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Building health systems resilience: understanding the social, economic, and cultural impacts of climate change from stakeholders' perspectives in Indonesia

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Abstracts

Objectives This study explores stakeholders' perspectives on the direct, social, economic, and cultural impacts of climate change on health in Indonesia and identifies possible strategies to enhance health system resilience.

Methods This study followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines to ensure comprehensive and transparent reporting. Purposive sampling was used to select 22 stakeholders with relevant expertise, including government officials, representatives from international and professional health organizations, health workers, and community representatives. Semi-structured interviews were conducted, and data were analyzed using directed content analysis. Data saturation was reached when no new themes emerged.

Results The findings reveal significant challenges to Indonesia's health system due to climate change. Community awareness varies widely, with higher levels in disaster-prone areas. Socially, climate change has fostered community cooperation through collective adaptation efforts but has also led to tensions due to inequitable resource distribution. Economically, rising healthcare costs and financial instability, particularly in rural and disaster-prone regions, place a strain on the system. Culturally, there is a growing emphasis on environmental conservation, promoting eco-friendly practices and the integration of traditional and modern health approaches.

Conclusion Building health system resilience in Indonesia requires addressing the social, economic, and cultural impacts of climate change. Possible strategies include enhancing public health education, strengthening healthcare infrastructure, improving inter-agency coordination, and leveraging technology to support effective responses to climate-related health threats, ultimately promoting national health, social stability, and economic growth.

Keywords Climate change, Health system resilience, Social, economic, and cultural impacts, Public health adaptation, Indonesia

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Text box 1. Contributions to literature

- This study provides new insights into the health impacts of climate change in Indonesia, emphasizing regional disparities in awareness and adaptive capacity.
- It contributes to the literature by addressing the social and economic pressures climate change exerts on rural and disaster-prone communities, extending current discussions on healthcare system stressors.
- By integrating traditional and modern health practices within policy frameworks, the research proposes a culturally sensitive approach to health system resilience that could inform adaptation strategies in similar developing contexts.

Introduction

Health system resilience has gained global attention, especially after the COVID-19 pandemic exposed vulnerabilities in health systems during major crises [1, 2]. The World Health Organization (WHO) defines health system resilience as the ability of health professionals, institutions, and communities to prepare for, respond to, and recover from crises while maintaining essential functions. A resilient health system is crucial for protecting lives and ensuring positive health outcomes during and after a crisis [3].

Beyond pandemics, climate change poses a significant threat to health systems. Human activities such as fossil fuel combustion and deforestation drive climate change, leading to increased greenhouse gas emissions [4]. In 2023, the World Meteorological Organization (WMO) reported the highest global average temperature anomaly on record, at 1.40 degrees Celsius above pre-industrial levels [5]. The impacts of climate change on health systems are extensive, including heat-related illnesses, respiratory and cardiovascular diseases, and increased infectious disease burdens [6–10]. Additionally, shifts in the distribution of disease vectors and impacts on nutrition due to food insecurity are growing concerns [11, 12]. For instance, in 2017, approximately 2 billion people worldwide faced food insecurity, with over 150 million children affected by stunting [13].

Indonesia, an archipelagic nation with over 17,500 islands and a coastline of 81,000 km, is particularly vulnerable to the effects of climate change [14]. The Climate Risk Profile Indonesia (2021) highlights the country's susceptibility to climate-related disasters such as heatwaves, droughts, floods, sea level rise, and typhoons [15]. Between 2001 and 2019, southern regions of Indonesia, including South Sumatra, Kalimantan, and parts of Sulawesi, experienced a significant increase in the duration of the rainy season by up to 49 days. Similar trends were observed in other parts of the country [16].

In 2019, Indonesia experienced over 3,600 climate-related disasters, with the vast majority (90%) being hydrometeorological in nature [17]. By 2023, the number of such events had increased significantly to nearly 5,000, including a substantial rise in forest and land fires, floods, and extreme weather incidents. These disasters had severe human and economic consequences, resulting in hundreds of fatalities, thousands of injuries, and the displacement of millions of people. Coastal cities, where approximately 75% of Indonesia's urban population resides, are particularly vulnerable, with around 42 million people living in low-lying areas susceptible to sea level rise. Additionally, extreme heat events recorded in late 2023, with temperatures reaching up to 38 degrees Celsius, have exacerbated public health issues, notably increasing cases of heat exhaustion, dehydration, and respiratory disorders [18, 19].

In response to these threats, Indonesia has integrated climate change considerations into various policies. Law No. 16/2016 guarantees the right to a healthy environment and mandates actions for climate change mitigation. The ratification of the Paris Agreement through this law underscores the country's commitment to addressing climate change with a focus on health [20]. Additional legislation, such as Law No. 32/2009 on Environmental Protection and Management and Law No. 36/2009 on Health, further supports environmental and health protection [21, 22]. Subsequent regulations, including Government Regulation (PP) No. 66/2014 on Environmental Health and Minister of Health Regulations No. 1018/2011 and No. 035/2012, provide guidelines for health sector adaptation to climate change [23–25].

Despite these policies, Indonesia continues to experience significant climate-related disasters and their associated health impacts. In 2021, climate change led to high rates of diseases such as diarrhea, pneumonia, tuberculosis, and dengue, especially in Java. Regions like Maluku, Papua, Bali, and Nusa Tenggara saw the most significant increases, with diarrhea in Kalimantan up by 48%, tuberculosis in Bali and Nusa Tenggara up by 94%, pneumonia in Maluku and Papua up by 96%, and dengue in Bali and Nusa Tenggara up by 227%. Alarmingly, climate change is projected to burden Indonesia's health system significantly, with health sector losses due to climate-related diseases from 2021 to 2050 expected to reach 1.86% of the national GDP, or approximately USD 21.6 billion [26].

The ongoing challenges posed by climate change threaten Indonesia's progress towards achieving Sustainable Development Goals (SDGs) and Universal Health Coverage (UHC), while adding stress to an already strained health system [27, 28]. To build a robust health system resilience, it is essential to understand the social,

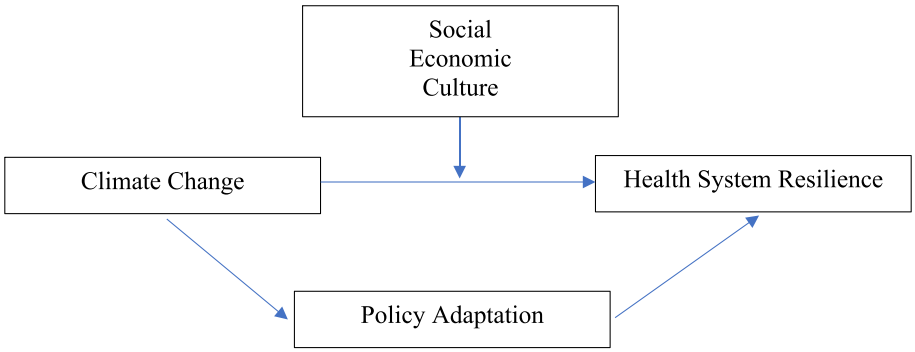

Fig. 1 Conceptual model

economic, and cultural impacts of climate change [2, 3]. The social aspect examines community adaptation, the economic aspect considers financial impacts on individuals and healthcare systems, and the cultural aspect explores values influencing adaptation [29–35].

Therefore, this research aims to investigate stakeholders' perspectives on (1) the direct impacts of climate change on health in Indonesia, (2) the social, economic, and cultural impacts of climate change on health in Indonesia, and (3) possible strategies to strengthen a health system resilience that is responsive to climate change.

Methods

Semi-structured interviews were used to gather insights into stakeholders' perspectives on the direct impacts of climate change on health in Indonesia, the social, economic, and cultural impacts, and possible strategies to strengthen a health system resilience responsive to climate change. The study followed COnsolidated criteria for REporting Qualitative studies (COREQ) guidelines to ensure comprehensive reporting [36].

Conceptual model development

The conceptual model Fig. 1. For this study was developed by three authors (WS, RW, and EB) following a thorough review of WHO documents on climate change and health system resilience, specifically tailored to the Indonesian context [3, 37, 38]. This model illustrates that climate change threatens the resilience of Indonesia's health system, leading to increased disease burdens and natural disasters. Despite existing policies, challenges remain due to social, economic, and cultural factors that affect policy effectiveness. To improve health system resilience, these factors must be considered in policy adaptation, ensuring a more effective response to the health impacts of climate change.

Interview guide development

Based on the conceptual model, initial themes and the interview guide were developed to align with the research objectives. To refine the guide, pilot interviews were conducted with seven stakeholders, including local officials, healthcare professionals, and a representative from a vulnerable community. These interviews helped clarify the questions and refine the themes, resulting in adjustments such as making the questions more open-ended. As the pilot interviews were conducted solely to improve the interview guide, they were not included in the final data analysis. Once finalized, the interview guide (appendix 1) was shared with stakeholders in advance to ensure they were well-prepared.

Participant recruitment

A purposive sampling method was used to recruit stakeholders with relevant knowledge and experience regarding the impacts of climate change on health. The target participants included government officials from the health and environment sectors, representatives from international organizations such as WHO, UNICEF, and the World Bank working in Indonesia, members of Indonesian health professional associations, health workers (including doctors, pharmacists, nurses, and nutritionists), and community representatives (social activists, traditional leaders, and members of vulnerable communities). The aim was to recruit at least three participants from each category to ensure triangulation of resources, as per the standards in qualitative research [39]. All participants were required to have a minimum of five years of relevant experience to ensure that they could provide informed insights and potential solutions for enhancing health system resilience. To capture diverse perspectives, participants were selected from various regions across Indonesia. Invitations were sent via official letters and emails, and interviews were conducted either in person or through teleconference.

Data collection

Data collection involved semi-structured interviews conducted either in person or via teleconference. The interviews were recorded and transcribed verbatim by WS and RW. To ensure the accuracy of the data, transcripts were returned to participants for review and feedback as part of a member-checking process. Data collection continued until no new information was obtained from the interviews, indicating that data saturation had been achieved.

Data analysis

Directed content analysis was conducted to systematically organize the qualitative data into a structured format, with support from MAXQDA software version 12.3.2. This approach was selected for its capability to categorize and interpret textual data based on predefined themes and subthemes [40]. The analysis process involved several steps. Initially, RW and WS independently reviewed and familiarized themselves with the data, followed by coding the transcripts to identify information relevant to each subtheme. During this coding process, specific segments of text were assigned codes corresponding to the research objectives, ensuring that each theme and subtheme was thoroughly explored. The analysis was conducted with a focus on deriving key findings for each subtheme, allowing the research team to identify patterns, insights, and significant points within each category. Following the initial coding, the research team (RW, WS, NM, WT, DA, and EB) discussed and finalized the themes and subthemes, ensuring that the findings accurately reflected the data and provided a comprehensive understanding of the stakeholders' perspectives.

Table 1 Participant demographic characteristics

Category	N	%
Total Participants	22	100
Sex		
Male	13	59.1
Female	9	40.9
Age		
36 – 40 years	4	18.2
41 – 50 years	11	50
51 – 60 years	7	31.8
Professional Category		
Government	5	22.7
Central Government	2	9.1
Local Government	3	13.6
International Organization	3	13.6
WHO Member	1	4.5
UNICEF Member	1	4.5
World Bank Member	1	4.5
Professional Health Organization	3	13.6
Health Worker	8	36.4
Community	3	13.6
Education Level		
Doctorate	15	68.2
Master	3	13.6
Bachelor	4	18.2
Years of Work Experience		
5 – 10 years	6	27.3
11 – 15 years	8	36.4
16 – 20 years	8	36.4
Origin		
Western Indonesia	14	63.6
Central Indonesia	5	22.7
Eastern Indonesia	3	13.7

Results

Participants

A total of 30 individuals were approached during the recruitment process. Out of these, 22 agreed to participate in the study, while eight declined due to busy schedules (five participants), lack of response to the invitation (two participants), or lack of time for interviews (one participant). The final participants included representatives from various categories: government (five participants), international organizations (three participants), professional health organizations (three participants), health workers (eight participants), and community representatives (three participants). This diverse representation ensured that each category included at least three participants, fulfilling the triangulation of sources requirement. The participants' ages ranged from 36 to 60 years, and all had a minimum of five years of relevant experience, ensuring a knowledgeable cohort. This diverse sample provided a comprehensive perspective on the impacts of climate change on health across different regions of Indonesia. Detailed demographic information is presented in Table 1.

Interviews and analysis of transcripts

Semi-structured interviews were conducted with stakeholders between January and June 2024 by RW. The interviews were conducted face-to-face with 5 participants and through teleconference with 17 participants, in locations that were comfortable for the participants. All interviews were conducted in Bahasa Indonesia, with each session lasting approximately one hour. The interview guide, based on predetermined themes and subthemes, ensured that all key areas of interest were

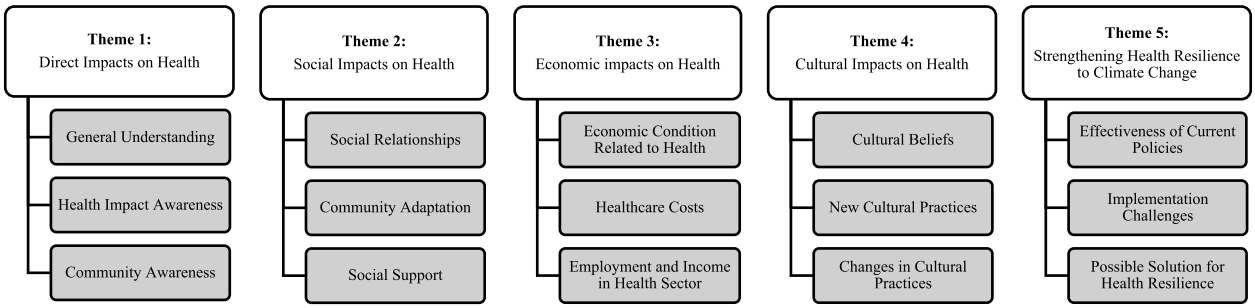

Fig. 2 Themes and sub-themes

thoroughly explored. The results indicated that all predetermined themes and subthemes were sufficiently covered during the interviews. During the analysis, several segments of the transcripts could not be easily coded into the initial themes. These segments were frequently mentioned by multiple stakeholders, suggesting the emergence of additional themes. WS and RW identified these new themes and discussed them with the rest of the research team (NM, WT, DA, and EB). Through consensus, these new themes were incorporated into the final categorization. The final themes were organized into five main topics, each of these main themes was further divided into three subthemes, as illustrated in Fig. 2. The following sections provide a detailed explanation of each theme and subtheme, supported by participant statements.

Theme 1: direct impact on health

General understanding

Participants demonstrated a strong understanding of climate change and its impacts on the environment and human health, recognizing primary causes like fossil fuel burning and deforestation, direct impacts such as global temperature rise and increased extreme weather events.

> *"Climate change is a significant long-term change in weather patterns, mainly triggered by human activities such as burning fossil fuels and deforestation." (Participant 1).*

> *"These changes impact global weather patterns and increase the occurrence of extreme weather events." (Participant 3).*

Health impact awareness

Participants highlighted significant health impacts from climate change, including increased incidence of infectious diseases, poor sanitation and water quality, and the effects of natural disasters and extreme temperatures.

> *"Climate change has led to a noticeable increase in dengue cases due to more frequent and intense rainy seasons." (Participant 6).*

> *"Many areas suffer from poor sanitation and water quality, which has worsened with climate change, leading to more health problems." (Participant 15).*

> *"We are experiencing more heatwaves, which are causing heat strokes and dehydration." (Participant 20).*

Community awareness

Participants highlighted that community awareness of climate change and its impacts varies widely, with higher awareness in disaster-prone areas and lower awareness of long-term impacts in general.

> *"People in flood-prone areas are more aware of climate change because they experience its effects firsthand." (Participant 12).*

> *"Awareness of climate change varies widely; some people understand it well, while others are still unaware of its long-term consequences." (Participant 5).*

Theme 2: social impacts on health

Social relationships

Participants indicated that climate change has fostered increased solidarity and cooperation in addressing health issues within communities, but also led to stress among healthcare workers and internal conflicts over resource allocation.

> *“Collaborative activities like health education and cleanliness campaigns have become common, though conflicts over resource allocation and prioritization occasionally arise." (Participant 7).*

"Social support has increased through joint activities such as health posts and health education. However, tensions can still arise when there are perceptions of unfairness in aid distribution." (Participant 22).

Community adaptation

Participants highlighted communities have taken various adaptive measures such as enhancing early warning systems, improving sanitation infrastructure, conducting health education, and implementing greening initiatives.

"Several adaptation steps, such as enhancing early warning systems, improving sanitation infrastructure, and organizing health education and environmental health outreach programs." (Participant 1).

"Our community has started adaptation measures like improving healthcare infrastructure, tree planting for greening, and educating the public about the importance of sanitation and hygiene (Participant 21).

Social support

Participants identified various social support initiatives and collaborations to address the health impacts of climate change, including international projects, local government programs, and community-driven efforts.

"Yes, the Ministry of Health collaborates with UNDP and WHO on the Green Climate Fund (GCF) project to enhance climate resilience in health services." (Participant 1)

"The Proklim (Climate Village) program helps communities adapt to climate change more effectively and sustainably." (Participant 6)

Theme 3: economic impacts on health

Economic condition related to health

Participants highlighted that climate change adversely affects economic conditions related to health, disrupting financial stability and access to healthcare, particularly in rural and disaster-prone areas.

"Families in disaster-prone areas have to spend more on healthcare, worsening their economic condition." (Participant 12).

"People often have to choose between buying food or paying for medical treatments." (Participant 17).

"Limited financial resources make it harder for families to access necessary medical care, especially in rural areas." (Participant 20).

Healthcare costs

Participants noted healthcare costs have risen due to climate change-related diseases, requiring more resources such as medications, specialized treatments, and additional medical staff.

"Healthcare costs have risen due to climate-related diseases. The increased incidence requires intensive and expensive medical treatment." (Participant 1).

"I've noticed higher healthcare expenses linked to climate change. Frequent extreme weather events elevate the risk of diseases and increase medical costs." (Participant 6).

Employment and income in health sector

Participants noted that Climate change has increased demand for healthcare services, creating job opportunities but also imposing significant pressure on existing healthcare systems.

"Climate change affects public health, leading to increased demand for healthcare services." (Participant 3).

"Climate change has increased the workload in the health sector due to the rise in patients with weather-related diseases." (Participant 9).

"The increased workload from climate-related illnesses makes our jobs much harder, but our pay hasn't changed." (Participant 11).

Theme 4: cultural impacts on health

Cultural beliefs

Participants indicated that climate change has heightened awareness of environmental conservation for health, emphasizing the need for sanitation, hygiene, and sustainable living practices.

"Climate change has made people more conscious of the need for clean water and sanitation for their well-being." (Participant 11).

"Climate change has affected how people view health by increasing awareness of the importance of maintaining the environment." (Participant 14).

New cultural practices

Participants identified new practices such as eco-friendly technologies, better waste management, urban farming, and use of traditional medicinal plants have emerged in response to climate change.

"Some new practices, like using eco-friendly technologies and better waste management systems, have become more common in our community." (Participant 7).

"The use of natural materials as alternatives for everyday products, such as bamboo toothbrushes to reduce plastic usage, has increased." (Participant 13).

Changes in cultural practices

Participants indicated that there is a blend of traditional and modern health practices, with communities integrating herbal medicine with modern healthcare and focusing more on cleanliness and sanitation.

"We still use traditional remedies, but now there's greater acceptance of combining them with modern medicine." (Participant 15)

"Traditional health practices such as herbal medicine is now combined with routine medical check-ups." (Participant 23)

Theme 5: strengthening health resilience to climate change

Effectiveness of current policies

Participants indicated that while current policies addressing climate change's health impacts are positively perceived, their effectiveness is limited by challenges such as resource constraints and inadequate coordination.

"The government's commitment to the Paris Agreement is commendable, but the implementation at the local level still needs significant improvement to be truly effective." (Participant 6).

"Programs like Proklim are great in theory, but their impact is limited due to poor coordination and insufficient resources." (Participant 3).

Implementation challenges

Participants highlighted several key challenges in the implementation of climate change-related health policies. The primary issues include poor inter-agency coordination, limited resources, and low public awareness, which hinder the effective execution of policies and programs.

"The main problem is the lack of coordination between different government bodies, which leads to inefficiencies and fragmented efforts." (Participant 13).

"Limited budget and insufficient trained personnel are major hurdles in implementing climate resilience programs effectively." (Participant 19).

Possible solutions for health resilience

Participants suggested several possible solutions to enhance health resilience to climate change. These include increasing public education and awareness, strengthening infrastructure, improving coordination, securing adequate funding, leveraging technology for early warning systems, and integrating traditional and modern health practices.

"Enhancing public awareness and education on the impacts of climate change on health is crucial for building community resilience." (Participant 3).

"Investing in robust infrastructure and ensuring proper coordination between agencies can significantly improve our health system's response to climate challenges." (Participant 7).

Discussion

This study explored the relationship between climate change and health in Indonesia, focusing on stakeholders' perceptions of the social, economic, and cultural factors shaping these impacts. From the diverse perspectives gathered, several key themes emerged, underscoring the need for targeted and adaptive strategies to strengthen health system resilience.

A key finding is the variation in community awareness about the health risks posed by climate change. Communities in disaster-prone areas demonstrate higher awareness and understanding of these risks, while other regions may not fully grasp the potential impacts. This disparity suggests the need for a unified approach to public health education across Indonesia. By fostering consistent awareness, especially in less frequently affected regions, the country can build stronger collective responsibility and preparedness [41, 42]. A well-informed population is crucial not only for immediate disaster response but also for long-term resilience against the effects of climate change [43, 44].

Socially, our study finds that climate change has both strengthened and tested the bonds within Indonesian communities. The collective adaptation efforts observed, such as implementing early warning systems and improving sanitation, align with the concept of social capital, which has been widely recognized in the literature as a key factor in enhancing community resilience [45, 46]. Previous studies show that strong social networks can significantly mitigate the impacts of climate change by facilitating resource sharing and collective action [47]. However, our findings also highlight the tensions that arise from inequitable resource distribution, which can lead to conflict and undermine social cohesion. This observation is consistent with

research in other developing regions, where resource scarcity often exacerbates social inequalities and triggers conflict [48]. Improving resource management and ensuring fair distribution are therefore essential, as recommended in this study. Moreover, addressing these social tensions may require not only better resource allocation but also strengthening local governance and promoting community participation in decision-making processes [49, 50].

In addition to social impacts, the economic consequences of climate change on health are profound, particularly in rural and disaster-prone areas where financial instability and limited access to healthcare are most pronounced. These findings align with previous research, which similarly notes that rural communities in developing countries often bear a disproportionate burden of climate-related health costs due to inadequate infrastructure and limited economic resources [51, 52]. For example, studies in Southeast Asia document how increased healthcare costs from diseases like dengue fever and respiratory illnesses exacerbate existing financial vulnerabilities [53, 54]. Our findings further contribute to this body of knowledge by illustrating how these economic pressures are not only immediate but also compound over time, leading to long-term systemic issues. While increased healthcare demand has created job opportunities, this benefit is offset by the strain placed on already under-resourced healthcare systems, echoing concerns raised by other researchers about the sustainability of such economic gains [42, 55].

Culturally, this study reveals a growing awareness of environmental conservation and its connection to health, driving the adoption of eco-friendly practices and a blend of traditional and modern health approaches. This finding resonates with earlier research, which observes similar trends in other parts of Southeast Asia, where communities are increasingly integrating sustainable practices into their daily lives in response to climate change [56–58]. However, our study adds to the literature by highlighting the unique ways in which Indonesian communities are merging traditional medicinal practices with modern healthcare, particularly in rural areas where access to formal healthcare is limited. Previous studies document the effectiveness of such integrative approaches in enhancing community resilience, but they also warn of potential conflicts between traditional and modern practices, especially if not carefully managed [59, 60]. By incorporating these cultural dynamics into health policies, as suggested by our study, Indonesia could promote more sustainable and culturally sensitive health practices. However, it is important to recognize that such integration requires careful planning and community involvement to avoid undermining either system [61, 62].

The stakeholders generally perceive existing health policies positively but acknowledge that their effectiveness is often limited by resource constraints and poor inter-agency coordination. These challenges are compounded by low public awareness in regions less frequently affected by disasters, hindering broader adoption of adaptive health practices. Addressing these issues requires a multifaceted approach. First, it is essential to increase public education on the health impacts of climate change, particularly in regions with lower awareness. This might enhance immediate disaster response and contribute to long-term resilience by fostering a well-informed population [63, 64]. Second, strengthening healthcare infrastructure is crucial to accommodate increased demand and mitigate the financial burdens associated with climate-related diseases [65, 66]. Third, improving coordination between agencies is imperative to ensure efficient resource distribution and avoid duplication of efforts. Securing adequate funding is also vital, especially in under-resourced areas [67]. Finally, leveraging technology, such as early warning systems and telemedicine, alongside investments in critical infrastructure—such as dams, dikes, canals, and landslide protection—can improve the system's ability to respond effectively to climate-related health threats. This interdependence between health resilience and infrastructure highlights the need to redesign or even relocate vulnerable communities to withstand future climate impacts [67, 68].

These recommendations align with the broader framework suggested by the World Health Organization, which emphasizes the importance of public education, robust infrastructure, effective coordination, and technology integration in building a resilient health system. By addressing these areas, Indonesia might enhance its health system's resilience, ensuring that it responds effectively to immediate impacts while also establishing a sustainable foundation for future challenges [2, 3, 69].

While this study gathered insights from a diverse group of stakeholders, it does not necessarily capture the full range of perspectives across all settings. The qualitative nature of the research means that findings may not be generalizable to all contexts. However, the participants provided valuable insights based on their extensive experience, and the interview process allowed for in-depth exploration of key issues. Importantly, the study adhered to COREQ guidelines, ensuring comprehensive reporting and methodological rigor [36].

Building resilience in Indonesia's health system to address climate change is essential for promoting healthier populations and sustainable development. This study emphasizes the social, economic, and cultural challenges posed by climate change. Additionally, the unpredictability of climate change impacts—such as the emergence of new diseases and water-related health threats—further underscores the need for a health system that is both flexible and adaptive. Future research about building health resilience could also consider the evolving public health landscape, including emerging threats such as an aging population, demographic shifts, antimicrobial resistance, urbanization, the high burden of noncommunicable diseases, political instability, and mass displacements, as highlighted by the World Health Organization [2, 3].

Conclusion

In conclusion, climate change significantly impacts the social, economic, and cultural aspects of health in Indonesia. Socially, it has fostered community cooperation but also highlighted disparities in resource distribution, leading to potential conflicts. Economically, climate-related health issues have increased healthcare costs and strained access to services, particularly in rural and disaster-prone areas. Culturally, there is a growing integration of traditional and modern health practices, driven by heightened environmental awareness, though careful planning is needed to avoid conflicts. To build a resilient health system, it is essential to address these social and economic disparities, strengthen infrastructure, and enhance coordination across sectors, ensuring the system can effectively and adaptively respond to the ongoing and future challenges of climate change.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13690-024-01403-4.

Supplementary Material 1.

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Authors' contributions
WS, RW, and EB initiated the study. Information gathering and cleaning were performed by WS, RW, and WT, while WS, RW, and NB conducted data analysis. WS and RW drafted the manuscript, with inputs from EB, DA and WT. All authors have reviewed and approved the final version of the manuscript for publication.

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was reviewed and approved by the Ethics Committee of Universitas Indonesia, with approval reference number: Ket-532/UN2.F10.D11/PPM.00.02/2024. All participants provided informed consent prior to participation. Participants provided informed consent and were assured of their privacy and confidentiality. Data were anonymized and securely stored.

Consent for publication
Not applicable, as this study does not involve any identifiable personal data.

Competing interest
The authors declare no competing interests.

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