


Towards a Resilient City: Analyzing Semarang Preparedness in Facing Disaster Related to Climate Change, Indonesia

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ARTICLE INFO	ABSTRACT
<p>Article History: Received: 2024-02-13 Accepted: 2024-03-26 Published: 2024-03-30</p> <p>Keywords: City Resilient; Climate Disaster; Climate Change; Semarang City</p> <p>Corresponding author: Aprillia Findayani Email: aprilliafinda@mail.unnes.ac.id DOI: 10.37905/jgej.v5i1.24470</p> <p>Copyright © 2024 The Authors</p>  <p>This open access article is distributed under a Creative Commons Attribution-NonCommercial (CC-BY-NC) 4.0 International License</p>	<p>Semarang, a populous Indonesian coastal city, faces rising sea levels, tidal floods, and potential increases in rainfall intensity due to climate change. Measuring urban resilience is crucial to understanding current and future disaster risks, informing the development of effective climate and disaster resilience policies. This study analyzes Semarang City's preparedness for climate-related disasters using a qualitative approach. Focus group discussions (FGDs) and surveys involving stakeholders and representatives from each sub-district were conducted. The Climate Disaster Resilience Index (CDRI) framework was employed to assess preparedness across natural, social, economic, institutional, and physical dimensions. The findings reveal that preparedness in Semarang is a multi-faceted and ongoing effort. While initial analysis suggests a moderate level of preparedness, areas for improvement include strengthening the climate action plan, expanding early warning system reach, and enhancing community flood coping capacity. These actions are essential to safeguard society and the environment, bolstering the city's resilience and adaptability to climate change impacts.</p>
<p>How to cite: Findayani, A., Hayati, R., Amrullah, M. F., & Rahman, A.-U. (2024). Towards a Resilient City: Analyzing Semarang Preparedness in Facing Disaster Related to Climate Change, Indonesia. <i>Jambura Geo Education Journal</i>, 5(1). https://doi.org/10.37905/jgej.v5i1.24470</p>	

1. Introduction

Across the world, urbanization is accelerating, exposing cities to environmental problems and the risk of disaster (J. Carter & Sherriff, 2016). According to the United Nations, by 2050, approximately 68% of the world's population is projected to live in urban areas, with much of this growth occurring in developing countries. This rapid urbanization is expected to pose significant challenges for cities in terms of infrastructure development, provision of services, environmental sustainability, and social equity. In developing countries, such as Indonesia, this is increasingly worrying because it results in a decline in people's quality of life. Disaster risk reduction and environmental management are two inseparable things in this context. Climate change further exacerbates the situation by increasing the potential for danger in many cities (Shaw, 2014). Developing countries, such as Indonesia, will feel the impact hardest and fastest, with lower adaptive capacity. This can be seen from the increasing frequency and intensity of extreme weather, such as heavy rain and floods, in various regions of Indonesia (Joerin & Shaw, 2011).

Semarang City the capital of Central Java, located in Indonesia with 1.5 million residents, is one of the cities heavily impacted by climate change and also an example of a city experiencing severe environmental pressure (Findayani et al., 2019). As a major port city with manufacturing and tourism industries, Semarang faces various problems, such as storms, floods, landslides, land subsidence, coastal erosion, drought, and water crises. The impact of climate change is increasingly worsening this situation (Network, 2009). One of Semarang's main problems is tidal flooding, exacerbated by land subsidence (Ujung et al., 2019). Land subsidence in Semarang is more severe in the northern region due to the highlands in the south. Soft soil on the coast of Semarang also accelerates land subsidence. Industrial activities, construction, reclamation, and groundwater extraction on the coast of Semarang exacerbate land degradation. Space use patterns along the coast also worsen the situation (Pratiwi et al., 2016).

The effects of climate change in Semarang are diverse and pose significant challenges to the city's infrastructure, environment, and communities (Marfai, 2018). Semarang is prone to sea-level rise due to its coastal location. Semarang is situated on the north coast of Java Island, making it vulnerable to coastal hazards such as sea-level rise, storm surges, and coastal erosion. The city's low-lying topography increases the risk of flooding, particularly during high tides and heavy rainfall events, threatening both urban and rural areas.

The combination of sea-level rise and intense rainfall patterns has led to a higher risk of flooding in Semarang. The city's low-lying areas, poor drainage systems, and excessive urbanization exacerbate this risk (Safitri, 2021). Floods not only damage infrastructure but also disrupt daily life and can lead to displacement and loss of lives (Findayani et al., 2019). On the other hand, Semarang is experiencing land subsidence, which amplifies the effects of sea-level rise. Groundwater extraction, uncontrolled development, and poor land management practices contribute to the sinking of the land (Permanahadi, 2022). This subsidence makes the city more vulnerable to flooding, as even small increases in sea level can have significant impacts. Furthermore, Climate change is causing more frequent and intense heatwaves in Semarang. The urban heat island effect, caused by the high concentration of buildings and paved surfaces, exacerbates this issue. Heatwaves not only increase the risk of heat-related illnesses but also put a strain on energy resources as people rely more on air conditioning.

One important step to understanding the current and potential future risks of cities is to measure urban resilience. This will help create policies and strategies that are in line with climate and disaster resilience (J. G. Carter et al., 2015). However, the process of measuring and maintaining the level of urban resilience requires the participation and equal work of various stakeholders. Because bureaucrats work in various agencies, a lack of coordination of data and information is also a problem. Many studies have been conducted on Semarang City's response to climate change disasters, but not many studies have measured the city's overall preparedness.

To increase the overall robustness of policy strategies and decision-making, the World Development Program (UNDP) and the Hyogo Framework for Action (HFA) emphasize risk understanding and communication (Center, 2015). Understanding current conditions and levels of resilience will help cities prepare for situations where disasters are more frequent and severe. Therefore, each component of the urban system must be able to bounce back, adapt, and recover from damage and disasters within a specific time frame to minimize economic, environmental, and social losses. Thus, cities must be considered resilient.

Building a disaster-resilient city requires a multidisciplinary approach and multiple levels, making it a complex and challenging task (Hunt & Watkiss, 2011). To make cities disaster resilient, cooperation and contributions from various stakeholders are essential to integrate climate change and disaster risk reduction measures. Thus, this study examines how important it is to measure urban resilience to increase awareness about current risks and future possibilities for better disaster risk management. This research aims to see how the City of Semarang prepares to face climate change disasters. This includes finding out what influences preparation and making plans to improve preparation. These climate change-related disasters pose significant challenges to the city's infrastructure, environment, and the well-being of its residents. Semarang City must enhance its preparedness and resilience to mitigate the impacts of these disasters and adapt to a changing climate.

2. Method

The Rockefeller Foundation states that urban resilience refers to the ability of cities to operate, so that the people who live and work in cities, especially those who are poor and vulnerable, can survive and thrive, no matter what they face or not. The purpose of the City Resilience Index is to provide cities with a robust, holistic, and accessible basis for assessment so that they are better placed to make investment decisions and engage in urban planning practices that ensure people living in cities – particularly the poor and vulnerable – survive and thrive no matter what shocks and stresses they encounter (Da Silva, 2013).

This research will use a descriptive-qualitative approach. As shown in Table 1, five variables from the Climate Disaster Resilience Index (CDRI) physical, social, economic, institutional, and natural factors were used in this research. This Climate Disaster Resilience Index is used to assess city preparedness because it provides a comprehensive and systematic framework for evaluating a city's ability to withstand, adapt to, and recover from climate-related disasters. This holistic approach allows for a comprehensive assessment of a city's preparedness for climate-related disasters, capturing the interdependencies and complexities of resilience. A simple additive method for calculating a Climate Disaster Resilience Index involves summing up the scores of individual indicators to obtain an overall resilience score for a city or region. In addition, additional information was obtained through interviews with various relevant parties, such as the Semarang City Government, the Regional Disaster Management Agency (BPBD), non-governmental groups (NGOs), academics, and literature investigations. The data obtained will be analyzed descriptively and interpreted to show how Semarang City is preparing to face climate change disasters (Table 1).

Table 1. Variabel dan Sub-Variabel CDRI

VARIABLE	SUB VARIABLE
Physical	Electricity
	Water
	Sanitation and Solid Waste Disposal
	Accessibility of Roads
	Housing and Land Use
Social	Population
	Health
	Education and Awareness
	Social Capital
	Community Preparedness
Economy	Income
	Employment
	Household Assets
	Finance and Savings
	Budget and Subsidy
Institutional	Mainstreaming of DRR and CCA
	Effectiveness of city's crisis management
	Effectiveness of a city's institution to respond to a disaster
	Institutional collaboration with other organizations and stakeholders
	Good Governance
Natural	Intensity/ Severity of natural hazards
	Frequency of natural hazards
	Ecosystem services
	Land use in natural terms
	Environmental security and food security

Source: (Joerin & Shaw, 2011).

This research is expected to provide a complete picture of Semarang City's preparedness to face climate change disasters, including actions taken, supporting and inhibiting factors, and suggestions for improving preparedness. It is hoped that the results of this research can be a reference for the Semarang City government in developing preparedness policies and programs for facing climate change disasters.

3. Results and Discussion

3.1. Semarang City Climate Disaster Risk

It is recognized that climate change is one of the main challenges in achieving sustainable development. In the Sustainable Development Goals (SDGs), climate change is the 13th goal. These SDGs demand national action to address climate change and its impacts immediately. The world's population has felt the consequences of increasing natural disasters, such as floods due to continuous rain, storms, prolonged droughts, rising sea levels, and increasing populations of disease vectors that can threaten human life. In addition, it increases poverty, especially for those who depend on agriculture, plantations, and livestock for their livelihoods. In addition, the government of the Republic of Indonesia has stated its commitment to dealing with climate change within several frameworks of the United Nations Framework Convention on Climate Change (UNFCCC).

Situated at 6°58' S dan 110°25' E on the northern coast of Java, Semarang is the capital of Central Java Province. It has a coverage area of about 37,370 ha, a coastline length of 13.6 km, and a population of 1.81 million people, with a growth rate of 1.57% per year, (Yuwono et al., 2019). Semarang is highly vulnerable to coastal flooding due to its low-lying coastal areas and rising sea levels. Along the Semarang coast, 20 villages and their neighbors are prone to coastal hazards. The sedimentation rate along the coast is 8–15 m per year, and inundation heights are 40–60 cm from the ground, (Marfai & King, 2008). Historically, the worst tidal flood circumstances occurred in 2013, which were caused by high tides. As a result, six districts in Semarang were drowned, with inundation levels reaching one meter, (Irawan et al., 2021). According to (Handoyo et al., 2016), the tidal flooding in the Semarang Utara district in 2014 spanned 823.5 acres, with Tanjung Mas being the most heavily impacted hamlet.

High tides, storm surges, and intense rainfall events can cause the sea to overflow, resulting in widespread flooding in the city. In addition to coastal flooding, Semarang is also prone to river flooding. Heavy rainfall, inadequate drainage systems, and the encroachment of rivers exacerbate the risk of river overflow, leading to flooding in urban and low-lying areas.

Semarang is experiencing land subsidence, which amplifies the impacts of sea-level rise. Excessive groundwater extraction, improper land use, and uncontrolled development contribute to the sinking of the land. This subsidence increases the city's vulnerability to flooding and exacerbates the impacts of coastal disasters. Meanwhile, the hilly areas surrounding Semarang are susceptible to landslides, especially during periods of heavy rainfall. Deforestation, improper land management, and steep slopes contribute to the instability of the terrain, increasing the risk of landslides and posing a threat to communities living in these areas (Findayani, 2015).

Recently, Semarang has experienced frequent and intense heatwaves, particularly during the dry season. High temperatures, coupled with high humidity levels, can have adverse effects on human health, leading to heat-related illnesses and discomfort. Vulnerable populations, such as the elderly and children, are particularly at risk during these heatwave events. Despite being a coastal city, Semarang is also susceptible to drought conditions. Changing rainfall patterns and increased temperatures can lead to water scarcity, affecting agriculture, water supply, and livelihoods dependent on these resources. Droughts can have severe implications for food security and economic stability in the region. Figure 1 shows the numerous climate disaster risks faced by Semarang City.

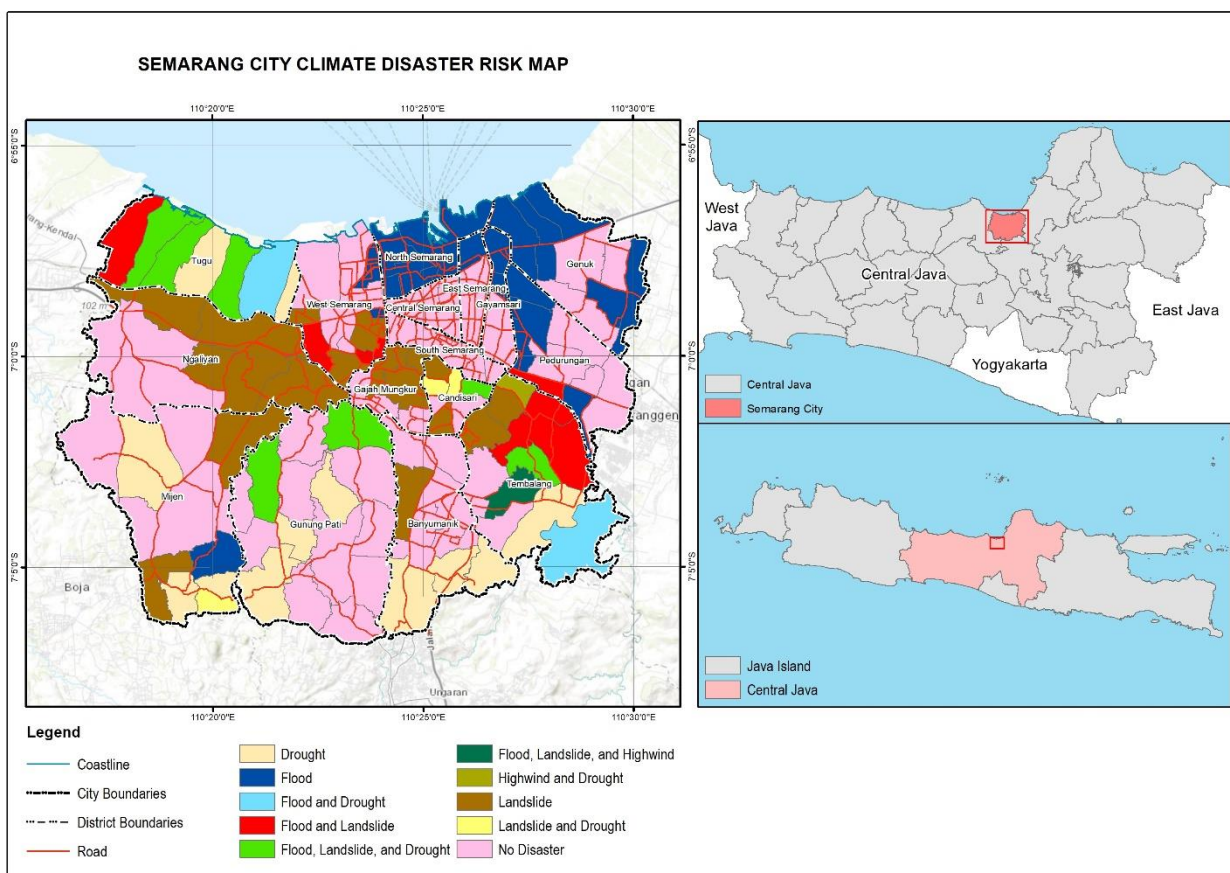


Figure 1. Semarang City Climate Disaster Risk Map

On the other hand, rapid urbanization and population growth in Semarang have led to the proliferation of informal settlements, often located in high-risk areas such as floodplains, riverbanks, and coastal zones. Residents of informal settlements are vulnerable to displacement, loss of homes, and disruption of livelihoods due to natural disasters, land tenure insecurity, and inadequate access to basic services and infrastructure.

Semarang has taken various measures to reduce and adapt to this problem (Findayani et al., 2019). Semarang has dramatically improved its drainage system, increased sea wall capacity, rehabilitated rivers, and raised public awareness about climate change and disaster preparedness. The City of Semarang collaborates with the central government and external parties for mitigation and adaptation. Mitigating the impacts of climate change also includes efforts to reduce greenhouse gas emissions at the local level. Collaboration among government

agencies, civil society organizations, the private sector, and affected communities is essential for building resilience, reducing vulnerabilities, and enhancing the well-being of urban residents in Semarang.

3.2. Semarang City Preparedness

The city of Semarang has increased its preparedness to face climate change disasters over the last ten years. This is because Semarang is one of the cities most vulnerable to the impacts of climate change, significantly rising sea levels. Here are some examples:

3.2.1. Physical Aspects

Semarang City has made various structural efforts to increase its capacity to deal with climate change disasters ([Figure 2](#)).



Figure 2. Clockwise: Jatibarang Reservoir; Tidal embankment in Kaligawe; East Flood Canal; West Flood Canal Control Structure
Source: Research documentation. 2023.

Improved Drainage and Flood Control: Drainage and flood control measures in Semarang are crucial due to the city's vulnerability to flooding, both from river overflow and coastal inundation. Semarang has been working on improving its drainage systems to effectively manage stormwater runoff. This includes regular maintenance and cleaning of existing drainage channels, as well as the construction of new drainage infrastructure in areas prone to flooding. The government and the private sector are working together to improve the drainage system and flood control by cleaning rivers and waterways and building infrastructure to reduce the risk of flooding. One action is to build solid embankments or water retaining walls in areas prone to flooding and carry out routine repairs and maintenance on water channels ([Adi & Wahyudi, 2020](#)).

Clean Water Management: Optimizing Semarang City's clean water management through improving drinking water supply infrastructure, maintenance and rehabilitation of wells, and efficient wastewater management ([Priyambodo & Sarminingsih, 2021](#)). In addition, the government is increasing public awareness about the importance of using water-saving technologies for households and businesses. Semarang has been undertaking river normalization projects to improve the flow capacity of rivers and reduce the risk of overflow. This involves dredging, widening, and straightening of rivers to increase their carrying capacity and mitigate flood hazards.

Urban Spatial Planning: Semarang incorporates flood control measures into its urban planning process. The city aims to control the extent of urban development in flood-prone areas and enforce regulations that consider flood risk factors. This integrated approach helps prevent future flood-related problems. Planned urban spatial planning considers climate change mitigation and adaptation, such as changing land use according to the level of disaster risk, considering environmentally friendly building layouts, and reducing development patterns that damage the ecosystem ([Maimunah et al., 2011](#)).

The government of Semarang City has made construction of channels and canals, such as the Banjir Kanal Barat (West Flood Canal), to divert and manage excess water during heavy rainfall and high tide events. On the other hand, there are also retention ponds and reservoirs to store excess water during heavy rainfall, helping to reduce the volume of water entering the urban drainage system and mitigating flood risks.

3.2.2. Social Aspect

Semarang City's efforts to increase the community's ability to face climate change disasters depend on the social sector. Semarang actively involves the community in flood control and drainage management efforts. This includes awareness campaigns, training programs, and encouraging citizens to adopt practices such as waste management and maintaining clean waterways to reduce flood risks. There is no doubt that high community capacity can reduce the possibility of disasters occurring in society.

Community Awareness and Involvement: Semarang City has carried out several social efforts, such as increasing public awareness about the impacts of climate change and the importance of preparing for disasters. This can be achieved by holding regular campaigns that involve communities in climate change mitigation and adaptation efforts and encourage them to participate actively in decision-making processes (Sari & Prayoga, 2018). Semarang conducts capacity-building programs and training sessions for local institutions involved in climate change disaster management. These programs aim to enhance their knowledge, skills, and capabilities in areas such as risk assessment, early warning systems, emergency response coordination, and community engagement. By strengthening the capacity of local institutions, Semarang ensures a more effective response to climate-related disasters.

Furthermore, Semarang facilitates regular information sharing and communication channels among local institutions and networks involved in climate change disaster management. This can include the establishment of communication platforms, regular meetings, workshops, and seminars to exchange knowledge, experiences, and best practices. Effective communication ensures that relevant information reaches the appropriate stakeholders in a timely manner.

The Initiative for Urban Climate Change and Environment is referred to as IUCCE. In order to make local partners such as Disaster Preparedness Groups (KSB), PKK, Community Empowerment Institutions of sub-district (LPMK), and organizations who have been collaborating in IKUPI program activities more recognizable, IUCCE decided to rebrand as IKUPI in 2018. The address of this organization is in Semarang, Indonesia's Central Java. The organization's goals and beliefs have been influenced by the significance of our home city in the Indonesian setting. As the city itself, IUCCE serves as a center for the adoption of stakeholders from the public, commercial, and academic sectors in order to advance urban sustainability, particularly in the context of Indonesia. IUCCE offers a platform for anyone who is interested in enhancing urban regions' ability to adapt to climate change, (IKUPI, 2020). [Figure 3](#) shows the community capacity building as a collaborative activity between Semarang City and IKUPI, which are parties that care about climate change adaptation.



Figure 3. Capacity Building of Semarang City Community in Adaptation to Climate Change
Source: IKUPI.2020

Social Networks: Building solid relationships between private organizations, governments, communities, and civil society organizations can help more people collaborate and cooperate when facing climate change disasters. The city of Semarang has formed a volunteer group to assist in post-disaster relief and recovery and teach the community how to prevent and respond to disasters. In addition, women and children can help meet

their needs by participating in planning and implementing policies related to disasters and climate change (Octastefani & Rum, 2019)

Semarang conducts educational campaigns to raise awareness among residents about the importance of flood control and drainage management. These campaigns provide information on the causes and impacts of flooding, as well as the role individuals can play in reducing flood risks. Increase community access to information, understanding, and skills needed to deal with climate change and disasters. This can be achieved by providing training and education to communities on preventing, preparing, and responding to climate change disasters. In addition, the government is increasing the capacity of government institutions and communities to develop, implement, and evaluate programs that increase disaster resilience.

The city also establishes volunteer programs where community members can actively participate in flood control and drainage management efforts. Volunteers may assist in monitoring water levels, reporting potential drainage issues, distributing early warning information to neighbors, or participating in emergency response activities during flood events. Improve the Early Warning and Disaster Management System: Improve the early warning system to detect disaster threats such as floods, landslides, and strong winds. The government is also developing a comprehensive disaster mitigation plan involving various related parties, such as the community, research institutions, and the government. Routine activities like disaster simulations and evacuation training can also increase community preparedness to face disasters (Maimunah et al., 2011).

Semarang City has implemented an early warning system to monitor rainfall, river water levels, and tides. This system provides timely alerts to residents and authorities, allowing them to take necessary precautions and evacuate if required. Furthermore, the city has developed mobile applications that provide real-time information and alerts to residents regarding potential flood risks, evacuation routes, and emergency shelters. In terms of community involvement, the city has established Community Emergency Response Teams (CERT) comprising community volunteers who are trained in basic first aid, search and rescue techniques, and disaster management. These teams play a vital role in assisting during emergencies and providing immediate response at the community level.

3.2.3. Economic Aspects

Semarang is a coastal city that faces many challenges, from flooded areas to lost goods. The economic aspect is a vital aspect that is both directly and indirectly affected by the climate change disaster in Semarang. Semarang recognizes the importance of economic diversification as a strategy to mitigate the impact of climate disasters on the local economy. By diversifying its economic sectors, Semarang aims to reduce its reliance on industries that are highly vulnerable to climate-related risks and enhance its resilience. The city of Semarang has taken several actions, including:

Economic Diversification: The government encourages the development of various economic sectors to reduce dependence on sectors that are vulnerable to climate change. The government is also encouraging the development of new economic sectors that focus on reducing greenhouse gas emissions, such as renewable energy technology or the green energy industry (Wijaya, 2015).

Semarang is actively promoting and supporting the growth of green industries that contribute to climate change mitigation and adaptation. This includes sectors such as renewable energy, sustainable agriculture, eco-tourism, and waste management. By encouraging the development of these sectors, Semarang not only reduces carbon emissions but also creates new job opportunities and economic growth that are less susceptible to climate disasters.

Recently, the city has implemented strict environmental regulations and standards to ensure that industries operate in an eco-friendly manner. This includes guidelines for reducing pollution, waste management, and sustainable resource usage. Compliance with these regulations is essential for businesses operating in Semarang City. In addition, Semarang City is actively developing eco-industrial parks that provide infrastructure and facilities for green industries. These parks are designed to support sustainable practices, energy efficiency, waste recycling, and green technologies. They offer a conducive environment for green businesses to operate and grow.

Investment in Climate Change Resilient Infrastructure: Semarang is investing in resilient infrastructure that can withstand climate disasters. Strengthen infrastructure that is resilient to climate change disasters, such as road networks, drainage systems, waterways, and buildings that are resistant to shocks and floods. Apart from that, there is also investment in developing sustainable and environmentally friendly infrastructure, such as using renewable energy, efficient water management, and sustainable transportation. By ensuring the resilience of infrastructure, Semarang creates an enabling environment for economic diversification and reduces the economic losses caused by climate disasters (Yunita, 2010).

Sustainable infrastructure projects can enhance the attractiveness of Semarang City as a destination for investment, tourism, and business development. This can stimulate economic activity, increase property values, and generate revenue for the city. Integrating green spaces and landscaping into urban areas enhances the aesthetic appeal of Semarang City, providing recreational opportunities for residents and visitors alike. Parks, gardens, and waterfront promenades contribute to the city's livability and attractiveness as a destination for leisure and tourism, attracting investment in the hospitality, retail, and entertainment sectors.

Strengthening Micro, Small, and Medium Enterprises (MSMEs). Providing support and assistance to MSMEs to increase their resilience to climate change disasters, such as providing training on adaptation techniques, implementing green technology, or gaining access to broader markets. Collaboration between MSMEs with research and financial institutions to develop environmentally friendly solutions. Recently, Semarang has been actively supporting entrepreneurship and small and medium-sized enterprises (SMEs) that are resilient and adaptable to climate disasters (Neise et al., 2021). The city provides support in terms of access to finance, business development services, and capacity-building programs for SMEs. This helps create a diverse and robust local economy that can withstand climate-related shocks.

The Role of Private Companies Involves the private sector in fighting climate change disasters by collaborating and cooperating in implementing sustainable and environmentally friendly projects. In addition, the government also encourages the use of environmentally responsible business practices, such as reducing greenhouse gas emissions, efficient waste management, or sustainable use of resources.

Insurance and Risk Management: Use disaster insurance to protect the economic sector from losses caused by climate change disasters. This risk management system includes disaster risk assessment, disaster response planning, and post-disaster recovery (Kalfin et al., 2022). Semarang promotes the importance of insurance coverage, particularly for individuals, businesses, and organizations at risk of climate disasters. This includes encouraging residents to obtain property and natural disaster insurance, as well as promoting insurance options for businesses to protect their assets and operations. Insurance coverage provides financial protection and helps expedite the recovery process after a climate disaster.

The implementation of insurance and risk management systems in Semarang involves a combination of policy measures, risk assessment, public-private partnerships, community engagement, and emergency response efforts aimed at reducing vulnerability, increasing resilience, and protecting the well-being of residents and businesses in the face of natural disasters and other risks. For example, in Risk Management, relevant government agencies, NGOs, and academic institutions gather data on historical disasters, including their frequency, severity, and impacts. This includes collecting information on hazards such as floods, earthquakes, landslides, and tsunamis. In addition, experts analyze the vulnerability of infrastructure, communities, and ecosystems to different hazards. This involves assessing factors like population density, building codes, land use patterns, environmental degradation, and socio-economic indicators. Furthermore, Geographic Information Systems (GIS) technology is used to create hazard maps, vulnerability maps, and risk maps. These maps identify high-risk areas, evacuation routes, critical infrastructure, and areas requiring mitigation measures. By systematically assessing risks, planning for emergencies, and implementing timely and coordinated responses, Semarang City can enhance its resilience to disasters and protect the well-being of its residents.

3.2.4. Institutional Aspect

In facing the climate change disaster, the institutional aspects of the City of Semarang continue to increase their institutional capacity. Clear policies, good government coordination, appropriate resource allocation, a robust early warning system, and consistent evaluation and monitoring are essential in situations like these. Semarang City has taken the following actions:

Policies and Preparations Policies and plans to deal with climate change are made at all levels of government and sectors. In addition, the government supports mitigation, adaptation, and post-disaster recovery efforts related to climate change by establishing laws, regulations, and guidelines. By collaborating with research institutions and experts, the government ensures that the policies made are sustainable (Opitz-Stapleton et al., 2016).

Semarang has developed a Climate Adaptation. The process of developing a Climate Action Plan (CAP) in Semarang City involves several key steps to ensure that the plan is comprehensive, inclusive, and effective in addressing the city's climate challenges. This process is tailored to its unique context, informed by stakeholder input, grounded in scientific evidence, and responsive to the evolving challenges of climate change. Action Plan that outlines strategies and measures to address climate change impacts. The plan includes specific actions to reduce flood risks, improve water management, enhance coastal resilience, and promote sustainable land use practices (Sutarto & Jarvie, 2012). Furthermore, Semarang participates in international initiatives and

commitments related to climate change, such as the Global Covenant of Mayors for Climate and Energy. Through these commitments, the city aligns its efforts with global agendas and benefits from knowledge exchange and support from other cities facing similar challenges.

Cooperation between institutions. Government institutions at regional and national levels must establish robust coordination mechanisms to increase synergy in dealing with climate change disasters. This will also encourage collaboration across sectors, districts/cities in developing climate change adaptation and mitigation strategies. Semarang actively collaborates with local institutions, including government agencies, research institutions, universities, and non-governmental organizations. These collaborations aim to leverage the expertise, resources, and networks of these institutions to jointly address climate change disasters. Partnerships can be formed through formal agreements or informal collaborations, fostering a multi-stakeholder approach to disaster management.

Cooperation between various institutions toward climate change adaptation and mitigation in Semarang City, Indonesia, is essential for effectively addressing the complex challenges posed by climate change (Handayani et al., 2020). While specific projects and initiatives may vary, collaborations typically involve multiple stakeholders, including the Semarang City Government, regional and national governments, academic institutions, NGOs, international organizations and donors, the private sector, and community groups. One of the most known in Semarang is the engagement between community groups and NGOs called CAMAR, which is located in Tambakrejo Village, in the north part of Semarang City. These community groups are doing several activities to preserve coastal and mangrove ecosystems. This activity has also been supported by Universitas Negeri Semarang from institutional parties.

On the other hand, the project "GroundUp: A practice-based analysis of groundwater governance for integrated urban water resources," funded by Ristek DIKTI (Indonesia) and the Dutch Research Council (NWO), proposed three ways to mitigate the effects of urban flooding in Semarang City. First, to reduce Semarang's groundwater consumption, second, to limit the city's enormous infrastructure, and third, to modify urban residents' behavior. That research demonstrated the importance of people's decisions and activities in affecting the distribution of surface and groundwater throughout the city, leading to the conclusion that the urban population influences flood management practices in Semarang City.

Budget and Resources: Allocate sufficient budget to support the implementation of policies and programs related to climate change and increase institutional capacity to manage available resources for disaster risk reduction, post-disaster recovery, and adaptation to climate change (Tompkins & Adger, 2005). In this case, Semarang City also conducts regular evaluation and monitoring of the implementation of climate change adaptation and mitigation policies, programs, and strategies. The government of Semarang City is seeking collaborations with private entities to fund and implement disaster risk reduction and climate adaptation programs. For example, infrastructure projects like the construction of sea walls, canal improvements, or sustainable housing can be executed under public-private partnership frameworks.

3.2.5. Natural Aspect

Semarang City's environmental and natural resilience can be increased to fight climate change disasters. Essential steps to preserve nature and reduce vulnerability to natural disasters caused by climate change emphasize conservation, water management, pollution reduction, reforestation, weather monitoring, and environmental education.

Ecosystem Conservation and Management: Increasing efforts to conserve and restore ecosystems such as mangrove forests, urban forests, and water buffer areas; carrying out sustainable land management by considering ecosystem protection, and biodiversity, and reducing vulnerability to natural disasters. This effort is significant for climate change mitigation and adaptation (Akram et al., 2023). Engaging the community in natural resource management can help mitigate climate change impacts and reduce vulnerability to associated disasters. This can involve initiatives such as reforestation, mangrove restoration, or sustainable land and water management practices. Community participation in these activities fosters a sense of ownership and generates environmental benefits.

Frequency of Natural Hazards: Semarang experiences a relatively high frequency of natural hazards due to its geographical location. Heavy rainfall during the rainy season often leads to flooding, while cyclones and storms can occur in the coastal areas. The frequency of these natural hazards poses challenges for the city's preparedness, response, and recovery efforts, as well as for the resilience of its residents and infrastructure. In the case of Semarang City, higher sea levels increase the risk of coastal flooding and inundation, particularly during storm events and high tides, threatening coastal communities and infrastructure (Rus et al., 2018). For example, the flood on February 5, 2021, significantly damaged the city's transportation networks, preventing

Tawang and Poncol stations and airports from operating. Many residents were forced to evacuate their homes, particularly in their northern neighborhoods.

Ecosystem Services: Semarang's natural ecosystems provide vital ecosystem services that contribute to the well-being and resilience of the city. These services include flood regulation, water purification, carbon sequestration, and biodiversity conservation. However, climate disasters can negatively impact these ecosystems, leading to a decline in their capacity to provide these valuable services. This underscores the importance of protecting and restoring natural ecosystems as part of climate resilience strategies ([Handmer et al., 2012](#)).

Semarang is home to extensive mangrove forests along its coastal areas, particularly in estuaries, river mouths, and tidal flats. Mangroves serve as important coastal habitats, providing breeding grounds for fish and other marine organisms, protecting shorelines from erosion, and mitigating the impacts of storms and tsunamis. These mangrove ecosystems are rich in biodiversity, supporting a variety of plant and animal species adapted to saline and brackish water conditions.

Environmental Security and Food Security: Climate disasters can pose significant threats to environmental security and food security in Semarang. Environmental security involves safeguarding natural resources, ecosystems, and biodiversity from the impacts of climate change and disasters. By preserving and restoring ecosystems, Semarang can enhance environmental security. Additionally, climate disasters can disrupt agricultural activities, leading to food shortages and insecurity. Promoting resilient and climate-smart agricultural practices, ensuring access to safe food sources, and diversifying food production systems are crucial for addressing food security concerns. As sea levels rise, saline water from the ocean can penetrate inland, infiltrating freshwater sources such as rivers, estuaries, and aquifers ([Wakweya, 2023](#)). In coastal areas like Semarang, where groundwater is a vital source of freshwater for agriculture and drinking water, saltwater intrusion can contaminate aquifers, making the water unsuitable for irrigation and human consumption.

Addressing these aspects is essential for enhancing Semarang's resilience to climate disasters. The city must implement measures to manage and reduce the intensity and frequency of natural hazards, protect and restore ecosystem services, adopt sustainable land-use practices, and strengthen environmental security and food security. Collaborative efforts involving government agencies, community organizations, businesses, and residents are necessary to effectively address these challenges and ensure a more climate-resilient future for Semarang.

4. Conclusion

In conclusion, Semarang, Indonesia, faces significant climate change challenges, including coastal and river flooding, land subsidence, landslides, heatwaves, and droughts. The research underscores the importance of a holistic and integrated approach to building resilience in Semarang, one that addresses the interconnected social, economic, environmental, and institutional dimensions of climate change-related disasters. This study provides valuable insights into the challenges and opportunities for building resilience in Semarang in the face of climate change-related disasters. Through a comprehensive analysis of vulnerability, resilience measures, and stakeholder perspectives, the research sheds light on the current state of preparedness and identifies key strategies for enhancing resilience in the city. The city has taken proactive measures to enhance its preparedness and resilience through physical infrastructure improvements, community engagement, and early warning systems to mitigate the impacts of climate-related disasters and protect its urban residents. By taking proactive steps to reduce vulnerability and build climate resilience, Semarang can better protect its population and infrastructure from the detrimental effects of climate-related disasters. Sustainable efforts involving various aspects, such as Semarang City's preparedness to face climate change disasters, are part of that.

5. Acknowledgments

We would like to express our sincere gratitude to the Institute of Research and Community Services Universitas Negeri Semarang for their financial support in conducting this research. Their generous funding has played a crucial role in the successful completion of this study. We would also like to extend our appreciation to the authors for their guidance and support throughout the research process. Their valuable insights and expertise have greatly contributed to the quality and rigor of this work.

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