] assessed heat health risk in 139 cities in the Philippines and reported high heat health risk in the Manila metropolitan area. The researchers indicated how their research can assist in risk reporting and improve knowledge of city-scale health risks.

4.6. Water Supply/Drought

Most studies raised concerns about the impact of climate issues relating to water supply and demand, water use and management, and drought. For example, Gober et al. [109] reported that current per capita water use in Phoenix, Arizona, can be maintained in the absence of unmanageable groundwater use. For improved mitigation against drought disasters, Galvão et al. [110] stated that rainwater catchment structures are used in the urban areas in Brazil and Japan to increase water source and use. Again, Wilson and Weng [111] reported water quality (phosphorus concentration) issues in the Des Plaines River watershed in Chicago, Illinois, U.S.A. during late winter and early spring. The researchers underlined the importance of their study in contributing to the reduction of negative effect on surface water quality and improved mitigation [111]. Moreover, Jacinto et al. [112] informed us about the potential reduction in water use in Portugal until 2100 and recommended a proper adaptation plan. Additionally, Huang et al. [113] found variations in water resources and potential drying trends and their effects on water resources in Chinese cities. Huang et al. [113] suggested the need to address water resource challenges and adapt to the impacts of climate change. Ougougdal et al. [114] reported increased water demand and related water scarcity problems in Ourika, Morocco, and called for an appropriate adaptation plan. Alike, Alkhawaga et al. [115] underlined the potential water security condition in Kafr El Sheikh city, Egypt, and recommended the need for frequent evaluation of water security features for Egyptian cities.

Table 2 shows a summary of the key findings, recommendations, and specific evidence from the main concerns reviewed.

Table 2. Summary of the key findings, recommendation and specific evidence of main concerns. Note: - shows no recommendation or specific evidence.

Author	Key Findings	Recommendations	Specific Evidence
	Socio-economic concerns		
Salleh [58]	The impacts of climate change on agriculture and urban commerce in Malaysia and the developing countries of Southeast Asia, and its effects on poverty and food security	The need for better adaptation plans to prevent national and international conflicts in the region	-
Ruiz-Alvarez et al. [59]	The variations in monthly and annual precipitation and their negative effects on agriculture in Aguascalientes, Mexico	Advocated the need to store water during high humid precipitation months for use in the dry season	-

Table 2. *Cont.*

Author	Key Findings	Recommendations	Specific Evidence
		Socio-economic concerns	
Singh et al. [60]	Decreased freshwater access will have a surging effect on worldwide food security, livelihood, and widespread migration	Increased measures for water preservation and wastewater recycling for improved adaptation	-
Ye et al. [61]	projected an increase in food crop yield from 2030–2050 in China and indicated an increase in food supply in China	Called for significant policy alternatives to address the growing Chinese population	-
Zhao et al. [62]	Low and high adaptive capacity to climate problems in the inland and eastern coastal urban agglomerations, respectively, in China	Expansion of infrastructure and funding for improved adaptive capacity in the underdeveloped regions and the regular monitoring of climate change impacts in the developed areas of China	-
Wilder et al. [63]	Climate change adaptation at international (U.S.A.-Mexico) borders is conservatively seen as difficult, despite the possible improved resilience in regionalization of adaptive responses	-	Improved social learning and co-creation of climate knowledge
Khan et al. [64]	Vulnerable conditions of farmers in urban Punjab, Pakistan	The enabling of climate-smart adaptation initiatives for urban farmers through the execution of useful policies and investment strategies	-
Norman [65]	Challenges associated with urbanization in Australia	Declaration of a buffer zone, capacity building for local communities, the recognition of the unique natural and cultural heritage and local interest in coastal planning, among others	-
Xie et al. [66]	Shanghai metropolitan areas in China have the highest rates of increase in annual and seasonal average surface air temperature, ranging from 0.23 °C to 0.50 °C per decade due to urbanization	Adaptation plan should be given the needed attention by policymakers	-
Marelle et al. [67]	Urbanization increased the frequency and intensity of extreme urban precipitation in the megacities of Paris, Tokyo, Shanghai, and New York	Advocated the recognition of urbanization effects in urban planning assessments	-
Wilkinson [68]	Changes in environmental building elements in Melbourne, Australia	The need for policymakers to monitor building owners' integration of environmental elements into their stock to enhance sustainability	-
Rosatto et al. [69]	The usefulness of green roofs in regulating the thermal change of buildings in the autonomous city of Buenos Aires, Argentina	-	Green roofs
Kousis et al. [70]	Resin-based pavement binder made with waste bio-oils reduce urban noise	-	The global exploration of bio-oils in the urban pavement market

Table 2. *Cont.*

Author	Key Findings	Recommendations	Specific Evidence
	Air quality concerns		
Garg et al. [71]	Electric power generation division of India is the highest contributor of Sulfur dioxide (SO_2) emissions, while the power and transport divisions likewise lead in nitrogen oxide (NO_x) emissions	Mitigation elasticity to officials for efficient mitigation in India	-
Sthel et al. [72]	Ethanol production in Brazil generates pollutant gases like N_2O, SO_2, and NO_x	The need for better mitigation measures	-
Campbell et al. [73]	Decrease in future concentrations of NO_X, SO_2, volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH_3), and $PM_{2.5}$) due to decreasing on-road vehicle emissions in urban areas and increase in 8-hr ozone (O_3) in the U.S.A.	The need for appropriate mitigation measures	-
San José et al. [74]	By the year 2100, O_3 concentrations will decrease over most parts of Europe due to changes in temperature and precipitation, except Greece, Bulgaria, and Romania, and in the city of Milan, Italy	Advised on the need for the right mitigation measures	-
Xie et al. [75]	Biogenic VOC and soil NO_X emissions over the Yangtze River Delta (YRD) area of China in 2008 were 657 Gg of carbon and 19.1 Gg of nitrogen, correspondingly	The need for appropriate mitigation measures	-
Lam [76]	The potential increase in $P.M_{2.5}$ and O_3 in the Pearl River Delta region of China in 2050 under the RCP 8.5	The need for appropriate mitigation measures	-
Misra et al. [77]	Concentrations of $PM_{2.5}$ emissions are mostly contributed by residential areas, brick kilns, and industries in Indian cities	Right mitigation measures	-
	Sea level rise/flooding		
Bhuiyan and Dutta [78]	Increased salinity intrusion into the Gorai River in Bangladesh	Advocated for the appropriate adaptation plans	-
Wong et al. [79]	Regionally, megacities in Africa, South, Southeast, and East Asia, and the Small Islands States have the highest vulnerabilities to sea level rise	The need for adaptation plan	-
Wang et al. [80]	The potential impacts of rising tides on residential buildings in Australia	The need for adaptation	-
Abadie [81]	potential greater damage for Guangzhou, China and New Orleans, U.S.A. due to sea level rise risk	The need for potential huge adaptation assets in these countries	-
Mycoo et al. [82]	Vulnerable state of Greater Bridgetown, Barbados due to sea level rise	The significance of human adaptation and the safety of precious coastal assets	-
Moeslund et al. [83]	Potential flooding in Aarhus, Denmark in the event of extreme weather phenomena	The incorporation of appropriate flood models in potential city planning	-
Mortsch [84]	Flooding challenges in downtown London, Ontario, Canada	Increase adaptation	-
Le Cozannet et al. [85]	Probabilistic marine flooding in the urban Mediterranean basin in Lion, France	The consideration of a change-centered global sensitivity analysis of potential marine flooding	-

Table 2. *Cont.*

Author	Key Findings	Recommendations	Specific Evidence
	Sea level rise/flooding		
Cheng et al. [86]	the effectiveness of detention in decreasing flood hazards in the Charles River watershed in Boston, U.S.A.		The use of detention in controlling flood hazards
Samu and Kentel [87]	Greater part of Zimbabwe has low to medium (2.3% likelihood) flood incidence	The need for the execution of proper mitigation measures	-
Martínez-Gomariz et al. [88]	The effects of pluvial flood risk in Badalona, Spain	The need for a comprehensive adaptation plan	-
Abadie et al. [89]	Potential coastal flood damage in Guangzhou, China; Mumbai, India; and New Orleans, U.S.A.	The need to encompass the likelihood of high-end scenarios into coastal urban adaptation development	-
	Extreme temperatures		
Lee and Levermore [90]	An increase in mean surface temperature and its effect on heat and cold in the cities of Seoul and Ulsan, South Korea	The need for improved mitigation	-
O'Neill et al. [91]	Excessive heat events in 285 communities in the U.S.A	The need for more collaboration and economic resources to assist widespread mitigation actions	-
Adachi et al. [92]	Present and potential increased urban heat island (UHI) in Tokyo, Japan	Increase mitigation measures against UHI for the city	-
Tromeur et al. [93]	The energy needs for residential buildings and comfort (heat) in 10 French cities.	The need for city managers to think about green space spots, push polluting actions beyond the city, and lower car traffic for riders	-
McPhee et al. [94]	Potential heat events in Santiago, Chile due to increasing temperatures and decreasing precipitation	The need for effective adaptation plans	-
Shevchenko et al. [95]	Heat wave episodes in Lugansk and Henichesk, Ukraine	The need for adaptation	-
Cinar [96]	Increased UHI in Fethiye, Turkey due to a rise in night-time temperatures.	The need to consider street alignment of buildings and the dimensions of public and green areas in city management and design	-
Hamdi et al. [97]	Potential neutral and increased warming in annual mean UHI intensity and nocturnal UHI, respectively, in the cities of Brussels (Belgium) and Paris (France)	Appropriate adaptation plans	-
Alves et al. [98]	Residential thermal discomfort situation in São Paulo, Brazil	Improve adaptation plan	-
Invidiata and Ghisi [99]	Potential increase in residential energy demand of buildings in the cities of Curitiba, Florianópolis, and Belém, Brazil	The utilization of passive design plans in buildings	-
Li et al. [100]	Potential for higher temperatures and severe heat waves in Toronto, Ontario, Canada	The effectiveness of their research in helping policymakers realize potential temperature changes in Ontario	-
Lassandro et al. [101]	The effectiveness of green roofs, water jects, and cooling resources increasing temperatures	-	The use of green roofs, water jects, and cooling resources
Kotharkar et al. [102]	Significant variation in temperature regime and heat stress within Nagpur, India	Their research can provide heat response planning and mitigation plans to the area	-

Table 2. *Cont.*

Author	Key Findings	Recommendations	Specific Evidence
	Health		
Knol et al. [25]	14 European technocrats ranked a medium-to-high association between increased short-term ultrafine particle exposure and mortality and morbidity for cardiac and lung diseases	The need to consider ultrafine particles in potential health risk assessment	-
Baccini et al. [26]	Heat related mortality for summer went from zero (0) in Dublin, Ireland to 423 in Paris, France	The need for improved mitigation	-
Petkova et al. [27]	showed that heat-associated mortality per thousand population increased in Philadelphia, New York city and Boston, respectively, from 1985 to 2006	The effectiveness of their study in developing measures that can reduce potential heat effects	-
Muthers et al. [103]	Potential rise in heat-associated mortality of about 129% in the city of Vienna, Austria	The need for adaptation	-
Ostro et al. [104]	Increased premature deaths in California, U.S.A.	The increased use of air conditioners as a mitigation measure for heat risk	-
Kim et al. [105]	Projected increased mortalities in Seoul, Daegu, Gwangju, Busan, Incheon, and Daejeon, South Korea	The need for effective measures that can cause significant health improvement and decrease heat-associated mortality	-
Rasmussen et al. [106]	Increased ragweed species in the European countries of Denmark, France, Germany, and Russia by the year 2100	The need for preventive measures to limit ragweed seed spread and the application of inter-country management measures for increased mitigation of potential health risk	-
Chen et al. [107]	Potential increase in surface O_3 and associated mortality in China	The need for mitigation measures	-
Estoque et al. [108]	High heat health risk in the Manila metropolitan area, Philippines	The strength of their research can assist in risk reporting and improve knowledge of city-scale health risks	-
	Water supply/drought		
Gober et al. [109]	Current per capita water use in Phoenix, Arizona, can be maintained in the absence of unmanageable groundwater use	The need to monitor groundwater for improved adaptive plan	-
Galvão et al. [110]	Rainwater catchment structures are used in the urban areas in Brazil and Japan to increase water source and use	The need for improved mitigation	-
Wilson and Weng [111]	Water quality issues in the Des Plaines River watershed in Chicago, Illinois, U.S.A. during late winter and early spring	The effectiveness of their study in contributing to the reduction of negative effect on surface water quality and improved mitigation	-
Jacinto et al. [112]	Potential reduction in water use in Portugal until 2100	The need for proper adaptation plan	-
Huang et al. [113]	Variations in water resources and potential drying trends and their effects on water resources in Chinese cities	The need to address water resource challenges and adapt to the impacts of climate change	-

Table 2. *Cont.*

Author	Key Findings	Recommendations	Specific Evidence
	Water supply/drought		
Ougougdal et al. [114]	Increased water demand and related water scarcity problems in Ourika, Morocco,	Appropriate adaptation plan	-
Alkhawaga et al. [115]	Potential water security condition in Kafr El Sheikh city, Egypt	the need for frequent evaluation of water security features for Egyptian cities	-

5. Discussion

The study assessed the impacts of IPCC ARs on academic research on risk mitigation and adaptation concerns in urban areas. The study has shown how research advances before and after the release of each of the IPCC ARs. This review has revealed the little or no interest by the IPCC in their first three ARs (FAR, SAR, and TAR) in the concerns of risk mitigation and adaptation in urban areas, thereby showing few studies (only 2). This is also reflected in the 5 years before and 5 years after analyses of the IPCC ARs, where the combined total number of studies produced under FAR, SAR, and TAR was only 6 (see Figure 3). Notwithstanding, attention was given to risk mitigation and adaptation in urban areas 5 years after the release of the AR4, with increased attention from the AR5 in 2014. It is interesting to note that it was in this report (AR5) that the IPCC first recognized urban areas and the associated urbanization [46]. Since then, the IPCC's impact on risk mitigation and adaptation concerns in urban areas has increased. The impact in this regard influenced further investigations and the related increase in the number of studies by different researchers from different countries. For example, the highest number (74) comes from China, and 2019 was the year with the highest (51) number of publications on risk mitigation and adaptation in urban areas.

The studies problematizing the subject in question were conducted at a wide scale (from local to global scales) with the East Asia and Pacific, and Europe and Central Asia regions showing more interest in IPCC ARs. This is reflected in their increased number of studies and their attempt to address climate risk in urban areas through mitigation and adaptation measures. Little interest is observed in Sub-Saharan Africa, and this could be due to their low socio-economic and human capital. The study again revealed that data for urban risk mitigation and adaptation is obtained from secondary sources through governmental and non-governmental bodies and the academic community. For improved risk mitigation and adaptation, quantitative analysis of data and model techniques have increased and are highly utilized in many research studies such as [26,62].

The study systematically reviewed literature and showed the diverse concerns researchers bring up about risk mitigation and adaptation in urban areas. The concerns are grouped into six major categories: (i) socio-economic concerns; (ii) air quality concerns; (iii) sea level rise/flooding; (iv) extreme temperatures; (v) water supply/drought, and (vi) health concerns.

As mentioned elsewhere in the study, health plays a crucial role in socio-economic growth. It is, therefore, essential to emphasize the negative health effects due to extreme temperatures and air pollution, and more importantly, the role of the IPCC ARs in that regard. It is interesting to note that negative health-related issues with regard to this review only appeared in the years 2009−2020 and were based on scenarios at the national and local scales. Thus, this review did not find studies on negative health effects arising from extreme temperatures and air pollution in the IPCC's first four ARs (i.e., no study was identified from 1990−2007). However, from 2009−2020, 20 studies (indicating 5%, see Figure 4) were found, with more than half of the studies (14) appearing after the IPCC's AR5 in 2014. The high number of studies on the negative health concerns could be due to the introduction and significance that was first given to urban areas in the IPCC AR5 [46].

Considering the diverse concerns and issues confronting numerous urban areas indicated in this review, it is interesting to note that many studies failed to propose specific risk mitigation measures and adaptation plans. While the urban challenges were easily identified, most researchers made general recommendations, with only a few proposing specific solutions to the urban area under study and their potential application to other urban areas. With urban areas and cities at the center of climate risk mitigation and adaptation [18,34], and population growth in urban areas being considered as a driver of global warming [14], this study believes that researchers should provide more specific evidence of risk mitigation measures and adaptation plans. For example, Rosatto et al. [69] proposed the use of green roofs in regulating the thermal change of buildings; Kousis et al. [70] proposed the global use of bio-oils for increased mitigation against urban noise islands; Cheng et al. [86] proposed the use of detention in decreasing flood hazards in the Charles River watershed in Boston, U.S.A., and Lassandro et al. [101] proposed the use of vegetation, green roofs, and water jects for mitigating heat risk in Bari, Italy. It must be stated that this study does not stand to disregard general recommendations on risk mitigation and adaptation in urban areas. However, considering the present and potential vulnerable state of many urban areas, the provision of specific evidence is equally important for improved mitigation and adaptation of climate risks in urban areas.

There is a possibility of bias in the present results, especially on the statement that significant research studies appeared after the release of the IPCC AR5. The study placed emphasis on the relation between IPCC reports and academic research on climate risk mitigation and adaptation in urban areas, and excluded studies that did not mention IPCC. Here, we must state that climate-related problems of urbanization were known and discussed in scientific papers well before the formation of the IPCC. For instance, the studies of Clarke [116] on urban structure and heat mortality, and Oke [117] on climatic impacts of urbanization.

6. Conclusions

The impacts of IPCC ARs on academic research on risk mitigation and adaptation concerns in urban areas have been systematically appraised. It has been established that greater significance was attached to risk mitigation and adaptation in urban areas starting from the last two ARs. These ARs challenged countries and researchers to further risk mitigation and adaptation research for increased urban resilience and sustainability. This review has shown the great interest by the East Asia and Pacific, and Europe and Central Asia regions in IPCC ARs, reflecting their increased number of scientific studies on risk mitigation and adaptation in urban areas. The interests of the Americas (North America, Latin America, and the Caribbean regions) also need to be acknowledged. Notwithstanding, the Sub-Saharan African and the Middle East and North African regions need to be encouraged with motivation and resources for increased contribution and interest in IPCC ARs. Specific country determinations to risk mitigation and adaptation plans in urban areas were high in China and the U.S.A.

Several urban concerns, including socio-economic, air quality, extreme temperature, sea level rise/flooding, health, and water supply/drought, were revealed by the research following the release of each IPCC AR. This, thus, demonstrates the impact and influence of the IPCC ARs on risk mitigation concerns in urban areas. The concerns of most research studies were expressed in relation to socio-economic issues rather than extreme temperatures, which have received the most attention in the IPCC ARs, particularly the attempts to limit global warming at 1.5 °C (see https://www.ipcc.ch/sr15/faq/faq-chapter-1 accessed on 2 January 2022). Even though this raises doubt, we believe that these studies are moving in the right direction because increasing extreme temperatures are demonstrated by socio-economic and ecological impacts and the associated susceptibilities.

This review emphasized the negative health outcomes that arise from extreme temperatures and air pollution. This emphasis was made given the crucial role of health in urban development, especially in recent times where urban risk mitigation and adaptation are at the forefront. Considering the impact of IPCC ARs on climate risk mitigation and adaptation research promotion in urban areas, this review established that the negative health effects due to extreme temperatures and air pollution were not considered in the first four IPCC ARs. Thus, since the first release in 1990 until the fourth in 2007, no study on the negative health effects of extreme temperatures and air pollution was found with regard to this review. Negative health concerns, however, started to appear in 2009 and, with more concerns, raised after the launch of the IPCC AR5 in 2014. As the IPCC AR5 placed significant attention on urban areas and the urbanization process, it is equally important that the IPCC consider the negative health outcomes that arise from the climate–atmosphere interactions.

This review again demonstrated that risk mitigation policies in urban areas outnumbered adaptation policies or the combination of both policies. While this confirms urban centers' efforts to reduce climate risk, we advocate for the combination and increased use of both policies in urban areas as stressed elsewhere in this review. Although their integration comes with a huge cost, we believe that mitigation and adaptation complement each other. It must be stated that some countries and their urban centers already have both (mitigation and adaptation) policies. However, the extensive admission and application of both policies in all urbanized centers of the world should be the focus. The IPCC, with greater influence, can help push in that regard. Additionally, studies following the IPCC ARs and demonstrating their impact should also advocate for both risk mitigation measures and adaptation plans with specific evidence. The provision of specific mitigation and adaptation plans in the study outcome for a particular urban area can be applied to other urban areas with similar challenges. In this way, the new urban agenda in facilitating resilient urban areas and cities can be attained.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/cli10080115/s1, Table S1: Keywords combination used in WoS and Scopus databases, Table S2: Summary of all the studies (370) used in the systematic review.

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