sustainability

MDPI

Review

Study on the Progress in Climate-Change-Oriented Human Settlement Research

Qiang Yao [1], Na An [1,*], Ende Yang [2] and Zhengjiang Song [3]

[1] College of Architecture and Urban Planning, Tongji University, Shanghai 200092, China
[2] School of Humanities and Arts, Chongqing University of Science & Technology, Chongqing 401331, China
[3] Chengdu Institute of Planning & Design, Chengdu 610041, China
* Correspondence: anna2010255@tongji.edu.cn; Tel.: +1-3329105889

Abstract: Since the 20th century, the escalating impact of climate risks has led to a heightened global focus on climate-change-oriented human settlement research (hereafter referred to as CCHSR). This paper presents an econometric analysis of 6830 research papers published from 1975 to 2023 (first two months) to investigate the characteristics, key issues, and research trends in CCHSR, to provide valuable insights and recommendations for future research. We used CiteSpace, bibliometric software that constructs a knowledge-mapping analysis of annual publication volume, source publications, and country distribution; this study examines the characteristics of the literature sources in CCHSR. It also explores the literature distribution through an analysis of co-citation and collaboration. The study identifies the key topics of current research through a keyword clustering analysis, including extreme climate risk response, environmental safety and sustainability enhancement, and machine learning technology application. The study identifies three research trends for future investigations by analysing keyword emergence, including climate risk governance implementation, artificial intelligence technology application, and settlement security and resilience enhancement. Finally, the study presents recommendations for priority CCHSR in three areas: theoretical system development, mechanism strategy design, and technology implementation.

Keywords: climate-change-oriented; human settlements; key issues; research trends; knowledge mapping

check for updates

Citation: Yao, Q.; An, N.; Yang, E.; Song, Z. Study on the Progress in Climate-Change-Oriented Human Settlement Research. *Sustainability* **2023**, *15*, 5733. https://doi.org/10.3390/su15075733

Academic Editors: Linchuan Yang, Bao-Jie He and Junqing Tang

Received: 28 February 2023
Revised: 20 March 2023
Accepted: 22 March 2023
Published: 24 March 2023

1. Introduction

Since the 20th century, the impact of climate risks on various elements of human settlements, including ecology, settlement forms, and infrastructure, has been steadily increasing [1,2]. According to the United Nations Intergovernmental Panel on Climate Change (IPCC), the Earth's average temperature has risen by 0.4 to 0.8 °C since the 20th century, accelerating in the last 60 years [3]. It has sharply increased climate-related disasters, leading to significant human casualties and economic losses [4]. The number of such disasters between 2000 and 2019 nearly doubled compared to the previous 20 years [1].

Frequent climate extremes have prompted urgent climate action worldwide [5], such as the Kyoto Protocol, Paris Agreement, Nationally Determined Contributions, and other action plans under the United Nations Framework Convention on Climate Change [6–8]. As the virtual environment for human survival [9], human settlements are highly vulnerable to climate change's inevitable impacts [10]. Preparing for extreme climate change is necessary to mitigate the multifaceted effects of climate hazards on human settlements [11]. Hence, climate-change-oriented human settlement research (hereinafter referred to as CCHSR) is crucial for sustainable urban development and climate change mitigation.

Previous studies have examined the response of human settlements to climate change [12,13], with a focus on adaptation to change [14], risk identification [15], and disaster impacts [16]. However, few research results have utilised knowledge mapping to analyse the literature on CCHSR. Previous studies have primarily focused on the urban microclimate [17], ecosystem health [18], and carbon-oriented impacts of human settlements [2]. While these reviews have provided valuable insights into the relationship between human settlements and climate change, they have paid little attention to the characteristics and stages of research on climate-change-oriented human settlements. Knowledge mapping can analyse the network of relationships, knowledge lines, and hot trends among a large body of literature [19], and it is employed in this paper to explore the research characteristics and hotspot trends of climate-change-oriented human settlements. This analysis method enables readers to understand the content of this interdisciplinary field quickly and accurately as well as intuitively grasp its research hotspots and evolutionary patterns.

Therefore, this study aims to combine knowledge mapping analysis with traditional literature review methods to investigate three main aspects: (1) we collect CCHSR literature and analyse its research status, cooperation networks, research hotspots, and developmental stage features; (2) we analyse the methods and objects of CCHSR, summarise their characteristics, explore their research features and hotspot trends, and visualise them through central keyword frequency and emergent analysis, and (3) we discuss the limitations of CCHSR and identify future key topics related to climate change and human settlements.

2. Materials and Methods

In contrast to traditional mathematical and statistical software, the knowledge mapping software CiteSpace used in this paper offers visual analysis functions such as collaboration, citation, and literature coupling [20]. These functions enable the scientific analysis of research collaborations, assessment of academic influence, and exploration of research frontiers, thereby revealing trends and dynamics in scientific research. Co-citation studies in particular offer valuable insights into the underlying research patterns and help to summarise, synthesise, and integrate the characteristics of the research field [21].

This paper conducts a knowledge mapping visualisation and analysis of literature on CCHSR included in the Web of Science core database from 1990 to 2023 (first two months). The search was conducted on 15 February 2023, and the search period included all years (default 1975–2023). The search model used was "topic" + "document type", with "(human settlements OR living environments OR human settlements environment) + (climate change)" as the subject terms, and documents were limited to the English language, resulting in a total of 6830 entries, with the earliest publication year being 1990. The research framework of this paper is shown in Figure 1.

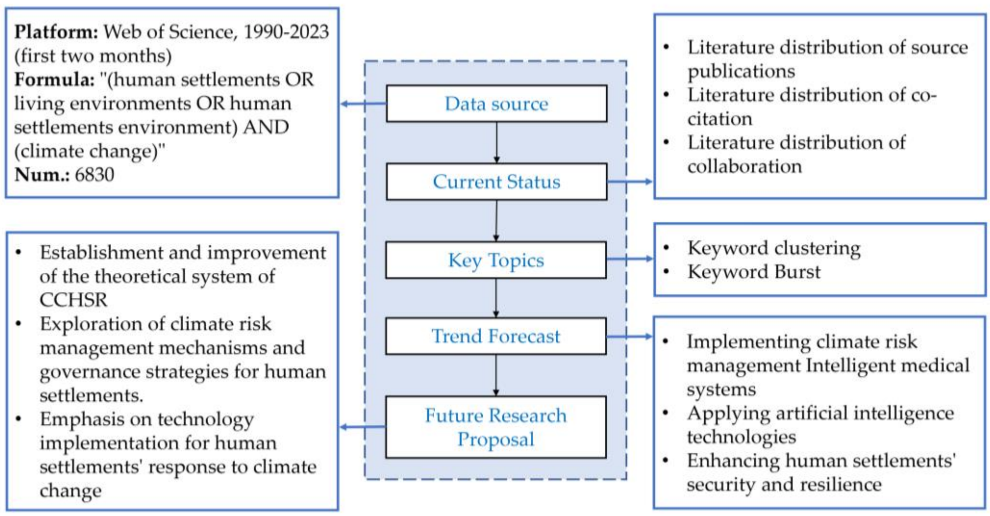

Figure 1. Outline of CCHSR design.

3. Results

3.1. Analysis of Literature Sources

Using the online analytical function of Web of Science (WOS), it is evident that the total number of CCHSR publications exhibits a fluctuating yet positive trend (Figure 2), with the highest number of publications occurring in the past five years. The number of literature studies published per year was relatively low until 2003 (fewer than 40 literature studies per year), indicating that CCHSR was still in its exploratory stage with less attention given to it. From 2003 to 2016, literature study numbers increased gradually. The main development phase of CCHSR can be considered to have occurred between 2017 and 2022, during which more than 57% of the literature studies (3900 out of 6830) were published. The number of literature studies is expected to exceed 900 in 2023. This trend shows that current CCHSR has become one of the current research hotspots.

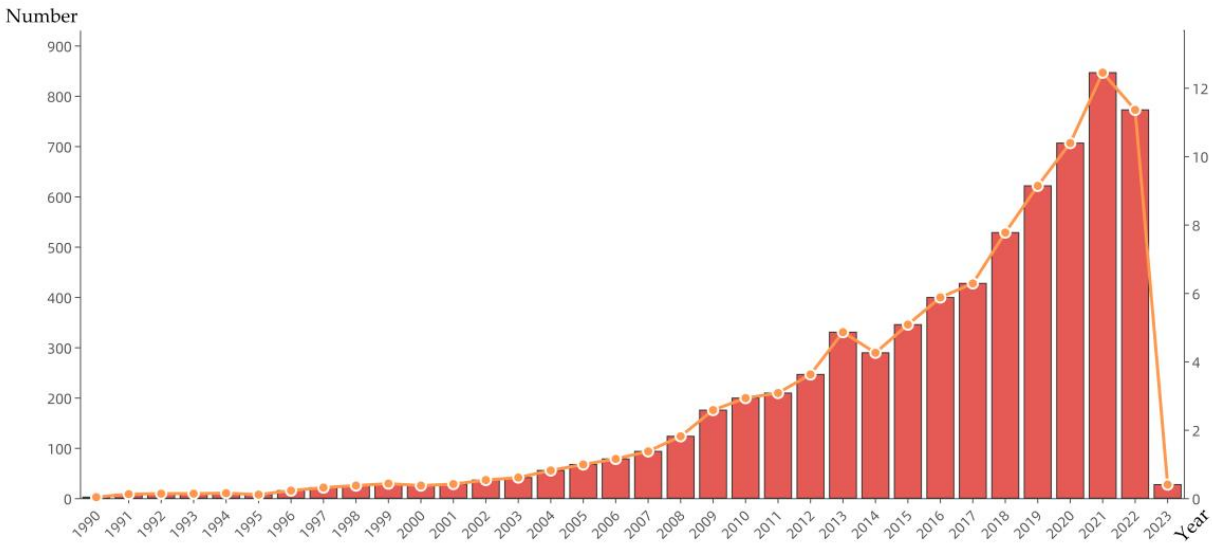

Figure 2. Number of publications on CCHSR, 1990–2023 (first two months).

The analysis of countries reveals that the USA is the leading country in CCHSR (Figure 3) with 1814 publications, followed by the UK, China, and Australia. Since 1990, the USA has been researching climate-change-oriented human settlements and the nation's research output has steadily increased, with more than 30 publications per year since 2004 and over 100 publications per year since 2015. In contrast, China's CCHSR started later in 1995 and its annual publication rate was lower than that of the USA, with less than 70 publications per year until 2019. However, there was a significant increase in the publication number of CCHSR studies in China in 2020, indicating potential for future development.

Based on the bibliographic data, the analysis in Figure 4 shows 2661 source publications related to CCHSR, with the highest number of literature studies published in *Quaternary International* (2.65%) and *Holocene* (1.97%). The top 10 source publications mainly focus on environmental, sustainability, and ecology themes. The H-index, which indicates the high citations for periodicals, highlights *PNAS USA* (H = 805) as the most influential source journal for CCHSR, focusing on biology and social science research. *Plos One* (H = 367) and *Ecology and Evolution* (H = 357) also have high H-indexes, suggesting that CCHSR is primarily published in ecology, public science journals, and palaeoclimatology.

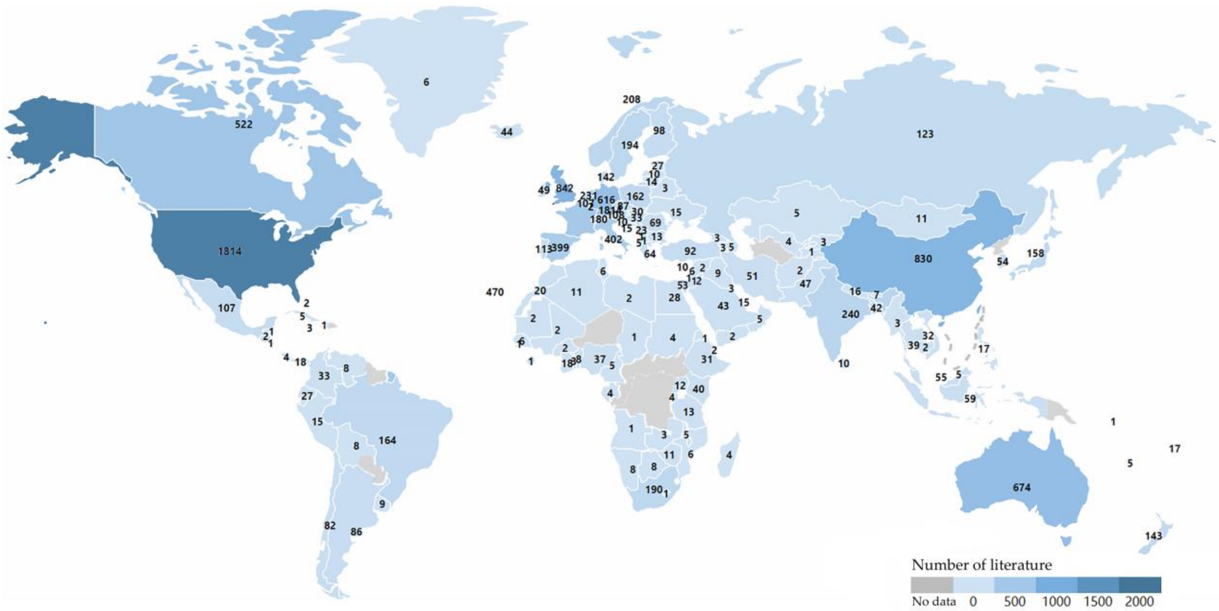

Figure 3. Distribution of countries publishing on CCHSR.

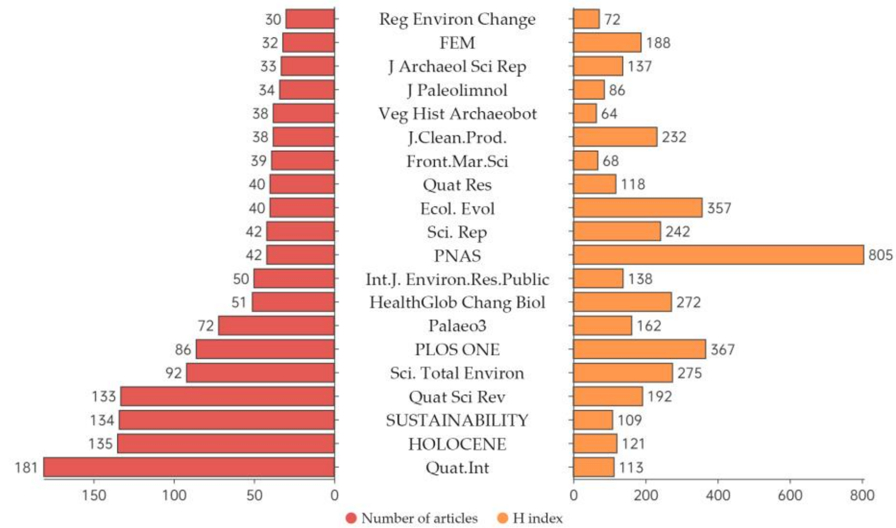

Figure 4. Distribution of publications on CCHSR.

3.2. Co-Citation Analysis of the Literature

3.2.1. Co-Citation Journals

This study used journal co-citation analysis to identify the core journals and disciplinary attributes of CCHSR [22]. CiteSpace software was used to create a visual map with 1285 nodes and citation rates were used to assess the importance of journals [23]. Each node in the resulting Figure 5 represents a journal and the strength of the co-citation relationship between two journals is indicated by the line connecting them, with node size proportional to the number of citations a journal receives. The red circles in the figure represent the nodes' centrality and the circle sizes reflect the strengths of the links between journals.

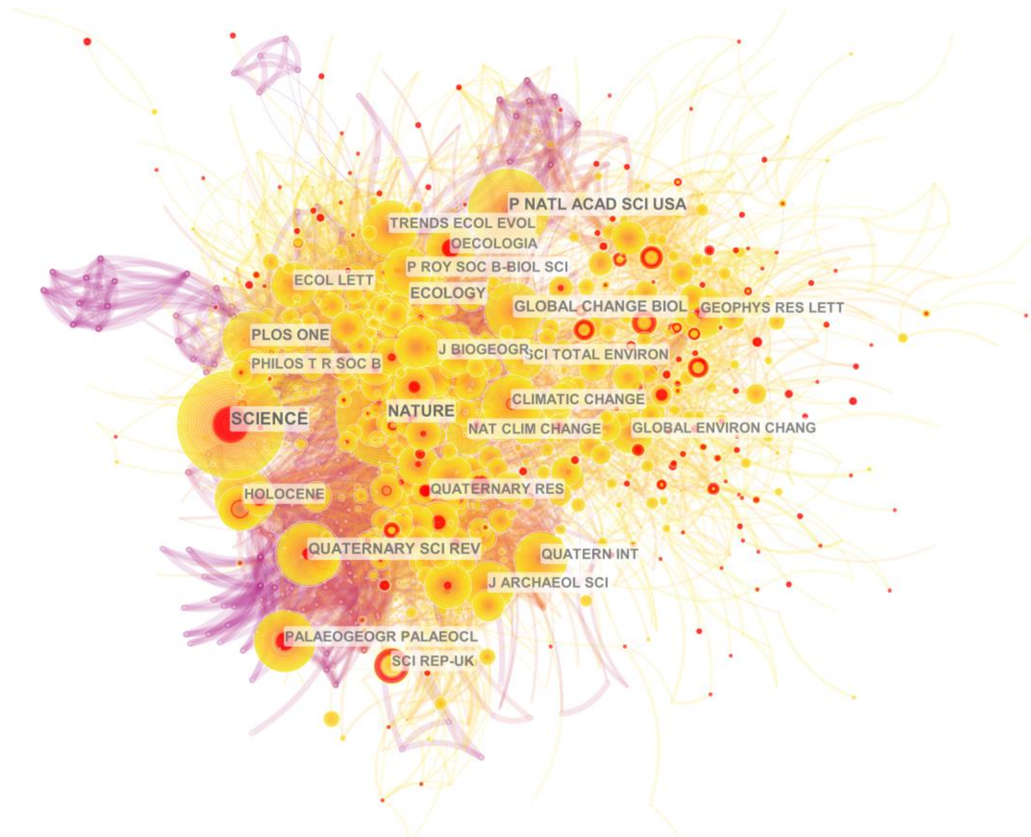

Figure 5. Co-citation mapping of CCHSR journals.

Figure 5 illustrates the most highly cited journals, with over 600 citations in CCHSR. The analysis indicates that *Science*, *Nature*, and *PNAS USA* are the most frequently cited journals, suggesting that they publish high-quality research and are core journals in this field. Table 1 shows the 20 most influential journals in CCHSR, ranked by the number of citations. These journals cover a range of disciplines, including climate, environment, biology, and social sciences, and reflect the multidisciplinary nature of this research area.

3.2.2. Co-Citation Literature

This study conducted a literature co-citation analysis to reflect the evolution of research and knowledge contexts at different stages [24]. Using CiteSpace, a network containing 1602 nodes was created based on a visual analysis of 6830 CCHSR literature studies in the Web of Science core database. The nodes in Figure 6 represent the literature citations in the database, with the connections between the nodes representing the co-citation relationships between the literature studies [25]. The strength of the co-citation relationships is reflected by the number of node connections, while the node size is proportional to the importance and novelty of the literature. The co-citation network in Figure 6 shows the documents cited more than 20 times, along with their primary authors and years of publication.

Table 1. Top 20 highly cited CCHSR journals.

Number	Journal Name	Reference	Years
1	*Science*	3180	1992
2	*Nature*	2788	1992
3	*Proceedings of the National Academy of Sciences of the USA*	2477	1997
4	*Plos One*	1759	2009
5	*Quaternary Science Reviews*	1291	1994
6	*Ecology*	1248	1991
7	*Global Change Biology*	1192	1998
8	*Climatic Change*	1096	1993
9	*Quaternary Research*	1042	1992
10	*Palaeogeography, Palaeoclimatology, Palaeoecology*	1041	1990
11	*Holocene*	1034	1995
12	*Quaternary International*	1032	2004
13	*Geophysical Research Letters*	979	1997
14	*Trends in Ecology & Evolution*	972	1994
15	*Science of The Total Environment*	970	1998
16	*Scientific Reports*	953	1999
17	*Nature Climate Change*	906	2014
18	*Proceedings of the Royal Society B: Biological Sciences*	897	2012
19	*Journal of Archaeological Science*	771	1994
20	*Journal of Biogeography*	767	1997

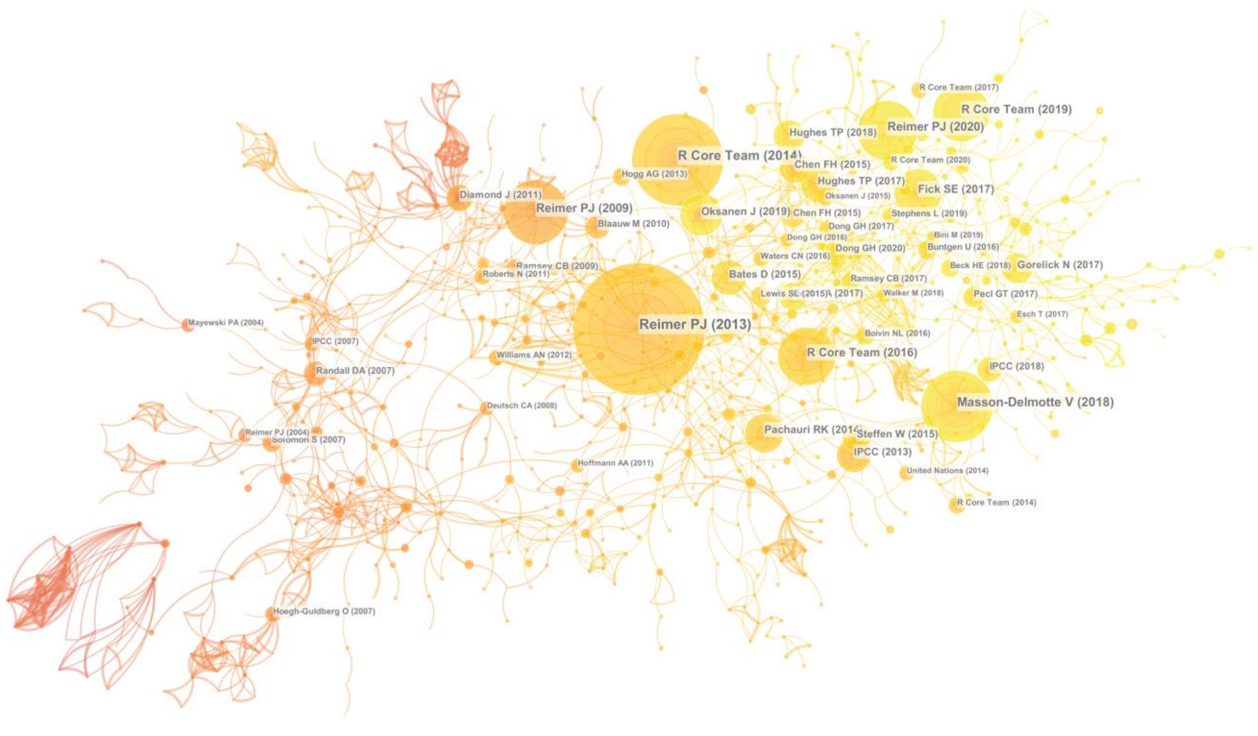

Figure 6. Co-citation mapping of CCHSR literature.

Table 2 presents the 20 most highly cited literature in CCHSR. Combined with Figure 6, it is evident that the two kinds of literature by Paula Reimer et al. investigating the environmental effects of past climate change [26,27] received the highest citation counts of 101 and 51, respectively. By examining the distribution of the top 20 cited literature, it can be observed that CCHSR mainly focuses on three areas: updating climate data and technology, developing strategies for addressing climate change, and exploring the adaptation of human settlements to climate change.

Table 2. Top 20 highly cited literature studies on CCHSR *.

Number	Literature Study Name	Cited Number	Years
1	Intcal13 and marine13 radiocarbon age calibration curves, 0–50,000 years cal BP [26]	103	2013
2	Intcal09 and marine09 radiocarbon age calibration curves 0–50,000 years cal BP [27]	72	2014
3	WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas [28]	57	2018
4	Evaluation of climate models. in: climate change 2013 [29]	51	2009
5	Global warming and recurrent mass bleaching of corals [30]	47	2020
6	R: A language and environment for statistical computing [31]	46	2016
7	Fitting linear mixed-effects models using lme4 [32]	44	2019
8	Composition and consequences of the intcal20 radiocarbon calibration curve [33]	38	2017
9	Climate change 2014 [34]	33	2019
10	Ar5 synthesis report: climate change 2014 [35]	31	2014
11	Agriculture facilitated permanent human occupation of the Tibetan plateau after 3600 B.P. [36]	28	2015
12	Planetary boundaries: guiding human development on a changing planet [37]	28	2013
13	Google earth engine: planetary-scale geospatial analysis for everyone [38]	28	2017
14	Spatial and temporal patterns of mass bleaching of corals in the Anthropocene [39]	25	2018
15	Holocene fluctuations in human population demonstrate repeated links to food production and climate [40]	24	2015
16	A report of working group I of the intergovernmental panel on climate change [41]	24	2015
17	A language and environment for statistical computing [42].	24	2017
18	Vegan: community ecology package. R package version 2.5-6. 2019 [43]	23	2017
19	Ar4 climate change 2007: the physical science basis [44]	23	2011
20	Methods and code for 'classical' age-modelling of radiocarbon sequences [45]	21	2018

* Highly cited literature studies 6 and 17 contain a free software environment for statistical calculations and graphics written by the R core team. Literature study 18 is an R language package for sorting methods, diversity analysis and other functions for community and vegetation ecologists written by Oksanen et al.

The first main area of focus in CCHSR consists of updates in climate data and technology. It covers various topics, such as temporal projections in remote areas, terrestrial climate projections, and updates in R-language techniques. One example of data-related research is Raymer's calibration of radiocarbon curves, which improves the accuracy of temporal predictions in remote areas [26,27]. Fick modelled a new 1 km spatially resolved climate surface over global land areas to analyse the accuracy of temperature, humidity, wind speed, and other factors on environmental climate predictions [28]. In terms of technical aspects, there has been an emphasis on the application and updating of new techniques, including cross-determination techniques in R-language [31,42], optimisation of lmer functions [32], and the use of environmental monitoring techniques such as Google Earth Engine [38,45], which have been recently updated and simplified.

The second main area of focus in CCHSR consists of strategies for sustainable development in response to climate change. Research in this area spans from policy analysis by IPCC organisations to investigations of the ecological impacts of climate risks, such as global warming [30,39]. For instance, Stocker predicted regional and international climate change to assess climate system components and interactions [46]. Pachauri argued that climate change would have severe and irreversible impacts on human settlements and ecosystems and that greenhouse gas emissions must be controlled [34]. Fahu Chen proposed a novel agropastoral economy in human settlements to address climate change challenges such as declining temperatures [36]. Steffen introduced the concept of planetary boundaries to quantify different climate changes, including stratospheric ozone depletion and ocean acidification, and emphasised the need to combine continued human development with environmental system maintenance to enhance resilience and adaptive capacity [37].

3.2.3. Co-Citation Authors

To identify the most prominent and active authors in CCHSR, this study employs co-citation analysis through Citespace (Figure 7). Each node corresponds to an author, while the interconnecting lines between nodes indicate their co-citation strengths. The size of each node fits the number of citations received by the author, thus signifying their research influence. Additionally, the red circles within each node denote the level of burstiness in citation frequency over a specific period. It identifies the authors demonstrating the potential for growth and research value during the period [45].

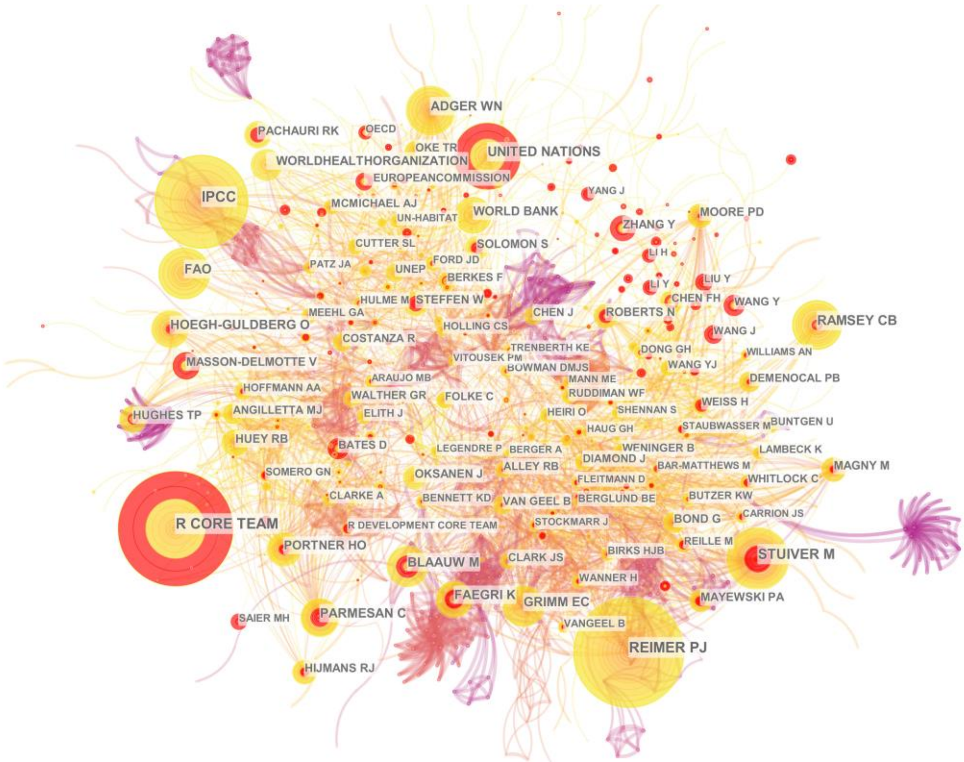

Figure 7. Co-citation mapping of CCHSR authors.

The present study sets the minimum threshold for visual analysis at 50 citations, highlighting authors with a minimum of 50 sources. R Core Team is the most highly cited author in CCHSR (cited by 400), focusing on using R language techniques in climate prediction [31,42]. Paula Reimer is the second most highly cited author in this field (cited by 385), having calibrated the accuracy of radiocarbon in paleoclimate prediction [26,27]. Several associations and institutions have been found to exhibit high co-citation frequencies. For instance, IPCC has a frequency of 349, while FAO has a frequency of 185. These organisations are involved in climate response, technology development, and food security. These findings underscore the importance of addressing the human settlement issues that arise from climate change [34]. Stuiver's highest centrality score indicates that this researcher's work is highly influential and well-connected within the scientific community. Stuiver's research focuses on paleoclimate and carbon calibration evolution in trees [47]. Table 3 shows the top 20 authors with the highest number of citations in the fields of climatology [26], human geography [48], and paleoecology [49], suggesting that core authors play a crucial role in advancing research on climate change and sustainability (CCHSR).

Table 3. Top 20 highly cited CCHSR authors.

Number	Cited Author	Cited Number	Year
1	R Core Team	400	2014
2	Reimer PJ	385	2008
3	IPCC	349	1998
4	STUIVER M	248	1997
5	United Nations	237	2007
6	Ramsey CB	192	2005
7	FAO	185	2010
8	Adger WN	185	2008
9	GRIMM EC	164	1997
10	Faegri K	162	1996
11	Parmesan C	161	1999
12	Blaauw M	157	2012
13	Hoegh-Guldberg O	152	2007
14	World Bank	142	2011
15	World Health Organization	130	2000
16	Portner HO	128	2005
17	HUEY RB	111	2009
18	Moore PD	108	1994
19	Hughes TP	108	2008
20	MAGNY M	101	1996

3.3. Collaboration Analysis of the Literature

3.3.1. Author Collaboration

Collaboration analysis is a valuable method for exploring the level of collaboration among authors in various fields of scientific research worldwide. In this study, we employ CiteSpace, a tool for network analysis, to investigate scientific research collaboration at the micro (author), meso (institution), and macro (country) levels, providing a comprehensive demonstration of the level of cooperation across different scales. Figure 8 presents the degree of collaboration in CCHSR at the micro level, where node size represents the number of publications, and the distance between nodes and the thickness of the connections represent the strength of collaboration. This approach allows for identifying the top eight author collaboration clusters in CCHSR.

Figure 8 highlights Guanghui Dong as the most collaborative author in CCHSR, forming the most significant research group with Fahu Chen, the second most collaborative author, and six other authors. This group's research focuses on the interactions between human settlements and climate [50], finding that climate change has impacted human settlements from ancient times to the present day [51] and that a durable and stable climate has contributed to human settlements' prosperity [52]. The second-largest research group, led by Egill Erlendsson, has five nodes and focuses on the impact of climate change, land use, and landscapes on Icelandic human settlements [53]. This group has found that continued climate warming can increase land erosion and vegetation destruction in human settlements [54]. Additionally, the top 20 most prolific authors in CCHSR, based on the number of publications listed in Table 4, demonstrate little collaboration between the two most prolific authors, Fahu Chen (17) and Melanie Jane Leng (14). The top eight author collaboration clusters indicate many individual authors, suggesting that researchers in climate-change-oriented human settlements tend to work as individuals or in small groups. Thus, promoting in-depth collaboration between researchers is necessary for future research in CCHSR.

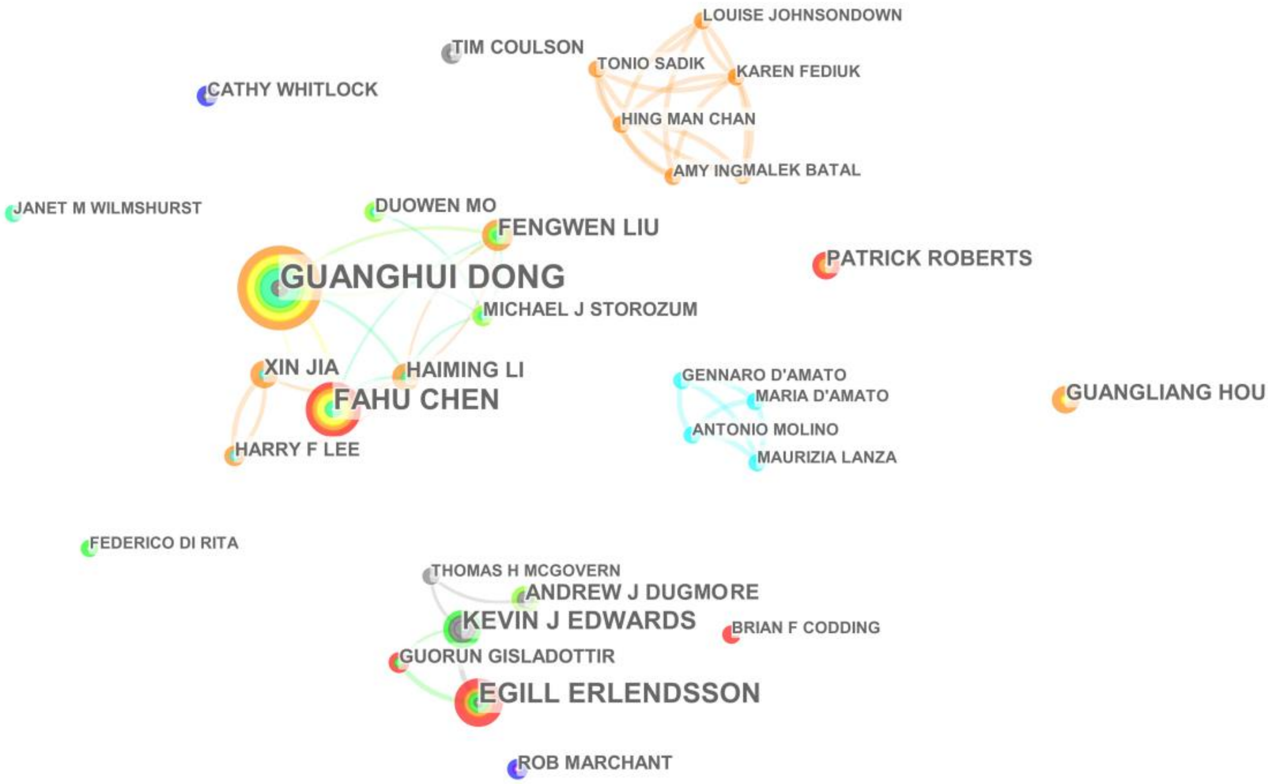

Figure 8. Collaborative mapping of CCHSR authors.

Table 4. Top 10 co-authors of CCHSR.

Number	Authors	Counts
1	Guanghui Dong	17
2	Fahu Chen	10
3	Alessio Palmisano	9
4	Egill Erlendsson	9
5	Stephen Shennan	7
6	Cheng Zhu	7
7	C Neil Roberts	7
8	Kevin J Edwards	7
9	Andrew Bevan	7
10	Jessie Woodbridge	7

3.3.2. Institutional Collaboration

Figure 9 presents the degree of collaboration in CCHSR at the meso level. Node size corresponds to the number of literature studies published by institutions, and the connections between nodes represent coordinated collaborations between different organisations. A higher number of connections between nodes indicates closer collaboration between institutions. The figure demonstrates a high level of collaboration and density between various institutions engaged in CCHSR.

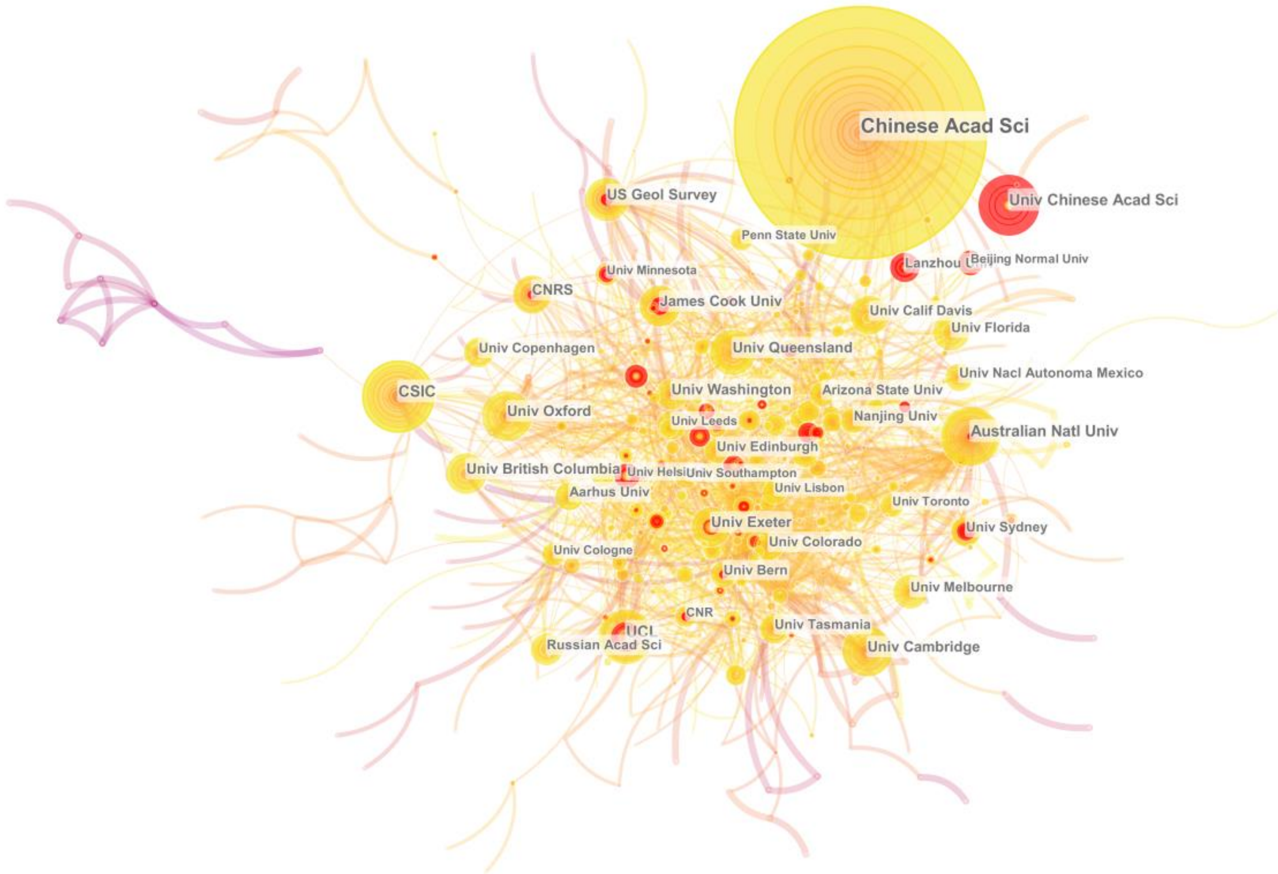

Figure 9. Collaborative mapping of CCHSR institutions.

Table 5 provides a detailed breakdown of the top 20 most influential institutions based on the number of publications, primarily from Europe, Australia, and China. The Chinese Academy of Sciences is the top-ranked institution with 922 publications, followed by the University of Chinese Academy of Sciences and Peking University (Peking University), with 344 and 180 publications, respectively. Notably, Chinese institutions contribute 39.4% of the literature studies in the top ten, showcasing their expertise and excellent research capacity in CCHSR.

3.3.3. National Collaboration

The macro level of collaboration analysis involves examining the collaboration between countries. Table 6 presents the top 20 countries for research collaboration, showcasing various publications between institutions. The top five countries alone account for 70% of the CCHSR literature, with the United States having the highest number of publications (1753).

Figure 10 presents a visual network for analysing national or regional collaboration in CCHSR. Each node in the figure represents a country, with node sizes representing the number of research literature studies published in that country and node connections reflecting the levels of collaboration. In the graph, a purple ring encircling a node indicates a country's centrality, with a ring's thickness reflecting the degree of its centrality and international influence. This visual representation highlights the key players in the network and their significance in shaping global interactions.

Table 5. Top 20 collaborating institutions for CCHSR.

Number	Institution	Year	Cooperation
1	Chinese Academy of Sciences	2001	922
2	University of Chinese Academy of Sciences	2013	344
3	Peking University	2004	180
4	Max Planck Inst Biogeochemistry	1999	172
5	Lund University	2001	168
6	The University of Exeter	2011	154
7	US Forest Service	2000	147
8	National Oceanic and Atmospheric Administration	2000	134
9	University of Helsinki	2002	132
10	Tsinghua University	2011	129
11	University of California, Berkeley	1998	128
12	US Geological Survey	1998	124
13	University Maryland	2005	123
14	University Colorado	2002	122
15	Columbia University	2003	122
16	National Aeronautics and Space Administration	1992	120
17	University of Copenhagen	1999	117
18	Russian Academy of Sciences	1998	109
19	Oak Ridge National Laboratory	1998	109
20	Colorado State University	1998	108

Table 6. Top 20 collaborating countries of CCHSR.

Number	Country	Year	Cooperation	Centrality
1	USA	1991	1753	0.54
2	PEOPLES R CHINA	1996	666	0.13
3	ENGLAND	1988	652	0.22
4	AUSTRALIA	1993	516	0.48
5	GERMANY	1992	492	0.11
6	CANADA	1993	397	0.28
7	FRANCE	1992	396	0.13
8	ITALY	1992	316	0.06
9	SPAIN	1991	316	0.06
10	NORWAY	2001	169	0.05
11	NETHERLANDS	1997	167	0.07
12	INDIA	1993	162	0.03
13	SWEDEN	1992	147	0.07
14	SWITZERLAND	1995	140	0.08
15	SOUTH AFRICA	1996	135	0.04
16	BRAZIL	1997	130	0.16
17	POLAND	1995	123	0.04
18	SCOTLAND	1998	118	0.05
19	JAPAN	1988	118	0.06
20	CAS	1997	115	0.01

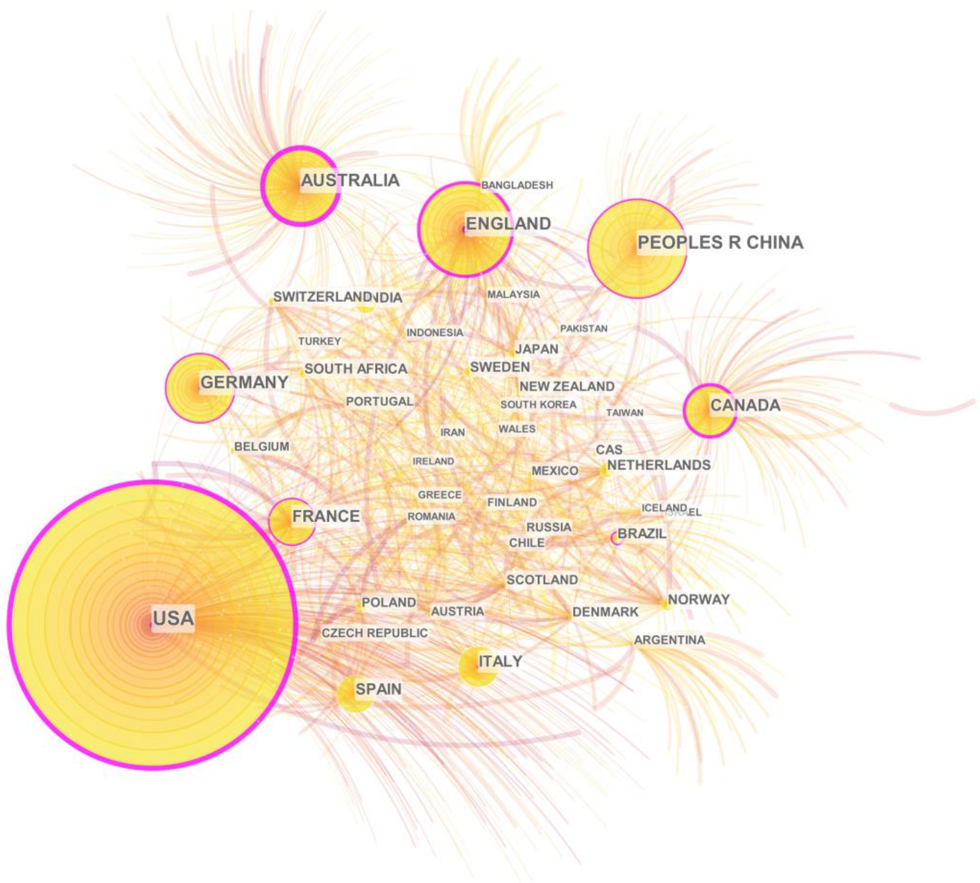

Figure 10. Collaborative mapping of CCHSR countries.

The country with the highest centrality is the United States (0.54), while China did not conduct research until 1996 and has a relatively low centrality (0.13) and a low overall citation rate of published papers.

3.4. Analysis of Key Topics Based on Keyword Clustering

3.4.1. Keyword Clustering Analysis

Keywords represent the authors' distillation and summarisation of the main content of articles and are often used in bibliometrics to identify research hotspots. This paper used CiteSpace to conduct a keyword analysis of CCHSR, resulting in 980 nodes. Figure 11 presents the keyword co-occurrence network of keywords with a frequency of 90 times or greater. Each node in the figure represents a keyword, with node size reflecting the frequency of keyword occurrences. The connecting lines between nodes represent the links between different keywords [55]. As shown in Figure 11, the most frequently studied keywords of CCHSR are climate, environment, adaptation, variability, vegetation, evolution, management, and environmental change.

Table 7 presents the top 20 most active and influential keywords in CCHSR. Initially, CCHSR focused on predicting and calibrating paleoclimate by analysing factors such as pollen [56], trees [57], and sediments [58] to explore the agricultural and landscape impacts of paleoclimate on human settlements [59]. Subsequently, the focus shifted to the effects of land use on human settlements and environmental change, particularly regarding vegetation [60]. Climate extremes can indirectly affect biodiversity and surface carbon levels, and researchers have predicted long-term climate trends through changes in climate in human settlements [61]. Growing biodiversity has led to increased consideration of human settlements' characteristics, such as adaptability and dynamism [62]. Over time, CCHSR has shifted its focus from studying the relationship between climate change and human settlements to examining habitat management and response, with a particular emphasis on understanding the vulnerability of human settlements under extreme climate change. For example, Drejza evaluates the effectiveness of human settlements zoning in reducing climate risks and stresses the need to strengthen the adaptive capacity of coastal communities to coastal hazards [63]. Tellman (2001) studied adaptation pathways for water supply and flood risk in human settlements and found that improving the climate robustness of human settlements can enhance their resilience to climate change [64].

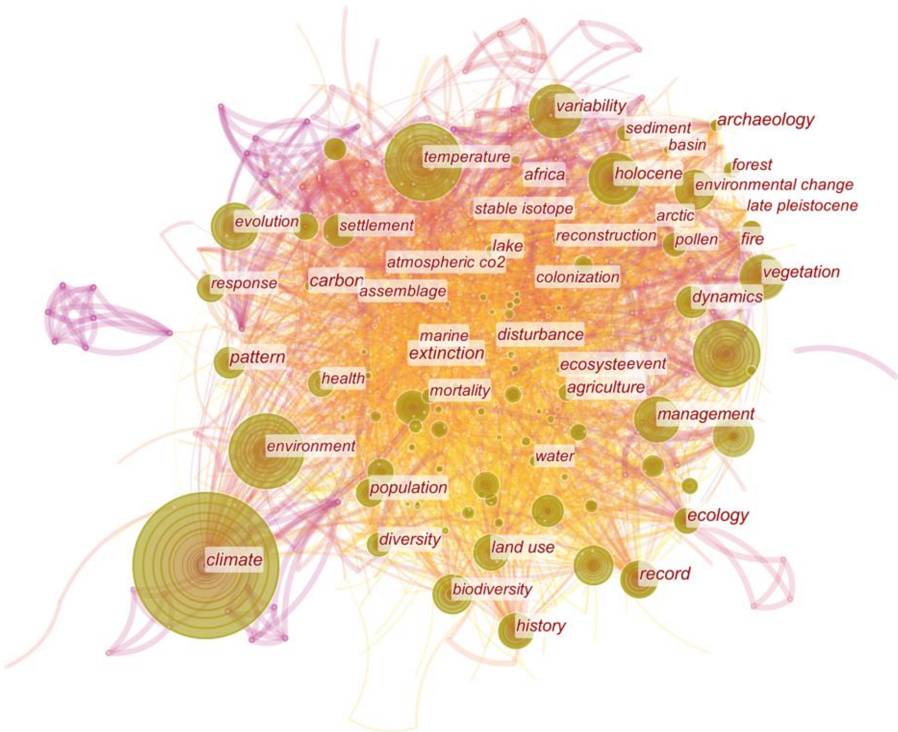

Figure 11. High-frequency keywords for CCHSR.

Table 7. Top 20 high-frequency keywords for CCHSR.

Number	Reference	Centrality	Years	Keywords
1	305	0.03	1991	holocene
2	717	0.08	1992	climate
3	220	0.04	1993	land use
4	406	0.04	1994	environment
5	243	0.02	1994	environmental change
6	238	0.03	1994	history
7	206	0.01	1994	conservation
8	296	0.05	1995	vegetation
9	229	0.03	1997	model
10	368	0.02	1998	adaptation
11	272	0.02	1998	evolution
12	227	0.05	1998	pattern
13	259	0.05	1999	record
14	234	0.02	2000	biodiversity
15	226	0.03	2000	dynamics
16	417	0.03	2001	temperature
17	302	0.03	2003	variability
18	259	0.04	2003	management
19	198	0.02	2004	settlements
20	239	0.01	2008	vulnerability

3.4.2. Summary of Key Issues

Keyword clustering is a practical approach for identifying research hotspots and trends in CCHSR. This paper employed CiteSpace to cluster the keywords in the literature, using the log–likelihood ratio algorithm to annotate each cluster. The clustering quality was assessed using module value (Q) and mean profile value (S). The module value (Q), which typically ranges from 0 to 1, with values above 0.3 indicating greater significance, measures the degree of connectivity between keywords in each cluster. The mean profile value (S), which ranges from −1 to +1, measures the similarity between cluster content and the cluster's stability and robustness.

The results of the keyword clustering analysis are presented in Figure 12 and Table 8. The module value (Q value) for the CCHSR clusters is 0.4, indicating moderate connectivity between the keywords within each cluster. The mean profile value (S value) is also 0.4, suggesting that most clusters are relatively stable and robust. The largest cluster is "urban heat island", comprising 227 literature studies and keywords such as built environment, urbanisation, gender, neocrown pneumonia, human health, poverty, mitigation, risk perception, and policy. The cluster with the highest profile value is "carbon dioxide", with keywords such as fossil forest, temperature, elasticity, vegetation, human impact, vulnerability, agriculture, biodiversity, ecology, urban, remote sensing, and drought. Overall, the keyword clustering analysis results suggest that current research in climate-change-oriented human settlements is focused on addressing extreme climate risks, improving environmental security and sustainability, and applying machine learning techniques.

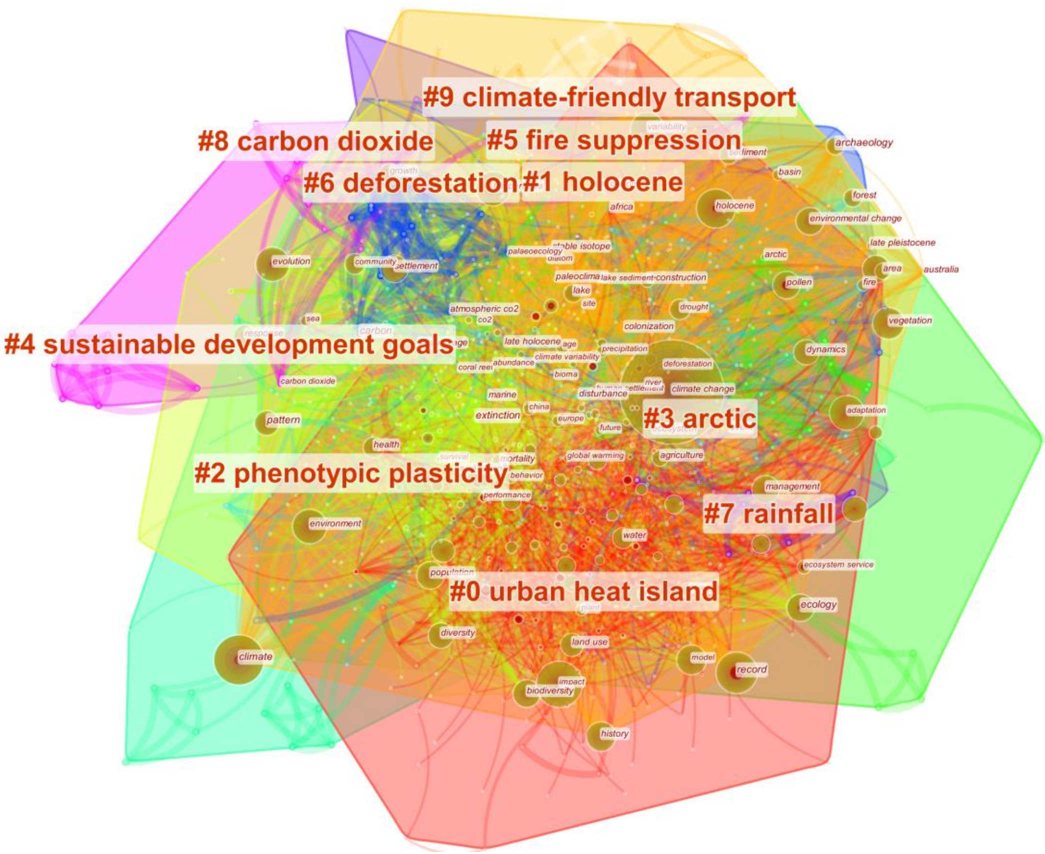

Figure 12. Visual mapping of keyword clustering for CCHSR. (# indicates keyword clustering).

Table 8. Keyword clustering for CCHSR. (# indicates keyword clustering).

Cluster Name	Size	Contour	Years	Main Keyword
#0.urban heat island	227	0.659	2014	built environment; urbanisation; gender; COVID-19; human health; poverty; mitigation; risk perception; policy;
#1.holocene	214	0.683	2005	human occupation; soil erosion; adaptation; vegetation history; cultural change;
#2.phenotypic plasticity.	184	0.682	2007	diversity; thermal tolerance; temperature; ocean acidification; conservation; heat; environment;
#3.arctic	78	0.861	2004	permafrost; tree mortality; forest management; human settlements suitability; earthquake; infrastructure;
#4.sustainable development goals	67	0.815	2007	economy; adaptation; historical consciousness; integrated management; water limitation; ecological restoration;
#5.fire suppression	54	0.85	2002	transmission; fire; fire regime; landscape ecology; microclimate; water use; spatial model; risk assessment;
#6.deforestation	53	0.877	2005	transmission; fire; fire regime; landscape ecology; microclimate; water use; spatial model; risk assessment; l
#7.rainfall	51	0.812	2011	disease outbreak; drinking water; deep learning; adaptation; land management; extreme events; land restoration; cover; risk analysis;
#8.carbon dioxide	26	0.928	1997	fossil forest; temperature; resilience; vegetation; human impact; vulnerability; agriculture; biodiversity; ecology; cities; remote sensing; drought;

The first main topic that CCHSR focuses on consists of investigated responses to extreme climate risks. Disaster Risk Reduction (DRR) is a key component of the UN's 2030 Sustainable Development Goals (SDGs). Climate extremes can threaten the sustainability of human settlements, and public health emergencies such as the COVID-19 pandemic can exacerbate the risks associated with extreme weather events and complicate disaster response and evacuation management [65]. Therefore, integrating resilience measures such as mitigation interventions into development policies, establishing frameworks for thermal resilience [66], and promoting appropriate urban form and land use [67] can help limit the socio-economic risks associated with climate extremes and enable human settlements to respond to the complex challenges posed by disasters.

The second main topic that CCHSR focuses on consists of augmented environmental security and sustainability. With cities now being the dominant form of human settlements, they face additional challenges in addressing unusual climatic events. There is a pressing need to improve the sustainability and resilience of urban areas while ensuring environmental safety. One approach is to enhance the robustness and resilience of building structures, reduce damage from major catastrophic events and enable the rapid resumption of daily activities [68]. Another approach is implementing Carbon Capture and Utilization (CCU) technologies [69], which can assist in the energy transition and facilitate the achievement of circular economy goals, leading to the establishment of urban structures that meet safety, reliability, and environmental standards.

The third main topic that CCHSR focuses on consists of the utilising Novel Technologies, such as Machine Learning. Machine learning (ML) and cloud computing have experienced substantial growth in recent years and have found wide-ranging applications in areas such as building energy simulation [70], urban land cover classification, water resource forecasting [71], and beyond. For instance, Mazhar used machine learning techniques to identify and analyse vegetation and urbanisation in Pakistan from 2013 to 2021, thereby illuminating extant trends in land use and human settlement suitability [72]. Emerging technologies such as machine learning present practical pathways for attenuating the challenges of human settlements that arise from climate change, thereby supporting sustainable land use and effective management of ecological resources. Future research in human settlement studies should prioritise deploying new techniques such as machine learning to predict, with greater accuracy and precision, the impact of climate change on human settlement ecosystems [73].

3.5. Analysis of Research Trends Based on Keyword Burst

3.5.1. Analysis of Keyword Burst Results

The Citespace software's keyword burst function can identify words with frequent changes within a specific period [74]. These high-burst keywords can serve as indicators of research frontiers and can be used to represent research trends and hotspots at a given stage [20]. In the present study, we selected the 20 most frequently occurring keywords among the 168 burst words generated by Citespace from 1990 to 2023 (first two months) in CCHSR. These keywords were then subjected to burst analysis (Figure 13).

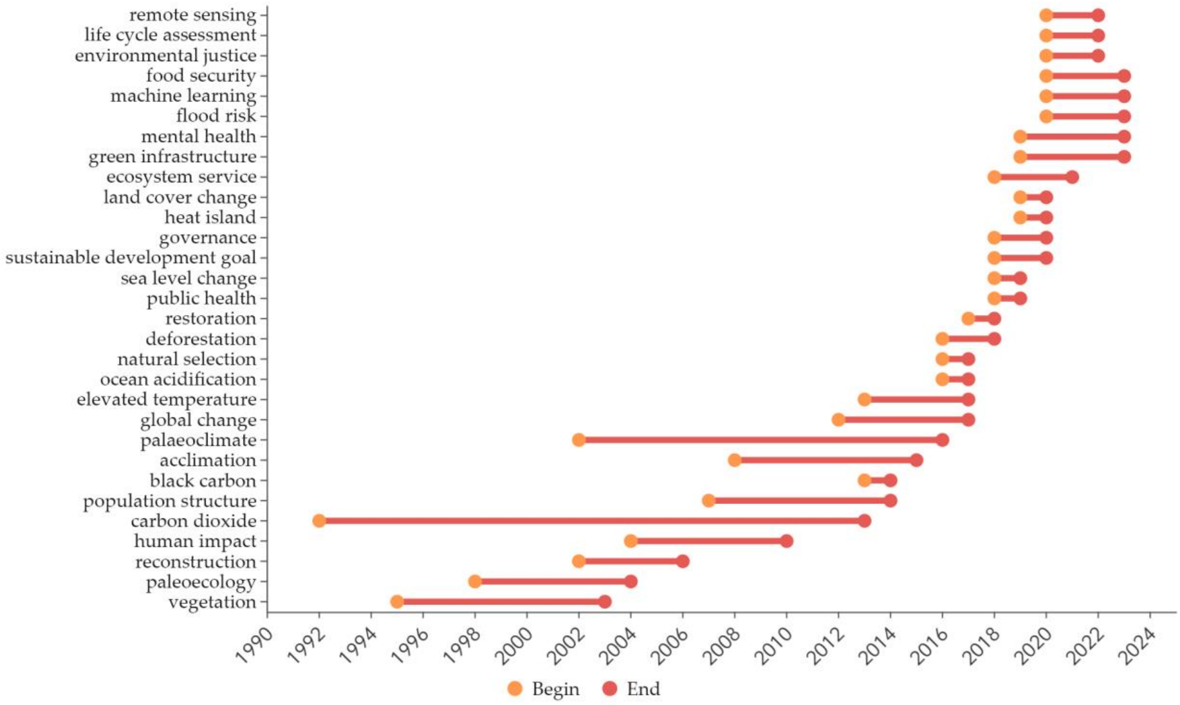

Figure 13. Burst keyword for CCHSR, 1990–2023 (first two months).

The research emphasis in CCHSR has evolved. Before 2013, the focus was primarily on vegetation restoration and human impacts on human settlements, predominantly within paleoecology and palaeoclimatology. From 2013 to 2017, research gradually shifted to the effects of climate change on human settlements within the context of global change. This phase incorporated several influential factors, such as CO_2, black carbon, and high temperatures, and brought attention to the hazards of high temperatures and ocean acidification induced by climate change. Strategies were proposed from the perspectives of natural selection and demographic adaptation. Research keywords progressively multiplied between 2014 and 2017, and the research objects and aims expanded. This phase witnessed the exploration of climate governance approaches, such as forest restoration and land cover change, as well as more significant consideration of the hazards posed by climate change and attempts to set objectives for sustainable development and public health. From 2017 to the present, the advent of the COVID-19 pandemic has propelled a greater emphasis on adapting green infrastructure to CCHSR. In addition, new research tools such as machine learning and remote sensing have also been employed, with attention given to food security, poverty reduction, and other factors such as mental health and environmental justice.

3.5.2. Research Trend Forecasting

Based on an analysis of keyword burst in CCHSR, this paper predicts that future research will take one of three paths: implementing climate risk management, applying artificial intelligence technologies, and enhancing human settlements' security and resilience:

(1) Implementation of Climate Risk Governance. Since the industrial revolution, the frequency and scale of climate change events, such as sea level rises, temperature increases, soil erosion, and associated disasters, have witnessed notable growth. As a result, there is a critical need for robust climate governance to strengthen the political interpretation of urban climate risk vulnerability, and the development of analytical models for human settlement risk management [75] is required to reduce the vulnerability of human settlements to climate change. The primary objective of future CCHSR will be to enhance the climate resilience of human settlement ecosystems [76], built environments [77], and infrastructure systems [78]. Such measures aim to prevent and manage climate change hazards;

(2) Applications of Artificial Intelligence Technology. In the context of the Fourth Industrial Revolution, research in artificial intelligence (AI) has had a significant impact on various fields, including the social sciences, architecture, and engineering and construction (AEC) [79]. Currently, machine learning techniques and intense learning represent the primary research component of AI technology [80]. Artificial intelligence technologies offer novel perspectives for climate adaptation and risk reduction in urban governance and can guarantee effective implementation [81]. Developing and utilising artificial intelligence technologies, such as neural networks, deep learning, and big data [82], will be the technological foundation for future research in climate-change-oriented human settlement studies;

(3) Enhancement of Settlement Security Resilience. Extreme weather events often result in human and economic losses [11]. Poorly developed areas and informal settlements with insufficient infrastructure and low economic levels are more vulnerable to climate shocks than urban areas [83]. Mitigating disaster risks and managing climate change more effectively in impoverished regions [84] and informal settlements [85] are critical to enhancing urban climate resilience and achieving sustainable development. Future CCHSR should actively develop community mechanisms for climate risk adaptation and promote collaborative community and local government efforts to manage climate risks, as such an approach constitutes an effective strategy.

4. Discussion

Human settlements constitute a critical area significantly impacted by climate hazards, and there is an immediate need to integrate climate adaptation strategies into constructing human settlements in the future [86]. Based on the distribution characteristics of relevant literature, key topics, and developmental trends in CCHSR, this paper suggests that future research prioritises the following three key topics:

(1) Establishment and improvement of the theoretical system of CCHSR. The distribution characteristics of relevant literature indicate that while CCHSR was initiated earlier (in 1991), it primarily focused on ecology and paleoclimatology during the early stages. Only after 2010 did literature studies on the theoretical system of CCHSR emerge, covering topics such as infrastructure improvement, population distribution optimisation [87], and low-carbon city policies [88]. In the future, the development of a robust theoretical system for CCHSR must incorporate various factors, including carbon potential, carbon pricing [89], fossil fuels [90], and renewable energy [91], to assess and classify climate change responses in human settlements based on different objectives. The impact of land use change on highly productive ecosystems has been well-documented [92], and previous research has employed the environmental Kuznets Curve to elucidate the relationship between arable land run-off and economic growth [93]. An established theoretical system for CCHSR can effectively respond to extreme weather events, such as hurricanes, droughts, and heat-waves, and chronic climate-change-induced environmental degradation, such as rises in sea

level, desertification, glacier retreat, land degradation, ocean acidification, and salinisation. Ultimately, it can enhance the resilience of human settlements to climate change;

(2) Exploration of climate risk management mechanisms and governance strategies for human settlements. This category includes research on climate risk management, ecological protection, and climate adaptation planning. Human settlements constitute the fundamental medium for human life, and their destruction can trigger and exacerbate climate risks. The interweaving of the uncertainty of climate change and urban development [94] may result in new coupled risks, thereby necessitating the development of effective climate risk management mechanisms and strategies to guide CCHSR. The 27th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP27) has now proposed measures such as establishing a dedicated fund for climate loss and damage and increasing the amount of climate finance [95]. In the future, it is critical to consider integrating climate change adaptation and climate risk management into urban planning [96], which may involve investing in extreme weather warning systems, cultivating drought-resistant food varieties, establishing security resilient frameworks for settlements [97], and promoting low-carbon lifestyles;

(3) Emphasis on Technology Implementation for Human settlements' Response to Climate Change. Artificial intelligence (AI) is recognised for its potential in combatting climate change [98]. Future research efforts in climate change education should explore the integration of artificial intelligence (AI), neural networks, and digital technologies (DT) [99] to enhance teaching practices. Additionally, it is imperative to identify human settlements [100] and implement sustainable development goals [101] to promote climate resilience. This can be achieved by developing climate-smart technologies and emphasising the efficiency of climate action implementation. Such efforts require international cooperation, such as promoting clean energy, increasing sustainable energy production, mitigating climate risks through technological investments such as solar energy [102] and hydrogen [103], and building green economic systems.

In recent years, digital technologies, including the Internet of Things (IoT), artificial intelligence (AI), big data, augmented reality (AR), virtual reality (VR), and 3D printing, have been introduced into industrial production, leading to the emergence of the concept of the "fourth industrial revolution" or Industry 4.0 [104]. Industry 4.0 is closely associated with energy efficiency and can help reduce manufacturing processes' climate impact. Thus, proposals have been made to enhance environmental sustainability and promote more sustainable energy use in the industrial sector. Industry 4.0 is expected to be crucial in achieving climate goals by enabling more efficient and sustainable production processes [105]. Its implementation can reduce carbon emissions and enhance human settlements' resilience to withstand the effects of climate change, respond effectively to catastrophic losses, and ultimately create inclusive, productive, healthy, and harmonious human settlements.

5. Conclusions

Based on a bibliometric analysis of the CiteSpace knowledge graph, this paper investigates the co-citation, collaboration, keyword clustering, and emergence of 6830 papers on CCHSR from 1990–2023 (first two months) to extract distribution characteristics, key issues, and research trends in this field. The aim is to provide valuable insights and practical guidance for future theoretical research and construction practices.

(1) The literature on CCHSR exhibits three distinct aspects: the number of literature studies, source publications, and country and time zones. The quantity of literature studies in this field is fluctuating and increasing, with a continuous rise in the number of studies. In addition, there has been a noticeable increase in the comprehensiveness of research disciplines, with a growing emphasis on ecosystem dynamics and conservation processes. Notably, the United States, the United Kingdom, China, and Australia have emerged as the predominant study countries in this field;

(2) The core academic journals in the CCHSR field are *Science*, *Nature*, and *PNAS USA*. The most highly cited literature studies focus on climate data and technology updates and explore sustainable development strategies to address climate change. The most cited authors are the R Core Team and Paula Reimer. Guanghui Dong possesses the highest number of authors and frequency of collaborative publications. As for research institutions, the Chinese Academy of Sciences has the highest collaborative impact, and the United States exhibits the highest collaborative effect among countries, followed by the United Kingdom, China, Australia, and Germany;

(3) Regarding key topics, the high-frequency keywords for CCHSR include climate, environment, adaptation, and others. The main clusters identified were "sustainability", "carbon dioxide", and "machine learning", among others. These clusters are mainly concentrated in the categories of "urban heat island" (the most frequent keyword) and "carbon dioxide" (the most significant profile value). The clustering of studies revealed three key themes: (1) response to extreme climate risks, (2) enhancement of environmental safety and sustainability, and (3) application of new technologies such as machine learning;

(4) Regarding research trends, based on keyword burst analysis, three development trends in CCHSR have been identified, namely the implementation of climate risk management, the application of artificial intelligence technology, and the improvement of the security and resilience of settlements;

(5) Regarding priority research recommendations for the future, firstly, there is a need to establish and improve the theoretical system of CCHSR. Secondly, exploring the mechanism and governance strategy for managing climate risk in human settlements is recommended. Finally, attention should be given to the technical implementation of human settlements in response to climate change.

In summary, the exacerbation of global climate change has rendered climate issues in the human settlement environment a pressing challenge for the worldwide community. To tackle this challenge, effective integration, planning, and design of the human settlement environment from a multi-disciplinary perspective are required in the future development of CCHSR. This paper employs bibliometric analysis to generate five analytical conclusions regarding CCHSR, which will facilitate researchers from diverse disciplinary backgrounds to gain comprehensive insights into its development, research hotspots, and research trends and offer valuable references and suggestions for their future research endeavours.

Author Contributions: Conceptualisation and visualisation, Q.Y.; methodology and writing, N.A.; audit and funding acquisition, E.Y.; data curation, Z.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Art Science Planning Foundation of Shanghai, China, grant number YB2022-G-088; National Natural Science Foundation of China, grant number 52278071; Social Science Foundation of Chongqing, China, grant number 22SKGH431.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Publicly available datasets were analyzed in this study. This data can be found on Web of Science.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Nomenclature

CCHSR	Climate-Change-Oriented Human Settlement Research
COVID-19	Coronavirus Disease 2019
DRR	Disaster Risk Reduction
FAO	Food and Agriculture Organization
IPCC	Intergovernmental Panel on Climate Change
PNAS	Proceedings of the National Academy of Sciences
SDGs	Sustainable Development Goals
WOS	Web of Science

References

1. UN Office for Disaster Risk Reduction. *The Human Cost of Disasters: An Overview of the Last 20 Years (2000–2019)*; UN Office for Disaster Risk Reduction (UNDRR): Geneva, Switzerland, 2020.
2. An, N.; Yao, Q.; Shen, Q. A Review of Human Settlement Research on Climate Change Response under Carbon-Oriented: Literature Characteristics, Progress and Trends. *Buildings* **2022**, *12*, 1614. [CrossRef]
3. IPCC. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*; Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., et al., Eds.; Cambridge University Press: Cambridge, UK, 2021.
4. Zheng, Y. Systemic Risk's of Climate Change and Coping Strategy. *Environ. Prot.* **2021**, *49*, 15–19. [CrossRef]
5. Lenton, T.M.; Rockström, J.; Gaffney, O.; Rahmstorf, S.; Richardson, K.; Steffen, W.; Schellnhuber, H.J. Climate Tipping Points—Too Risky to Bet Against. *Nature* **2019**, *575*, 592–595. [CrossRef]
6. UNFCCC. Available online: https://unfccc.int/ (accessed on 19 March 2023).
7. The Paris Agreement | UNFCCC. Available online: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed on 5 June 2022).
8. What Is the Kyoto Protocol? | UNFCCC. Available online: https://unfccc.int/kyoto_protocol (accessed on 19 March 2023).
9. Doxiadis, C.A. An Introduction to the Science of Human Settlements. *Science* **1968**, *170*, 393–404. [CrossRef]
10. Serrao-Neumann, S.; Schuch, G.; Harman, B.; Crick, F.; Sano, M.; Sahin, O.; van Staden, R.; Baum, S.; Low Choy, D. One Human Settlement: A Transdisciplinary Approach to Climate Change Adaptation Research. *Futures* **2015**, *65*, 97–109. [CrossRef]
11. Wang, Y.; Jin, C.; Lu, M.; Lu, Y. Assessing the Suitability of Regional Human Settlements Environment from a Different Preferences Perspective: A Case Study of Zhejiang Province, China. *Habitat Int.* **2017**, *70*, 1–12. [CrossRef]
12. Baiocchi, G.; Creutzig, F.; Minx, J.; Pichler, P.-P. A Spatial Typology of Human Settlements and Their CO_2 Emissions in England. *Glob. Environ. Chang.* **2015**, *34*, 13–21. [CrossRef]
13. McGranahan, G.; Balk, D.; Anderson, B. The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones. *Environ. Urban.* **2007**, *19*, 17–37. [CrossRef]
14. Wang, L.J. Sustainable Human Settlement and Climate Change Adaptation in China. *Adv. Mater. Res.* **2012**, *524–527*, 3674–3677. [CrossRef]
15. Froude, M.J.; Petley, D.N. Global Fatal Landslide Occurrence from 2004 to 2016. *Nat. Hazards Earth Syst. Sci.* **2018**, *18*, 2161–2181. [CrossRef]
16. AghaKouchak, A.; Chiang, F.; Huning, L.S.; Love, C.A.; Mallakpour, I.; Mazdiyasni, O.; Moftakhari, H.; Papalexiou, S.M.; Ragno, E.; Sadegh, M. Climate Extremes and Compound Hazards in a Warming World. *Annu. Rev. Earth Planet. Sci.* **2020**, *48*, 519–548. [CrossRef]
17. Zhou, Y.; An, N.; Yao, J. Characteristics, Progress and Trends of Urban Microclimate Research: A Systematic Literature Review and Bibliometric Analysis. *Buildings* **2022**, *12*, 877. [CrossRef]
18. Wang, J.; Zhang, J.; Wang, P.; Ma, X.; Yang, L.; Zhou, L. Progress in Ecosystem Health Research and Future Prospects. *Sustainability* **2022**, *14*, 15814. [CrossRef]
19. Chen, C. Science Mapping: A Systematic Review of the Literature. *J. Data Inf. Sci.* **2017**, *2*, 1–40. [CrossRef]
20. Chen, C. CiteSpace II: Detecting and Visualising Emerging Trends and Transient Patterns in Scientific Literature. *J. Am. Soc. Inf. Sci. Technol.* **2006**, *57*, 359–377. [CrossRef]
21. Chen, C.; Ibekwe-SanJuan, F.; Hou, J. The Structure and Dynamics of Cocitation Clusters: A Multiple-Perspective Cocitation Analysis. *J. Am. Soc. Inf. Sci. Technol.* **2010**, *61*, 1386–1409. [CrossRef]
22. Hu, C.-P.; Hu, J.-M.; Gao, Y.; Zhang, Y.-K. A Journal Co-Citation Analysis of Library and Information Science in China. *Scientometrics* **2011**, *86*, 657–670. [CrossRef]
23. McCain, K.W. Mapping Economics through the Journal Literature: An Experiment in Journal Cocitation Analysis. *J. Am. Soc. Inf. Sci.* **1991**, *42*, 290–296. [CrossRef]
24. Chen, C.; Song, M. Visualising a field of research: A methodology of systematic scientometric reviews. *PLoS ONE* **2019**, *14*, e0223994. [CrossRef]
25. Chen, C.; Chen, Y. Searching for Clinical Evidence in CiteSpace. *AMIA Annu. Symp. Proc.* **2005**, *2005*, 121–125.

26. Reimer, P.J.; Bard, E.; Bayliss, A.; Beck, J.W.; Blackwell, P.G.; Ramsey, C.B.; Buck, C.E.; Cheng, H.; Edwards, R.L.; Friedrich, M.; et al. IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years Cal BP. *Radiocarbon* **2013**, *55*, 1869–1887. [CrossRef]
27. Reimer, P.J.; Baillie, M.G.L.; Bard, E.; Bayliss, A.; Beck, J.W.; Blackwell, P.G.; Ramsey, C.B.; Buck, C.E.; Burr, G.S.; Edwards, R.L.; et al. IntCal09 and Marine09 Radiocarbon Age Calibration Curves, 0–50,000 Years cal BP. *Radiocarbon* **2009**, *51*, 1111–1150. [CrossRef]
28. Fick, S.E.; Hijmans, R.J. WorldClim 2: New 1-Km Spatial Resolution Climate Surfaces for Global Land Areas. *Int. J. Climatol.* **2017**, *37*, 4302–4315. [CrossRef]
29. IPCC. *Climate Change 2013: The Physical Science Basis*; Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK, 2013; 1535p.
30. Hughes, T.P.; Kerry, J.T.; Álvarez-Noriega, M.; Álvarez-Romero, J.G.; Anderson, K.D.; Baird, A.H.; Babcock, R.C.; Beger, M.; Bellwood, D.R.; Berkelmans, R.; et al. Global Warming and Recurrent Mass Bleaching of Corals. *Nature* **2017**, *543*, 373–377. [CrossRef]
31. R Core Team. *A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2018.
32. Bates, D.; Mächler, M.; Bolker, B.; Walker, S. Fitting Linear Mixed-Effects Models Using Lme4. *J. Stat. Softw.* **2015**, *67*, 1–48. [CrossRef]
33. Reimer, P.J. Composition and consequences of the IntCal20 radiocarbon calibration curve. *Quat. Res.* **2020**, *96*, 22–27. [CrossRef]
34. Pachauri, R.K.; Allen, M.R.; Barros, V.R.; Broome, J.; Cramer, W.; Christ, R.; Church, J.A.; Clarke, L.; Dahe, Q.; Dasgupta, P.; et al. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Pachauri, R.K., Meyer, L., Eds.; IPCC: Geneva, Switzerland, 2014; p. 151. ISBN 978-92-9169-143-2.
35. IPCC. AR5 Synthesis Report: Climate Change 2014—IPCC. Available online: https://www.ipcc.ch/report/ar5/syr/ (accessed on 31 July 2022).
36. Chen, F.; Dong, G.H.; Zhang, D.J.; Liu, X.Y.; Jia, X.; An, C.B.; Ma, M.M.; Xie, Y.W.; Barton, L.; Ren, X.Y.; et al. Agriculture Facilitated Permanent Human Occupation of the Tibetan Plateau after 3600 B.P. *Science* **2015**, *347*, 248–250. [CrossRef]
37. Steffen, W.; Richardson, K.; Rockström, J.; Cornell, S.E.; Fetzer, I.; Bennett, E.M.; Biggs, R.; Carpenter, S.R.; de Vries, W.; de Wit, C.A.; et al. Planetary Boundaries: Guiding Human Development on a Changing Planet. *Science* **2015**, *347*, 1259855. [CrossRef]
38. Gorelick, N.; Hancher, M.; Dixon, M.; Ilyushchenko, S.; Thau, D.; Moore, R. Google Earth Engine: Planetary-Scale Geospatial Analysis for Everyone. *Remote Sens. Environ.* **2017**, *202*, 18–27. [CrossRef]
39. Hughes, T.P.; Anderson, K.D.; Connolly, S.R.; Heron, S.F.; Kerry, J.T.; Lough, J.M.; Baird, A.H.; Baum, J.K.; Berumen, M.L.; Bridge, T.C.; et al. Spatial and Temporal Patterns of Mass Bleaching of Corals in the Anthropocene. *Science* **2018**, *359*, 80–83. [CrossRef]
40. Bevan, A.; Colledge, S.; Fuller, D.; Fyfe, R.; Shennan, S.; Stevens, C. Holocene Fluctuations in Human Population Demonstrate Repeated Links to Food Production and Climate. *Proc. Natl. Acad. Sci. USA* **2017**, *114*, E10524–E10531. [CrossRef] [PubMed]
41. IPCC. Working Group I the Physical Science Basis. Available online: https://www.ipcc.ch/working-group/wg1/ (accessed on 28 February 2023).
42. R Core Team. *A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2016.
43. Oksanen, J.; Simpson, G.L.; Blanchet, F.G.; Kindt, R.; Legendre, P.; Minchin, P.R.; O'Hara, R.B.; Solymos, P.; Stevens, M.H.H.; Szoecs, E.; et al. *Vegan: Community Ecology Package*; R Package: Vienna, Austria, 2022.
44. Bernstein, L.; Bosch, P.; Canziani, O.; Chen, Z.; Christ, R.; Riahi, K. *Climate Change 2007: Synthesis Report*; IPCC: Geneva, Switzerland, 2008.
45. Blaauw, M. Methods and Code for 'Classical' Age-Modelling of Radiocarbon Sequences. *Quat. Geochronol.* **2010**, *5*, 512–518. [CrossRef]
46. Stocker, T.F.; Qin, D.; Plattner, G.-K.; Alexander, L.V.; Allen, S.K.; Bindoff, N.L.; Bréon, F.-M.; Church, J.A.; Cubasch, U.; Emori, S.; et al. Technical Summary. In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Doschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M., Eds.; Cambridge University Press: Cambridge, UK, 2013; pp. 33–115.
47. Stuiver, M.; Reimer, P.J.; Bard, E.; Beck, J.W.; Burr, G.S.; Hughen, K.A.; Kromer, B.; McCormac, G.; Plicht, J.V.D.; Spurk, M. INTCAL98 Radiocarbon Age Calibration, 24,000–0 cal BP. *Radiocarbon* **1998**, *40*, 1041–1083. [CrossRef]
48. Adger, W.N. Vulnerability. *Glob. Environ. Chang.* **2006**, *16*, 268–281. [CrossRef]
49. Grimm, E.C.; Jacobson, G.L.; Watts, W.A.; Hansen, B.C.S.; Maasch, K.A. A 50,000-Year Record of Climate Oscillations from Florida and Its Temporal Correlation with the Heinrich Events. *Science* **1993**, *261*, 198–200. [CrossRef]
50. Huang, X.; Liu, S.; Dong, G.; Qiang, M.; Bai, Z.; Zhao, Y.; Chen, F. Early Human Impacts on Vegetation on the Northeastern Qinghai-Tibetan Plateau during the Middle to Late Holocene. *Prog. Phys. Geogr. Earth Environ.* **2017**, *41*, 286–301. [CrossRef]
51. Dong, G.; Yang, Y.; Zhao, Y.; Zhou, A.; Zhang, X.; Li, X.; Chen, F. Human Settlement and Human–Environment Interactions during the Historical Period in Zhuanglang County, Western Loess Plateau, China. *Quat. Int.* **2012**, *281*, 78–83. [CrossRef]
52. Dong, G.; Liu, F.; Chen, F. Environmental and Technological Effects on Ancient Social Evolution at Different Spatial Scales. *Sci. China Earth Sci.* **2017**, *60*, 2067–2077. [CrossRef]
53. Tinganelli, L.; Erlendsson, E.; Eddudóttir, S.D.; Gísladóttir, G. Impacts of Climate, Tephra and Land Use upon Holocene Landscape Stability in Northwest Iceland. *Geomorphology* **2018**, *322*, 117–131. [CrossRef]

54. Gathorne-Hardy, F.J.; Erlendsson, E.; Langdon, P.G.; Edwards, K.J. Lake Sediment Evidence for Late Holocene Climate Change and Landscape Erosion in Western Iceland. *J. Paleolimnol.* **2009**, *42*, 413–426. [CrossRef]
55. Schneider, J.W. Mapping Scientific Frontiers: The Quest for Knowledge Visualization. *J. Am. Soc. Inf. Sci. Technol.* **2004**, *55*, 363–365. [CrossRef]
56. Foster, D.R.; Zebryk, T.M. Long-Term Vegetation Dynamics and Disturbance History of a Tsuga-Dominated Forest in New England. *Ecology* **1993**, *74*, 982–998. [CrossRef]
57. Bush, M.B.; Colinvaux, P.A. Tropical Forest Disturbance: Paleoecological Records from Darien, Panama. *Ecology* **1994**, *75*, 1761–1768. [CrossRef]
58. Whitmore, T.J.; Brenner, M.; Curtis, J.H.; Dahlin, B.H.; Leyden, B.W. Holocene Climatic and Human Influences on Lakes of the Yucatan Peninsula, Mexico: An Interdisciplinary, Palaeolimnological Approach. *Holocene* **1996**, *6*, 273–287. [CrossRef]
59. Geel, B.V.; Plicht, J.V.D.; Kilian, M.R.; Klaver, E.R.; Kouwenberg, J.H.M.; Renssen, H.; Reynaud-Farrera, I.; Waterbolk, H.T. The Sharp Rise of Δ14C ca. 800 cal BC: Possible Causes, Related Climatic Teleconnections and the Impact on Human Environments. *Radiocarbon* **1997**, *40*, 535–550. [CrossRef]
60. Royer, P.D.; Cobb, N.S.; Clifford, M.J.; Huang, C.-Y.; Breshears, D.D.; Adams, H.D.; Villegas, J.C. Extreme Climatic Event-Triggered Overstorey Vegetation Loss Increases Understorey Solar Input Regionally: Primary and Secondary Ecological Implications. *J. Ecol.* **2011**, *99*, 714–723. [CrossRef]
61. Bigelow, G.F.; Ferrante, S.M.; Hall, S.T.; Kimball, L.M.; Proctor, R.E.; Remington, S.L. Researching Catastrophic Environmental Changes on Northern Coastlines: A Geoarchaeological Case Study from the Shetland Islands. *Arct. Anthropol.* **2005**, *42*, 88–102. [CrossRef]
62. Williams, C.M.; Ragland, G.J.; Betini, G.; Buckley, L.B.; Cheviron, Z.A.; Donohue, K.; Hereford, J.; Humphries, M.M.; Lisovski, S.; Marshall, K.E.; et al. Understanding Evolutionary Impacts of Seasonality: An Introduction to the Symposium. *Integr. Comp. Biol.* **2017**, *57*, 921–933. [CrossRef]
63. Drejza, S.; Bernatchez, P.; Dugas, C. Effectiveness of Land Management Measures to Reduce Coastal Georisks, Eastern Québec, Canada. *Ocean Coast. Manag.* **2011**, *54*, 290–301. [CrossRef]
64. Tellman, B.; Bausch, J.; Eakin, H.; Anderies, J.; Mazari-Hiriart, M.; Manuel-Navarrete, D.; Redman, C. Adaptive Pathways and Coupled Infrastructure: Seven Centuries of Adaptation to Water Risk and the Production of Vulnerability in Mexico City. *Ecol. Soc.* **2018**, *23*. [CrossRef]
65. IPCC. Intergovernmental Panel on Climate Change. Available online: https://www.ipcc.ch/ (accessed on 2 February 2023).
66. Serdar, M.Z.; Macauley, N.; Al-Ghamdi, S.G. Building Thermal Resilience Framework (BTRF): A Novel Framework to Address the Challenge of Extreme Thermal Events, Arising from Climate Change. *Front. Built Environ.* **2022**, *8*, 1029992. [CrossRef]
67. Abdollahzadeh, N.; Biloria, N. Outdoor Thermal Comfort: Analysing the Impact of Urban Configurations on the Thermal Performance of Street Canyons in the Humid Subtropical Climate of Sydney. *Front. Archit. Res.* **2021**, *10*, 394–409. [CrossRef]
68. Gervásio, H. Structural Eco-Efficiency: Harmonising Structural and Environmental Assessments. *Eur. J. Environ. Civ. Eng.* **2022**, *26*, 2463–2474. [CrossRef]
69. Klankermayer, J.; Leitner, W. Love at Second Sight for CO2 and H2 in Organic Synthesis. *Science* **2015**, *350*, 629–630. [CrossRef]
70. Wang, L.; Witte, M.J. Integrating Building Energy Simulation with a Machine Learning Algorithm for Evaluating Indoor Living Walls' Impacts on Cooling Energy Use in Commercial Buildings. *Energy Build.* **2022**, *272*, 112322. [CrossRef]
71. Zeng, H.; Elnashar, A.; Wu, B.; Zhang, M.; Zhu, W.; Tian, F.; Ma, Z. A Framework for Separating Natural and Anthropogenic Contributions to Evapotranspiration of Human-Managed Land Covers in Watersheds Based on Machine Learning. *Sci. Total Environ.* **2022**, *823*, 153726. [CrossRef]
72. Mazhar, S.; Sun, G.; Bilal, A.; Li, Y.; Farhan, M.; Awan, H.H. Digital and Geographical Feature Detection by Machine Learning Techniques Using Google Earth Engine for CPEC Traffic Management. *Wirel. Commun. Mob. Comput.* **2022**, *2022*, e1192752. [CrossRef]
73. Petrea, S.M.; Zamfir, C.; Simionov, I.A.; Mogodan, A.; Nuţă, F.M.; Rahoveanu, A.T.; Nancu, D.; Cristea, D.S.; Buhociu, F.M. A Forecasting and Prediction Methodology for Improving the Blue Economy Resilience to Climate Change in the Romanian Lower Danube Euroregion. *Sustainability* **2021**, *13*, 11563. [CrossRef]
74. Yu, D.; Xu, Z.; Pedrycz, W.; Wang, W. Information Sciences 1968–2016: A Retrospective Analysis with Text Mining and Bibliometric. *Inf. Sci.* **2017**, *418–419*, 619–634. [CrossRef]
75. Fraser, A. The Missing Politics of Urban Vulnerability: The State and the Co-Production of Climate Risk. *Environ. Plan. A Econ. Space* **2017**, *49*, 2835–2852. [CrossRef]
76. Ye, X.; Niyogi, D. Resilience of Human Settlements to Climate Change Needs the Convergence of Urban Planning and Urban Climate Science. *Comput. Urban Sci.* **2022**, *2*, 6. [CrossRef]
77. Fedele, G.; Donatti, C.I.; Harvey, C.A.; Hannah, L.; Hole, D.G. Transformative Adaptation to Climate Change for Sustainable Social-Ecological Systems. *Environ. Sci. Policy* **2019**, *101*, 116–125. [CrossRef]
78. Zuniga-Teran, A.A.; Gerlak, A.K.; Mayer, B.; Evans, T.P.; Lansey, K.E. Urban Resilience and Green Infrastructure Systems: Towards a Multidimensional Evaluation. *Curr. Opin. Environ. Sustain.* **2020**, *44*, 42–47. [CrossRef]
79. BuHamdan, S.; Alwisy, A.; Danel, T.; Bouferguene, A.; Lafhaj, Z. The Use of Reinforced Learning to Support Multidisciplinary Design in the AEC Industry: Assessing the Utilization of Markov Decision Process. *Int. J. Archit. Comput.* **2022**, *20*, 216–237. [CrossRef]

80. Sharma, N.; Sharma, R.; Jindal, N. Machine Learning and Deep Learning Applications-A Vision. *Glob. Transit. Proc.* **2021**, *2*, 24–28. [CrossRef]
81. Thaler, T.; Witte, P.A.; Hartmann, T.; Geertman, S.C.M. Smart Urban Governance for Climate Change Adaptation. *Urban Plan.* **2021**, *6*, 223–226. [CrossRef]
82. Cowls, J.; Tsamados, A.; Taddeo, M.; Floridi, L. The AI Gambit: Leveraging Artificial Intelligence to Combat Climate Change—Opportunities, Challenges, and Recommendations. *AI Soc.* **2023**, *38*, 283–307. [CrossRef]
83. Filho, W.L.; Balogun, A.-L.; Ayal, D.Y.; Bethurem, E.M.; Murambadoro, M.; Mambo, J.; Taddese, H.; Tefera, G.W.; Nagy, G.J.; Fudjumdjum, H.; et al. Strengthening Climate Change Adaptation Capacity in Africa- Case Studies from Six Major African Cities and Policy Implications. *Environ. Sci. Policy* **2018**, *86*, 29–37. [CrossRef]
84. Grasham, C.F.; Korzenevica, M.; Charles, K.J. On Considering Climate Resilience in Urban Water Security: A Review of the Vulnerability of the Urban Poor in Sub-Saharan Africa. *WIREs Water* **2019**, *6*, e1344. [CrossRef]
85. Corburn, J.; Karanja, I. Informal Settlements and a Relational View of Health in Nairobi, Kenya: Sanitation, Gender and Dignity. *Health Promot. Int.* **2016**, *31*, 258–269. [CrossRef]
86. Moore, J.; Schindler, D. Getting Ahead of Climate Change for Ecological Adaptation and Resilience. *Science* **2022**, *376*, 1421–1426. [CrossRef]
87. Andres, R.J.; Boden, T.A.; Bréon, F.-M.; Ciais, P.; Davis, S.; Erickson, D.; Gregg, J.S.; Jacobson, A.; Marland, G.; Miller, J.; et al. A Synthesis of Carbon Dioxide Emissions from Fossil-Fuel Combustion. *Biogeosciences* **2012**, *9*, 1845–1871. [CrossRef]
88. Balaban, O. Climate Change and Cities: A Review On The Impacts And Policy Responses. *METUJFA* **2012**, *29*, 21–24. [CrossRef]
89. About Carbon Pricing | UNFCCC. Available online: https://unfccc.int/about-us/regional-collaboration-centres/the-ciaca/about-carbon-pricing?gclid=CjwKCAjw5dqgBhBNEiwA7PryaDEjszSnex7oEo6iWrM7rR-HTtQRz9JNCTlUQ8z32OanE1UvXbg4EhoC47sQAvD_BwE#What-is-Carbon-Pricing?- (accessed on 19 March 2023).
90. Schmitt, G.; Aydt, H.; Fonseca, J.A.; Acero, J.; Perhac, J.; Nevat, I. Responsive Carbon Neutral Settlements. In *Intelligent Decarbonisation: Can Artificial Intelligence and Cyber-Physical Systems Help Achieve Climate Mitigation Targets?* Inderwildi, O., Kraft, M., Eds.; Springer International Publishing: Cham, Switzerland, 2022; pp. 149–162. ISBN 978-3-030-86215-2.
91. Armanfar, A.; Khanmohammadi, M. Renewable Energies in the Settlements (A Step Toward a Clean City). *IJESG* **2022**, *7*, 1–13. [CrossRef]
92. Sitthi, A.; Hassan, S.-U. Al-Based Remoted Sensing Model for Sustainable Landcover Mapping and Monitoring in Smart City Context. In *Proceedings of the Research and Innovation Forum 2022*; Visvizi, A., Troisi, O., Grimaldi, M., Eds.; Springer International Publishing: Cham, Switzerland, 2023; pp. 345–355.
93. Li, Y.; Chen, C.; Wang, Y.; Liu, Y. Urban-Rural Transformation and Farmland Conversion in China: The Application of the Environmental Kuznets Curve. *J. Rural. Stud.* **2014**, *36*, 311–317. [CrossRef]
94. Zhang, W.; Chen, L.; Yang, Y. Research Progress on Human Settlement Evolution. *Prog. Geogr.* **2013**, *32*, 710–721.
95. Five Key Takeaways from COP27 | UNFCCC. Available online: https://unfccc.int/process-and-meetings/conferences/sharm-el-sheikh-climate-change-conference-november-2022/five-key-takeaways-from-cop27 (accessed on 19 March 2023).
96. Zheng, Y. Resilient City: Mainstreaming Climate Risk Management and Adaptation to Climate Change into Urban Planning. *Urban Dev. Stud.* **2012**, *19*, 47–51.
97. Abdelhady, A.U.; Spence, S.M.J.; McCormick, J. A Framework for the Probabilistic Quantification of the Resilience of Communities to Hurricane Winds. *J. Wind Eng. Ind. Aerodyn.* **2020**, *206*, 104376. [CrossRef]
98. Leal Filho, W.; Wall, T.; Rui Mucova, S.A.; Nagy, G.J.; Balogun, A.-L.; Luetz, J.M.; Ng, A.W.; Kovaleva, M.; Safiul Azam, F.M.; Alves, F.; et al. Deploying Artificial Intelligence for Climate Change Adaptation. *Technol. Forecast. Soc. Chang.* **2022**, *180*, 121662. [CrossRef]
99. Nunes, J.A.C.C.; Cruz, I.C.S.; Nunes, A.; Pinheiro, H.T. Speeding up Coral Reef Conservation with AI-Aided Automated Image Analysis. *Nat. Mach. Intell.* **2020**, *2*, 292. [CrossRef]
100. Deng, S.; Wu, S.; Bian, A.; Zhang, J.; Di, B.; Nienkötter, A.; Deng, T.; Feng, T. Scattered Mountainous Area Building Extraction From an Open Satellite Imagery Dataset. *IEEE Geosci. Remote Sens. Lett.* **2023**, *20*, 1–5. [CrossRef]
101. Vinuesa, R.; Azizpour, H.; Leite, I.; Balaam, M.; Dignum, V.; Domisch, S.; Felländer, A.; Langhans, S.D.; Tegmark, M.; Fuso Nerini, F. The Role of Artificial Intelligence in Achieving the Sustainable Development Goals. *Nat. Commun.* **2020**, *11*, 233. [CrossRef]
102. Maka, A.O.M.; Alabid, J.M. Solar Energy Technology and Its Roles in Sustainable Development. *Clean Energy* **2022**, *6*, 476–483. [CrossRef]
103. Uyar, T.S.; Beşikci, D. Integration of Hydrogen Energy Systems into Renewable Energy Systems for Better Design of 100% Renewable Energy Communities. *Int. J. Hydrogen Energy* **2017**, *42*, 2453–2456. [CrossRef]
104. Fritzsche, K.; Niehoff, S.; Beier, G. Industry 4.0 and Climate Change—Exploring the Science-Policy Gap. *Sustainability* **2018**, *10*, 4511. [CrossRef]
105. Bildirici, M.; Ersin, Ö.Ö. Nexus between Industry 4.0 and Environmental Sustainability: A Fourier Panel Bootstrap Cointegration and Causality Analysis. *J. Clean. Prod.* **2023**, *386*, 135786. [CrossRef]