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Infrastructure Planning: Intermediary of Indonesia's Community Health in Climate Change Era (A Bibliometric Analysis)

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Article

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Abstract

Climate change has impacts on a broad spectrum of challenges, including social, economic, and environmental problems. The impacts of climate change on human health include increases in respiratory, vector-borne, and zoonotic diseases. The research focuses on one aspect of supporting human health that is often ignored in the climate change adaptation process: infrastructure planning. The method used in this research is a literature review, incorporating bibliometric analysis with VOSViewer to map research trends. The study primarily relies on Google Scholar and other databases, such as Scopus and ASPI-affiliated journals to explore the intersection of climate change, health, resilience, and infrastructure planning in Indonesia. This article discusses this problem through a review of various research studies, which are grouped thematically with case studies in Indonesia. Based on the thematic discussion, it was found that the research that had been carried out still lacks spatial studies on the discussion of infrastructure planning, especially those related to health-supporting infrastructure in the climate change era. These findings can ultimately provide a lot of input on research themes related to the importance of infrastructure planning as an intermediary towards a healthy and resilient society against climate change.

Keywords: climate change, infrastructure planning, health.

Introduction

Climate change poses challenges in the future across a broad spectrum, including social, economic, and environmental challenges. It has a negative impact on the availability of clean water, clean air, food supplies, as well as human health (Trombley *et al*., 2017).

Projections made by WHO indicate that there will be more than 250,000 deaths per year from 2030 to 2035 due to climate change. These deaths may occur due to natural disasters and health problems as a derivative problem of climate change (Watts *et al*., 2018). The impacts of climate change on human health include increases in respiratory and vector-borne diseases. One of the biggest obstacles to mitigating the effects of climate change is the variety of real and potential responses that might be found.

These, in turn, show how the science of climate change has evolved in a wide spectrum (Einecker & Kirby, 2020). The research focuses on one aspect of supporting human health that is often ignored in the climate change adaptation process: infrastructure planning.

Resilience, in general, can be defined as a measure of the persistence of systems and their ability to absorb change and disturbance while still maintaining the same relationships between populations or states. Therefore, resilient communities can be defined as communities that are able to cope with external stresses and disturbances because of social, political, and environmental change. In the climate change context, a resilient community means a group that can absorb recurrent climate change disturbances in order to retain essential structures, processes, and feedback (Holling, 1973; Adger, 2000; Adger *et al*., 2005; Brand & Jax, 2007).

Based on the nature of the system, resilience can be categorized as hard system resilience (e.g., physical-mathematical, engineering, and ecological), soft system resilience (e.g., social, psychological, and economic), and mixed-system resilience (e.g., socio-ecological and organizational) (Kais & Islam, 2016). They argue that a community, as an object, is part of soft system resilience. However, when 'community' is considered as a subject, means a resilient community can be built by retaining internal factors (soft system resilience within the community: social, psychological, and economic) and external factors (information canal, institution, and governance, policy, and infrastructure).

Infrastructure planning, conversely, can be part of hard-system resilience and can be categorized as mixed-system resilience due to its socio-economic-bounded, to build a resilient community in Indonesia. Infrastructure planning can take the form of networks (roads, electricity, telecommunications, energy, and other infrastructure network systems) and/or public service facilities with various service scales (national, provincial, city, sub-district, and neighborhood). These facilities include educational, health, and social infrastructure.

Research on climate change has been mostly on specific disciplines, and there is a lack of interdisciplinary research on the global stage (identified in English) about climate change adaptation, mitigation, and resilience. On the other hand, there is still an insignificant number of research on climate change specifically led by regional and urban planning experts with the locus on and within Indonesia, especially for research that combines spatial and non-spatial aspects.

The adjacent research that can be highlighted is regarding urban sustainability and resilience which focuses on the governance of climate change adaptation and disaster risk reduction. Adaptive governance requires the principles of flexibility and proactiveness. This research, however, does not take account into physical planning, which can be determined as infrastructure planning. This research is still important to emphasize, considering that infrastructure planning to achieve a resilient society requires adaptive governance in its implementation (Ni'mah *et al*., 2021).

Method

This paper uses a literature review method to provide an overview of what is known about a particular topic: health and climate change in Indonesia, as well as the importance of infrastructure planning to build resilient communities. For the initial research, the Google Scholar database used with the query: health* AND resilience* AND climate change AND infrastructure* AND Indonesia*. Google Scholar database was chosen as it had been acknowledged to be a robust resource in this context. Using Publish or Perish (PoP) 8 software, the results include not only the article's title but also its abstract to advance the bibliometric analysis based on text data. Given that the other scientific database is unable to do the same function in PoP 8. This is important because it can analyze the landscape of community health, climate change resilience, and infrastructure planning in the Indonesian context.

The results were then narrowed down to open-access articles only (almost 21% of the results). In both steps, the articles that have been collected were saved in Research Information Systems (RIS)

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format to be visualized in VOSViewer (bibliometric analysis). A bibliometric analysis consolidates extensive bibliometric data to elucidate the current intellectual framework and upcoming trends within a research topic or field (Donath *et al*., 2021). When creating the bibliometric map, the ideal keyword frequency is selected, and less important or irrelevant terms are eliminated. Based on the results of this VosViewer analysis, a diagram about the positioning of health infrastructure in climate change-related infrastructure planning was then created.

The articles reviewed based on the initial research proposition focused not only limited from the selected articles through the open-access journal within the designated query but also on articles from:

(1) The Directory of Open Access Journals (DOAJ) database, with the results of n=4;
(2) Scopus databases, with the results of n=4; and
(3) Indonesian Planning School Association's (Asosiasi Sekolah Perencana Indonesia - ASPI) journals network (SINTA-accredited only), with the results of n = 54.

Based on the scientific journal database at the Center for Scientific Data and Documentation (Pusat Data dan Dokumentasi Ilmiah - PDDI) Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia - LIPI) until 2023, 55 journals are affiliated with ASPI members. As of April 2024, there are 20 journals that have been accredited by SINTA. SINTA (Science and Technology Index) is a reliable database of scientific data in Indonesia that provides access to Indonesian knowledge and citations, designed by the Ministry of Research, Technology, and Higher Education (Ahmadi, 2019) . There are only 14 of 20 SINTA-accredited journals which have articles within the query. The keywords used in searching for articles that might be relevant to review are: "climate change"; "health" AND "climate change"; "resilient" AND "climate change"; or "infrastructure" AND "climate change". The articles reviewed are also limited to those that use English in the abstract.

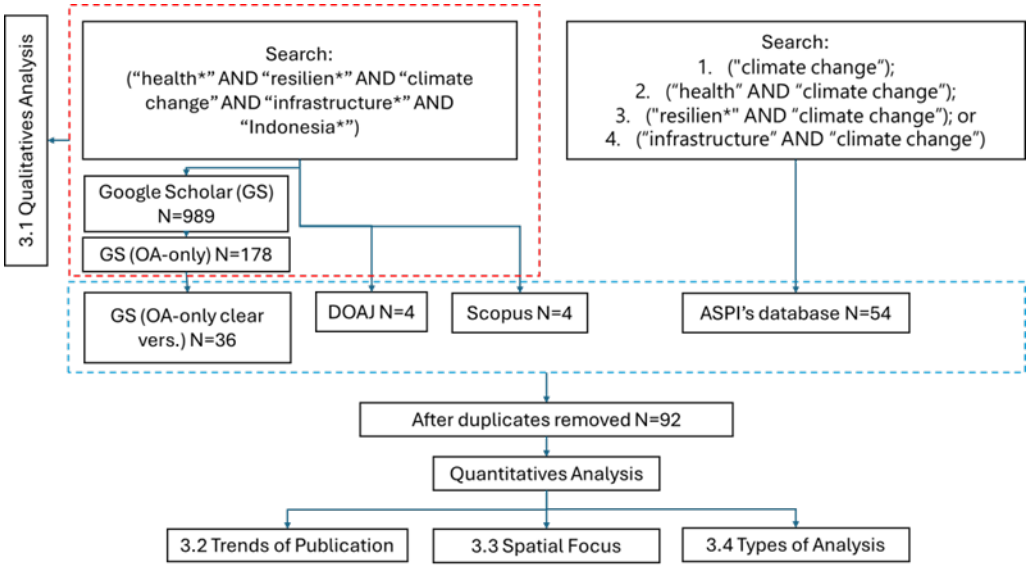


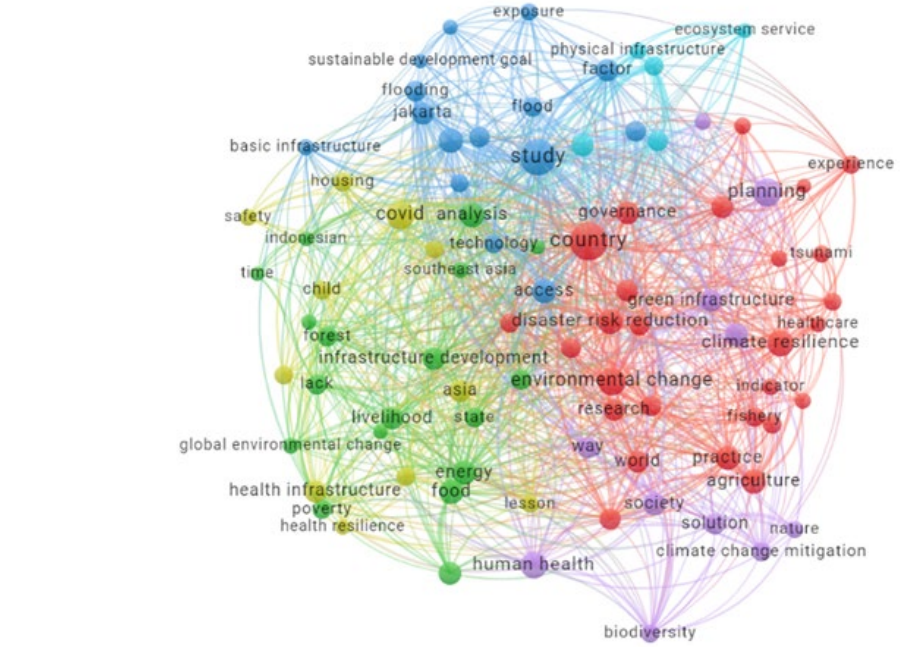
Figure 1. *Data collection and articles selection process*

Results and Discussion

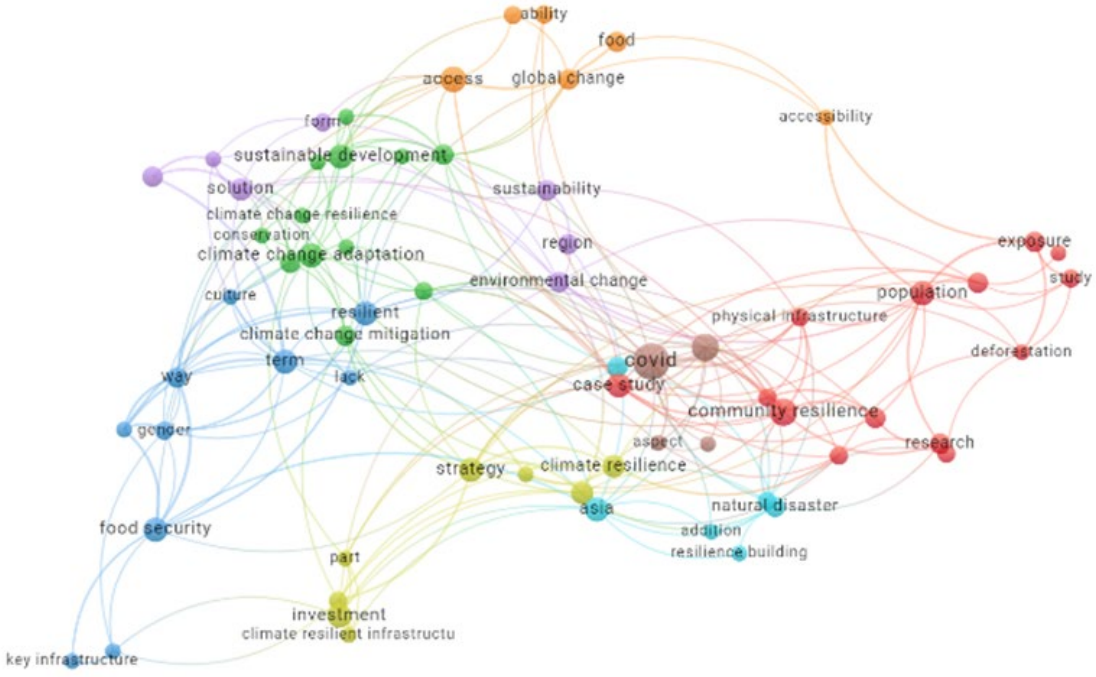
Infrastructure Planning in the Climate Change Era

There are around 989 results from the Google Scholar database within the query (Figure 2a). Based on the research network, there are seven infrastructure typologies that can be discussed: critical infrastructure, resilient infrastructure, basic infrastructure, urban infrastructure, health infrastructure, green infrastructure, and physical infrastructure. If limited to open access only (Figure 2b), it can be concluded that apart from the seven collocations related to infrastructure using the first prompt, there

are the addition of three collocations for infrastructures, making a total of eight infrastructure typologies, where all infrastructure objects overlap with each other, are related, and are part of categories: basic/critical/key infrastructure, physical infrastructure, social infrastructure, urban infrastructure, health infrastructure, green infrastructure, resilient infrastructure, and climate-resilient infrastructure. Figure 3 shows a conceptual diagram of infrastructure typology related to climate change resilience based on the interpretation of keywords co-occurrence.



(a)



(b)

***Figure 2**. (a) Keywords co-occurrence network map, n=989 (b) n=178, open access only*

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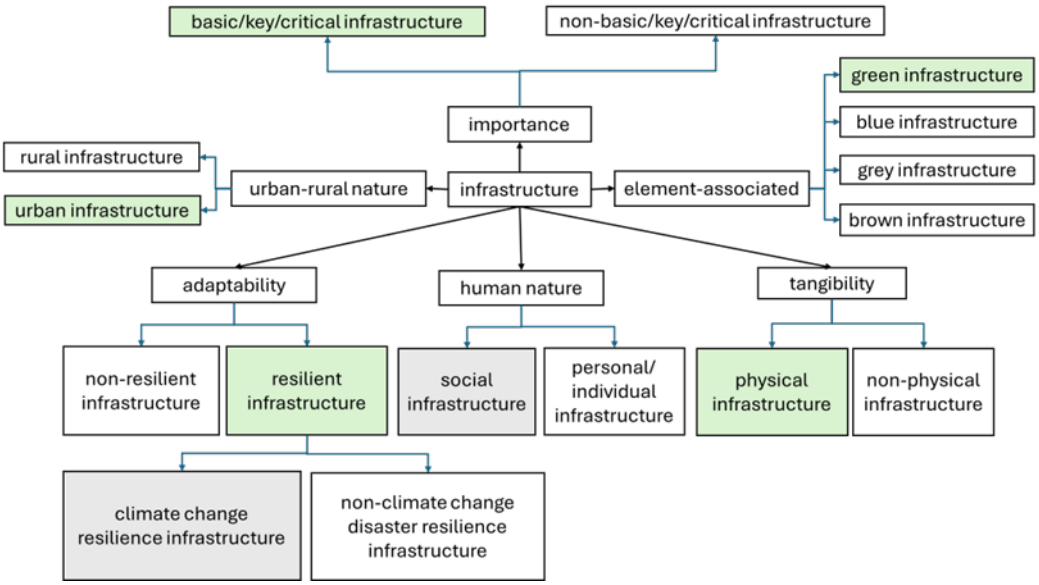

Figure 3. *Conceptual diagram of infrastructure typology related to climate change resilience.*

Basic infrastructure, also known as key or critical infrastructure, are services that enable individuals to live in a way that supports their income-generating activities, so they can maintain a healthy nutritional level and participate in society's regular activities. This includes housing, transportation, energy, water, sanitation, and solid waste disposal. These services can have a significant impact on other social services. For instance, access to clean water and proper sanitation can improve health and, consequently, impact health services (Menendez, 1991). Based on the diagram in Figure 6, it can be interpreted that several studies on basic infrastructure are closely related to healthcare, of which health infrastructure is a part. The element of poverty is also related to basic infrastructure in the context of health and climate change, especially regarding environmental change as the impact of climate change.

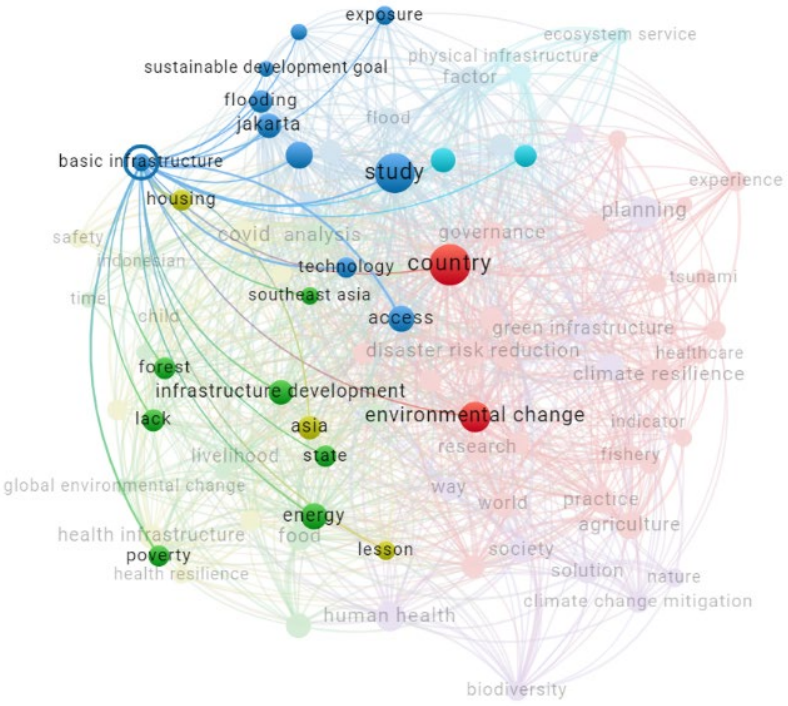

Figure 4. *'Basic infrastructure' co-occurrence network map.*

Critical infrastructures can also be defined as physical and cyber-based systems that are essential to the key operations of the economy and government (Amaratunga & Haigh, 2011). In the context of climate change resilience, it can be described as infrastructure that supports important societal sectors and can be seen as central elements in a widespread network of risk, such as the healthcare sector (Pescaroli & Alexander, 2016; Sörensen *et al*., 2016). The existence of basic/critical infrastructure means that there should be a categorization of non-basic or non-critical infrastructure. However, this is difficult to classify as it tends to be subjective.

Physical infrastructure, or hard infrastructure, denotes the essential concrete structures necessary for an economy's operation and sustainability, including transportation networks, power grids, and sewage and waste disposal systems (Malhotra, 2017). Physical infrastructure and ecosystems are important components of urban systems in terms of climate resilience (Beunen & Duineveld, 2023).

Resilient infrastructure refers to assets, which include things like electrical lines, bridges, and roadways, that can endure external shocks, especially natural ones (Hallegatte *et al*., 2019). Based on Figure 8, Resilient infrastructure is closely related to research related to disaster risk reduction. Therefore, climate-resilient infrastructure is long-lasting infrastructure assets that are susceptible to climate change both throughout the decades they are in use and during the period they were built. Examples of sector-specific climate-resilient infrastructure include those related to water, energy supply, transportation, and buildings (Kennedy & Corfee-Morlot, 2012)

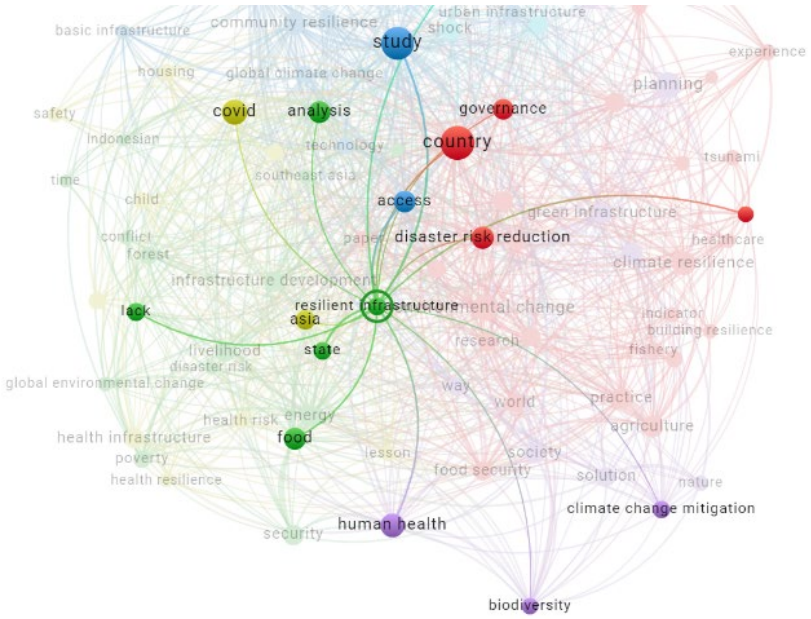

Figure 5*. 'Resilient infrastructure' co-occurrence network map*

Climate change can have direct and indirect impacts on public health. Examples include increases in temperature extremes, changes in rainfall patterns, the spread of infectious diseases, and rising levels of air pollution. Health infrastructure must be able to respond to these challenges and provide timely and effective services to affected communities. Climate change can increase the risk of natural disasters such as floods, storms, and drought. Health infrastructure must be able to survive and function during and after a disaster to provide necessary medical care to victims. This requires planning health infrastructure that is resilient and resistant to disasters. Research on health infrastructure is closely related to health resilience, which may be higher in quantity during the COVID-19 pandemic era. The health infrastructure is also related to forests which are part of green infrastructure, which can prevent the impacts of climate change and function in maintaining the physical and mental health of the community (Damayanti, 2019).

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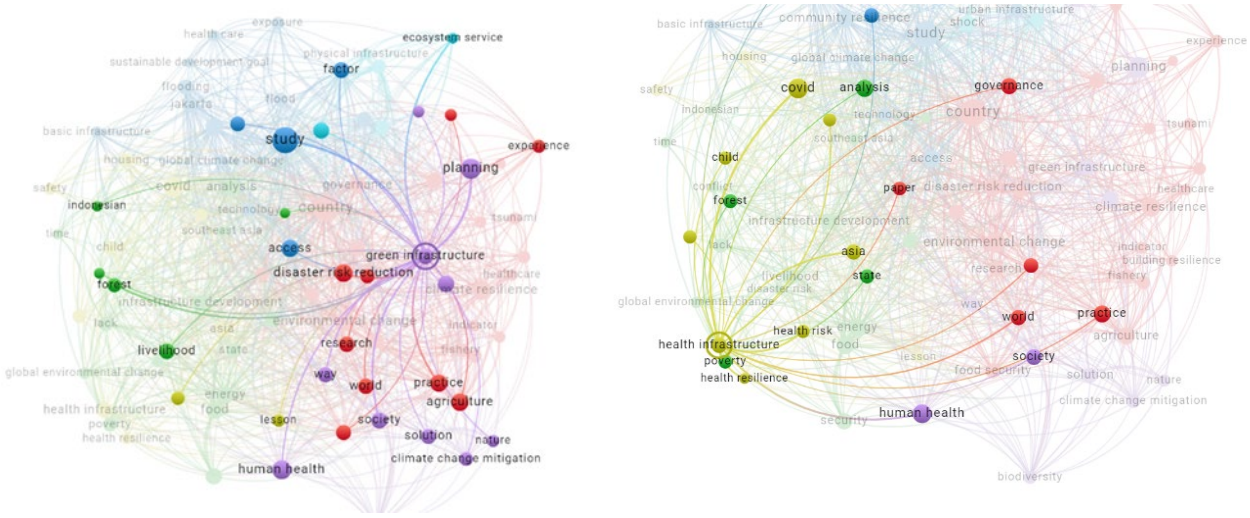

***Figure 6**. (a) 'Green infrastructure' co-occurrence network map, (b) 'Health infrastructure' cooccurrence network map*

Climate change can affect the accessibility and availability of health services, especially in remote or isolated areas. Health infrastructure must be designed and managed considering the challenges of transportation, access to clean water, and other supporting infrastructure that may be disrupted by climate change. Good health infrastructure can help reduce the risk of climate change-related diseases, for example, by providing safe sanitation facilities to prevent the spread of waterborne diseases or by providing public health services that promote healthy behavior and adaptation to climate change. Health infrastructure planning can also play a role in adaptation and mitigation efforts to climate change. This could include improving environmentally friendly building designs, using green technology to reduce carbon footprints, or developing early warning systems for natural disasters. Considering the complex relationship between climate change and public health, inclusive, resilient, and sustainable health infrastructure planning is essential to build resilience to the challenges faced by climate change.

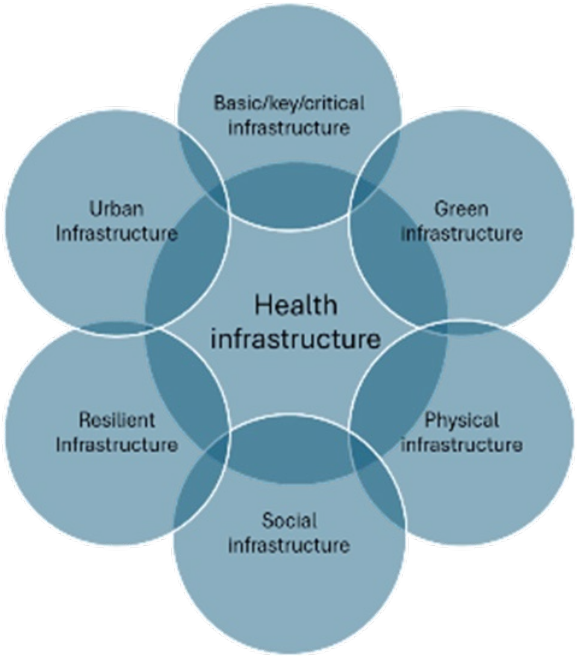

***Figure 7**. Health infrastructure*

Trends of Publication

The rise in health, resilience, climate change, and infrastructure research are closely related to COVID-19. Alongside the obvious COVID research theme, research on climate change mitigation has also intensified in 2020-2021. The global outbreak of COVID-19 in 2020 forced many countries to prioritize public health. This has led to a drastic increase in research, analysis, and publications related to health aspects, such as pandemic management, vaccine development, and mitigation strategies. Awareness of the increasingly pronounced impacts of climate change has also become a major focus in recent years. Extreme weather events, natural disasters, and rapid environmental change increase the need for research and solutions to address these problems.

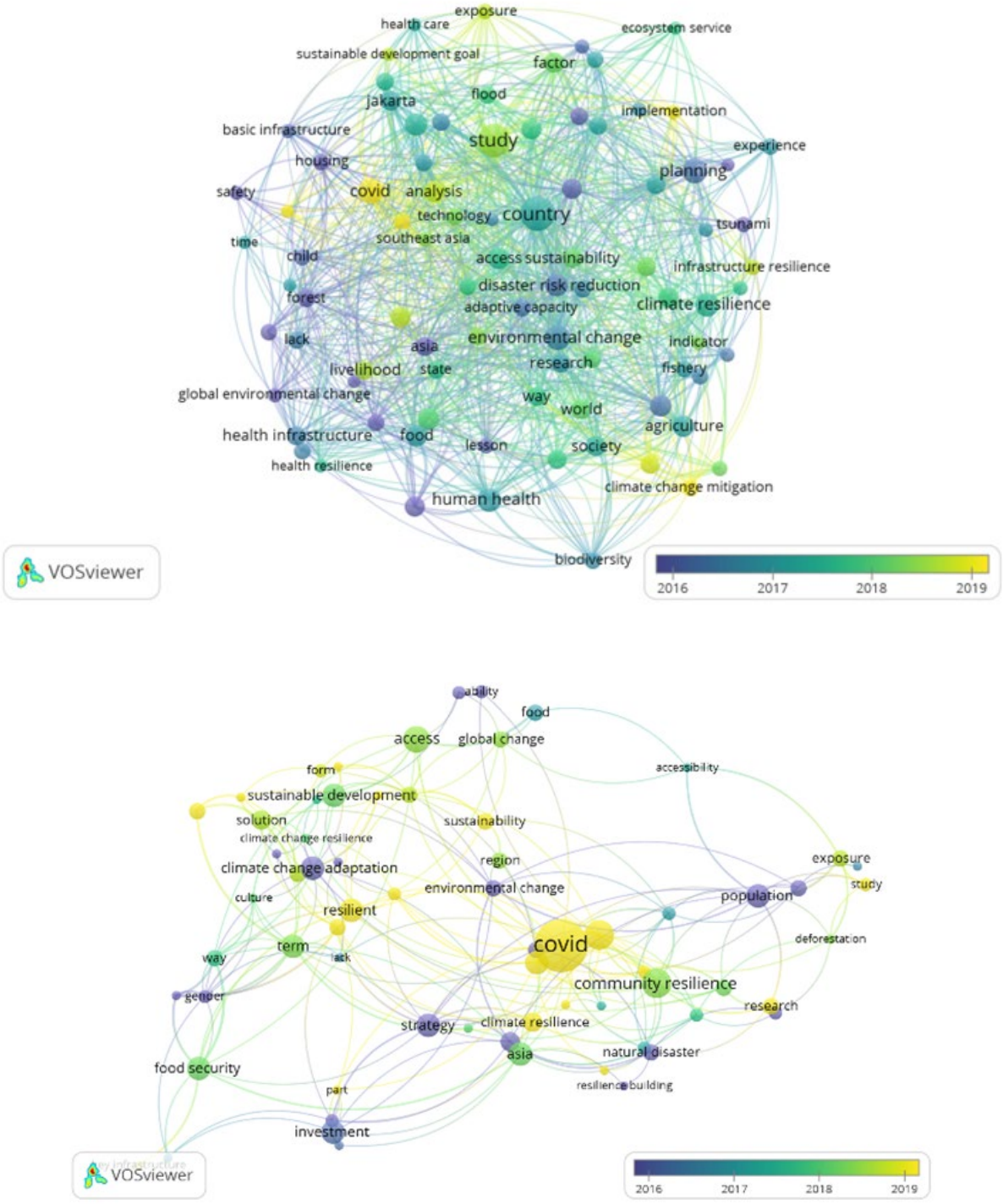

***Figure* 8**. *(a) Keyword co-occurrence network timeline map (N=989), (b) n=178, open access only*

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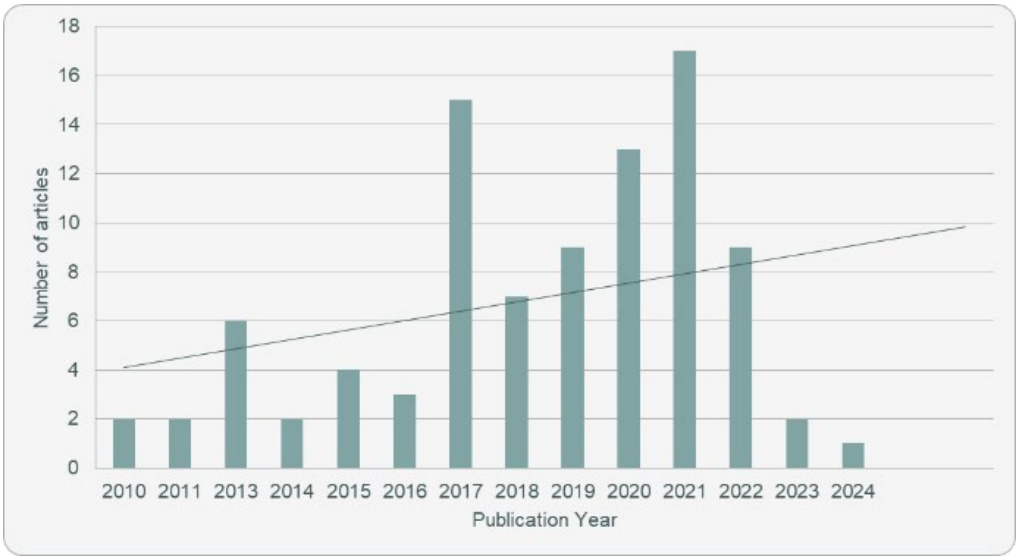

Figure 9. *Number of articles published annually on the theme of health, resilience, climate change, and infrastructure in Indonesia (Jan 2010 – April 2024, N=92)*

Spatial Focus

There is a tendency for fewer research loci in 3T areas (Frontier, Outermost, and Disadvantaged, or in Bahasa Indonesia: Terdepan, Terluar, dan Tertinggal) compared to non-3T areas. While 3T areas may have more pressing needs for research related to climate change and community resilience, other factors such as limited infrastructure and a lack of resources may make research on these issues more difficult to conduct in these areas. Economic and political factors may also influence the focus of research. For example, economic interests such as natural resource potential or the need for additional infrastructure may cause research to focus more on non-3T areas that have greater economic potential. Non-3T areas often have denser populations and concentrations of research centers and universities. As a result, research tends to be more concentrated in these areas, whereas the 3T areas may be neglected or underexplored.

Table 1.

Number of articles based on locus/study area (n = 92)

Locus/Study Area	No. of articles	Author (Year) - example
Indonesia	31	Hamel & Tan (2022)
Sumatra	1	Ward *et al*. (2021)
Central Kalimantan	2	Ayuningtyas *et al*. (2020);
Papua	1	Boissière *et al*. (2013)
South Kalimantan	1	Sarwo Edy Sudrajat & Subekti (2019)
South Sulawesi	1	Arifah *et al*. (2022)
West Java	3	Surachman *et al*. (2022)
Yogyakarta	1	Connor *et al*. (2021)
Ambon City	1	Barkey *et al*. (2017)
Bandar Lampung City	4	Ilmi *et al*.(2020, 2021)
Bandung City	1	Sagala *et al*. (2016)
Banyuwangi Regency	1	Fitriawati & Suroso (2017)
Berau Regency	1	Wolff *et al*. (2021)
Brebes City	1	Azahro & Ardi (2017)
Cirebon City & Cirebon Regency	1	Pratiwi *et al*. (2017)
Depok City	2	Fitrinitia (2018)
Dumai City	1	Hidayat (2022)
Gianyar Regency	1	Putu *et al*. (2020)
Gowa Regency	1	Dary Utomo & Handayani (2021)
Indramayu Regency	1	Argo *et al*. (2017)
Jakarta City	4	Sunarharum (2021)

Locus/Study Area	No. of articles	Author (Year) - example
Jepara Regency	1	Sunarti & Apriliasari (2015)
Kulonprogo Regency	1	Nucifera *et al*. (2020)
Lamongan Regency	1	Pamungkas *et al*. (2017)
Makassar City	1	Nganro *et al*. (2020)
Manado City	1	Halomoan *et al*. (2023)
Nganjuk Regency	1	Wahyudi (2018)
Pacitan Regency	2	Choirunnisa *et al*. (2022)
Pangandaran Regency	1	Suwarto (2011)
Pekanbaru City	1	Sasmita *et al*. (2022)
Pontianak City	2	Nurhidayati & Fariz (2021)
Semarang City	14	Astuti *et al*. (2021)
Surabaya City	2	Gai (2020)
Surakarta City	1	Mukaromah & Kusumastuti (2021)
Temanggung Regency	1	Susilowati & Suryanto (2018)
Tuban Regency	1	Mustikaningrum *et al*. (2021)

Source: Analytical result (2024)

***Figure 10**. Geographic distribution of articles (N = 92)*

Analytical Method

There are several reasons why research on health, climate change, resilience, and infrastructure, especially in the context of regional and urban planning, geography, and civil engineering, tends to use non-spatial analysis methods rather than spatial analysis methods. A considerable amount of research in these fields emphasizes qualitative aspects such as public perceptions, public policies, and social interactions. Non-spatial analysis methods, such as interviews, questionnaires, and content analysis, are often more appropriate for collecting and analyzing this qualitative data. Issues, such as health, climate change, and resilience, often involve complex and multi-dimensional factors, such as public policy, economics, and socio-culture. Non-spatial analysis is better suited to dealing with this complexity and understanding the relationships between variables.

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Table 2

Number of articles based on research method (N = 92)

Research methods	Number of articles
Case study	2
Content analysis	3
Co-production	1
Descriptive analysis	35
Ethnographic analysis	1
Literature review	2
Mixed methods	11
Policy analysis	8
Quadrant analysis	1
Spatial analysis and/or modelling	14
Statistical analysis	10
SWOT analysis	1
System dynamic modelling	1
Systematic Literature Review	2

Source: Analytical result (2024)

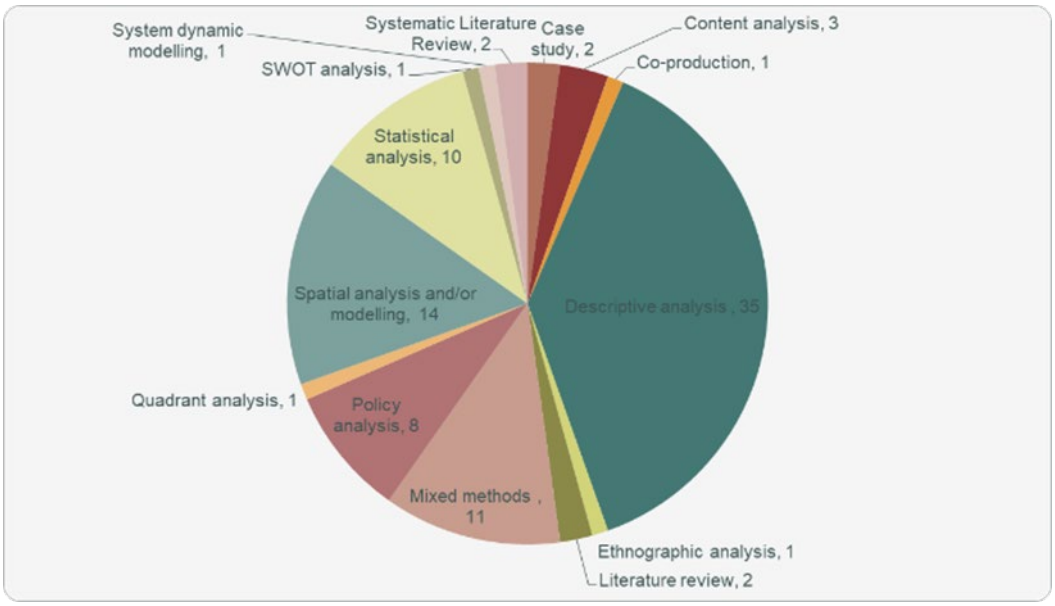

Figure 11. *Number of articles based on research method (N = 92)*

Adequate spatial data is not always available or easily accessible, especially in less developed areas or in countries with limited data infrastructure. This makes researchers more inclined to use non-spatial analysis methods that rely on data that is easier to obtain. Spatial analysis often requires high technical skills in geographic data processing and analysis, as well as the use of specialized software. Not all researchers or institutions have the skills or resources to perform this analysis, leading to a preference for simpler non-spatial analysis methods. The involvement of wider community groups as research objects is also considered important because there is a tendency to choose research titles that target certain community groups. As for the descriptive analysis that is most often carried out, on average it is not projective in nature, and is more effective in simply describing conditions that are or have occurred in society. In the years after 2020-2021, there may be a shift in focus from the immediate response to the COVID-19 pandemic towards post-pandemic recovery efforts. This could lead to a decline in publications on health due to less research on epidemiology and infectious disease control.

Conclusions

There is a trend of increasing research on climate change in relation to community health, resilience, and infrastructure planning during the COVID-19 pandemic. Additionally, there is a tendency for fewer research loci in 3T areas compared to non-3T areas. Based on a thematic discussion, it was found that the research that had been conducted still lacks spatial studies in the discussion of infrastructure planning, especially those related to health-supporting infrastructure in the climate change era. It is also crucial to include larger community groups as study subjects because research titles often focus on specific community groups. When it comes to the most common type of analysis, descriptive, it is generally less projective and more on summarizing current conditions as they are or have existed. These findings can provide a lot of input on research themes related to the importance of infrastructure planning as an intermediary towards a healthy and resilient society against climate change.

However, this literature review still lacks precision and replicability. The author's own bias still plays a role in making the method less systematic. The results or conclusions of this literature review are presented in a narrative format rather than statistical methods. The recommendation for further research is to conduct a systematic literature review (SLR) with less bias. The SLR may contain meta-analyses (statistical analyses) to produce more credible results.

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