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Enhancing Urban Resilience: Opportunities and Challenges in Adapting to Natural Disasters in Indonesian Cities

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Abstract: This study identifies the key challenges and opportunities for enhancing urban resilience in Indonesia, focusing on the implementation of green city concepts as a strategic solution to improve urban sustainability. Case studies of Banda Aceh, Jakarta, and Surabaya demonstrate the potential and limitations of this approach in addressing critical issues such as flooding, coastal erosion, and urban heat island effects. A systematic literature review (SLR) and policy analysis related to urban resilience were employed, along with an evaluation of green city initiatives implemented in several major cities across Indonesia. Findings reveal that inadequate infrastructure, rapid urbanization, and limited budgets constitute major obstacles to adopting sustainable solutions. However, significant opportunities exist for enhancing urban resilience through collaborative efforts between the government, society, and the private sector. These opportunities include the application of environmentally friendly technologies, the development of robust early warning systems, and the implementation of adaptive urban planning strategies. This study concludes that strengthening urban resilience necessitates cross-sector collaboration, investments in resilient infrastructure, and increased public awareness and involvement in mitigating disaster risks and addressing the challenges of climate change.

Keywords: urban resilience; natural disasters; green city; climate change; collaboration

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Academic Editor: Michalis Diakakis

Received: 19 January 2025
Revised: 13 February 2025
Accepted: 14 February 2025
Published: 16 February 2025

Citation: Fuady, M.; Buraida; Kevin, M.A.; Farrel, M.R.; Triaputri, A. Enhancing Urban Resilience: Opportunities and Challenges in Adapting to Natural Disasters in Indonesian Cities. *Sustainability* **2025**, *17*, 1632. https://doi.org/10.3390/su17041632

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1. Introduction

Climate change has become an urgent global challenge, especially in urban areas with high population density. Cities face an increased risk of disasters due to extreme weather intensity, such as floods, heat waves, and storms [1]. This creates the need for innovative adaptation strategies to improve urban resilience. Research shows that the integration of science and policy has great potential in effectively managing environmental challenges, as reflected in the management of air pollution in several countries. A similar approach can be adopted in other countries, including Indonesia, which have high vulnerability to the impacts of climate change.

Urban resilience is now a key component of the global sustainability agenda. Previous studies have confirmed that strengthening climate resilience in urban areas can support climate change mitigation efforts at the international level [2]. Cities have the potential to become centers of sustainability innovation, but this achievement requires an integrated approach. Research also shows that transformational change in disaster management requires the integration of social, economic, and environmental aspects, while addressing conflicts of interest among stakeholders [3].

Green spaces have been identified as a key element in improving urban resilience. Several studies have shown that climate-adaptive green space designs can reduce the effect of urban heat islands [4], as well as reduce the impact of floods and extreme heat, especially in subtropical areas [5]. In addition, the development of green space not only supports climate adaptation but also improves the quality of life of urban communities [6].

In this study's target cities, green spaces play a crucial role in climate adaptation, resilience, and disaster mitigation. Banda Aceh has integrated coastal green belts and mangrove rehabilitation efforts to enhance resilience against tsunamis and coastal flooding. Jakarta has several urban parks and riverbank green spaces, such as the revitalized Ciliwung River, but struggles with land-use conflicts and maintenance challenges. Surabaya, known for its progressive greening programs, has successfully expanded urban forests and city parks, such as Taman Bungkul, demonstrating the potential of green spaces to improve urban resilience. However, these cities face challenges in sustaining green space quality due to urban expansion, pollution, and inadequate governance, requiring more strategic and adaptive management approaches.

Open spaces also play an important role in energy efficiency and disaster risk management. Research shows that a well-designed open space system can reduce energy needs in large cities facing rapid urbanization [7]. Strategically designed urban green spaces help regulate microclimates, lowering surface temperatures and reducing the demand for artificial cooling. Tree canopies and vegetated areas provide shade, decreasing the urban heat island effect and minimizing energy consumption for air conditioning in densely populated areas. Additionally, well-planned open spaces enhance natural ventilation, improving air circulation and lowering indoor cooling costs. Beyond energy efficiency, open spaces also contribute to disaster risk management by acting as buffer zones that absorb excess rainwater, reducing flood risks, and serving as emergency evacuation sites during disasters.

Furthermore, the proposed quantitative framework for measuring the dynamic resilience of coastal cities integrates multiple environmental, social, and infrastructural indicators to assess urban vulnerability and adaptive capacity. This framework utilizes spatial and temporal data to evaluate factors such as land-use changes, flood susceptibility, infrastructure robustness, and community preparedness. By applying this data-driven approach, urban planners can identify high-risk zones, prioritize interventions, and develop targeted policies that enhance a city's ability to withstand and recover from climate-related disasters [8]

Indonesia, as a developing country with a high rate of urbanization, faces great pressure due to climate change. Rapid urbanization is increasing pressure on urban infrastructure and ecosystems, exacerbating the effects of climate change [9,10]. International reports also emphasize that poorly managed urbanization has the potential to increase the risk of disasters such as floods, extreme temperature rises, and environmental degradation [11].

Ecosystem-based approaches have proven effective in reducing disaster risk in urban areas. Studies show that urban green structures, especially in coastal areas, can reduce the risk of disasters such as floods and hurricanes [12,13]. In addition, the ecological approach also creates a strong foundation for disaster impact mitigation in urban areas [14]. In the context of planning, ecological-based design provides an opportunity to create cities that are more resilient to climate change [15]. This nature-based approach is a sustainable mitigation strategy for the long term, especially for cities that often experience disasters.

Indonesia has begun to adopt the concept of green cities as one of the efforts to increase urban resilience. An example is in South Sumatra, where the integration of smart technology and green practices has improved resource efficiency and environmental quality [16]. The

new National Capital City project also incorporates the principles of green and smart cities to create an inclusive and sustainable environment [17].

However, the implementation of the green city concept in Indonesia faces various challenges, including a lack of funding, consistent policies, and cross-sector coordination [18]. In addition, green transportation policy reforms, including the implementation of low-carbon technologies, are needed to support sustainable mobility [19].

This research aims to identify challenges and opportunities in urban resilience adaptation in Indonesia, with a focus on the integration of ecosystem-based strategies and green space management. This study is expected to make a significant academic contribution to the urban resilience literature in developing countries. In addition, the findings of this study can be a practical reference for policymakers in developing more effective adaptation strategies to face disaster risks and climate change. With a holistic evidence-based approach, Indonesia has the potential to become a model in the implementation of resilient and sustainable green cities [17,19].

2. Materials and Methods

This study uses a mixed approach that combines case studies on the implementation of the concept of green cities in three cities in Indonesia—Banda Aceh, Jakarta, and Surabaya—with a systematic literature review (SLR) of 66 international publications. This combination aims to identify challenges and opportunities in urban resilience adaptation in Indonesia by highlighting the integration of ecosystem-based strategies and green space management (Figure 1).

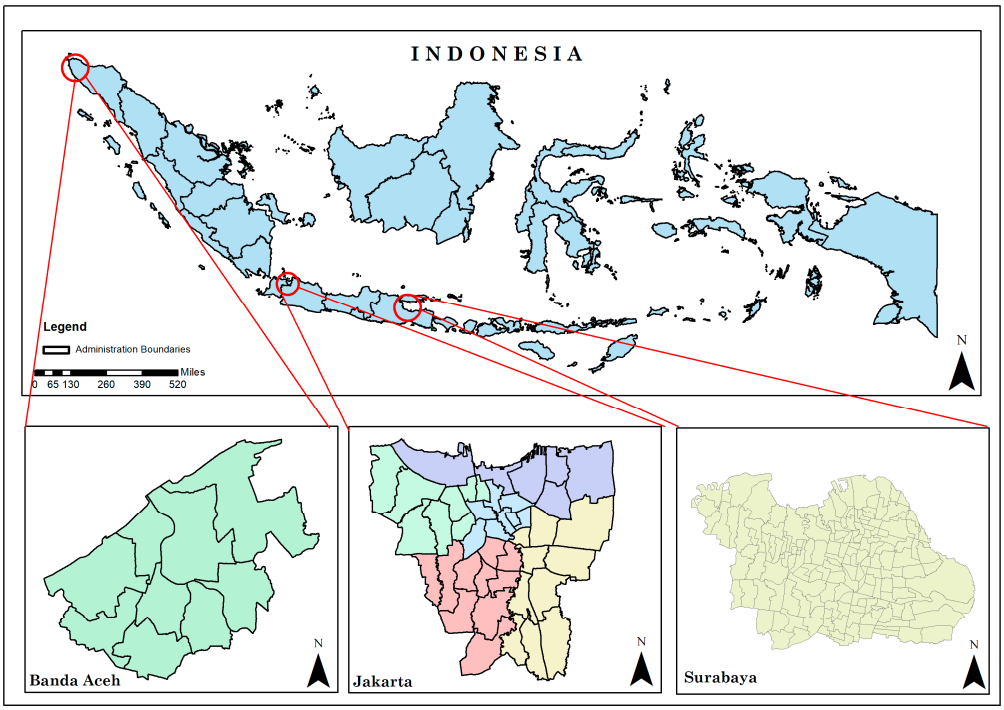

Figure 1. Geographical maps of three cities in Indonesia—Banda Aceh, Jakarta, and Surabaya.

The selection of the three cities was based on their distinct characteristics: Banda Aceh has experienced major disasters and implemented an ecosystem-based approach; Jakarta, the capital city, faces significant urbanization challenges and severe flood risks; and Surabaya is recognized for its progressive development of green open spaces. This combination offers a diverse and contextual perspective.

A systematic literature review is conducted to ensure the transparency and traceability of the process. The published analyses were obtained from various leading academic databases, such as Scopus, Web of Science, SpringerLink, and Google Scholar. The search keywords were compiled to reflect the focus of the research, including (a) urban resilience, (b) ecosystem-based strategies or nature-based solutions, (c) urban green space management, and (d) climate change adaptation in Indonesia and developing countries.

This combination of keywords was used alongside logical operators such as "AND" and "OR" to filter out the relevant literature. Inclusion criteria included (1) journal articles published in the last 10 years (2014–2024), (2) studies relevant to the topic of urban resilience and ecosystem-based approaches, and (3) articles that address the management of green spaces in the context of Indonesia and developing countries. Meanwhile, exclusion criteria included articles that are not available in full text, non-peer-reviewed publications, and studies that focus on the non-urban sector.

Data from case studies in Banda Aceh, Jakarta, and Surabaya were obtained through a review of documents, including research reports, scientific publications, and policies related to green city implementation. The review aims to identify best practices, implementation challenges, and the effectiveness of strategies implemented in each city. The focus on local policies allows for an analysis of the dynamics of integrating ecosystem-based strategies into urban governance, as well as providing in-depth insights into the factors that influence successful implementation.

The SLR method serves as the basis for building a comprehensive conceptual framework regarding urban resilience adaptation. The analysis of key themes from the literature, such as ecosystem-based approaches, green space management, and stakeholder engagement in disaster mitigation, provides a solid theoretical foundation. The case studies complement this analysis with an empirical perspective that includes local contexts, making the results more representative of the unique challenges and opportunities facing cities in Indonesia.

The combination approach between an SLR and case studies has several advantages. First, the analysis of three cities with different characteristics provides broad and representative coverage of the Indonesian context, allowing for the identification of patterns relevant to various urban conditions. Second, the application of strict criteria in SLRs ensures that only the high-quality and relevant literature is used, reinforcing the validity of the findings. Third, the exploration of local policies through case studies allows for an in-depth analysis of actual practices and challenges, making a significant empirical contribution to understanding the implementation of the green city concept.

Through this method, research is expected to produce findings that not only enrich the scientific literature but also provide practical recommendations that can be implemented. These recommendations are relevant for policymakers and practitioners who want to improve the resilience of cities to climate change through effective and adaptive green space management strategies. With an integrated approach, this research can provide a strong foundation for the sustainable development of green cities in Indonesia.

3. Results

3.1. Disaster Resilience in the City of Indonesia

A city's resilience to disasters is the ability of a city to survive and recover from natural disasters that threaten people's lives and infrastructure. The concept encompasses social, economic, and environmental factors. These elements help cities mitigate disaster impacts and accelerate recovery. Urban resilience also depends on the integration of existing systems, such as urban spatial planning, disaster preparedness, and sustainable development policies. Cities that have high adaptation capacity and effective mitigation

mechanisms can be more resilient to disaster threats such as earthquakes, tsunamis, floods, and the impacts of climate change [20,21].

In Indonesia, the status of urban resilience shows significant variation depending on the location, geographical conditions, and preparedness level of each city. Jakarta, for instance, grapples with significant challenges in mitigating the threats of flooding and coastal erosion exacerbated by rapid urbanization. In contrast, Surabaya has proactively addressed these issues through a robust greening program aimed at mitigating the impacts of urban heat and flooding caused by extreme rainfall events. Banda Aceh, which is located in a tsunami- and earthquake-prone area, demonstrates the need to strengthen disaster resilience infrastructure and risk-based adaptation policies. A similar phenomenon is found in several global cities, where immature urban planning is often a major obstacle to improving disaster resilience [22].

The main factors affecting urban resilience include the quality of infrastructure, mature urban planning, community preparedness, and government policies that support disaster risk reduction. Good infrastructure, such as earthquake-resistant buildings and adequate drainage systems, is essential to minimize the impact of disasters. Urban planning that takes into account geographical characteristics and disaster potential is also key in reducing vulnerability to risk. For example, the management of green open spaces not only supports flood mitigation but also contributes to improving air quality and carbon sequestration. In addition, community participation in disaster risk reduction contributes significantly to the effectiveness of mitigation strategies [23,24].

Several cities in Indonesia have begun to adapt to climate change and increase resilience through environmental sustainability-based approaches. For instance, while Jakarta faces challenges with flooding and coastal abrasion, Surabaya's greening initiatives offer a model for climate adaptation. In addition, green open spaces in Surabaya also function as rainwater absorption systems, reducing excessive surface flow. This kind of implementation is in line with ecosystem-based approaches, as implemented in Nagpur, India, which shows that the integration of environmental sustainability into urban planning can improve disaster resilience [25].

However, the implementation of the concept of green cities in Indonesia faces major obstacles, especially in large cities with high population density. Jakarta, for example, is still struggling with land constraints and the challenges of rapid urbanization. Expanding green open spaces often faces significant hurdles, including the competing demands of infrastructure development and economic growth. Moreover, uncontrolled urbanization exacerbates the city's vulnerability to flooding, a risk further compounded by the impacts of climate change. Therefore, collaborative efforts are needed between the government, the community, and the private sector to address these challenges and strengthen urban resilience [26].

Banda Aceh is an example of a city that has succeeded in increasing resilience after experiencing a major disaster. After the 2004 tsunami, Banda Aceh prioritized the development of earthquake-resistant infrastructure and tsunami early warning systems. The city has also developed an ecosystem-based coastal area management strategy, including the construction of green open spaces for disaster risk mitigation. This approach demonstrates the effectiveness of ecosystem-based risk management in increasing urban resilience while providing sustainable environmental benefits [27].

The concept of green cities also has an important role in reducing carbon emissions, mitigating climate change, and improving people's quality of life. A study in Fukuoka, Japan, shows that the effective management of green open spaces can lower city temperatures, reduce air pollution, and increase disaster resilience. This is relevant for cities in Indonesia that are transitioning towards environmental sustainability. Although some

cities have implemented this concept, there are still major challenges in terms of resources, policies, and technical capacity that need to be improved [24].

To deal with increasingly complex disaster risks, governments need to pay attention to key challenges, such as budget constraints and technical capacity in designing urban resilience policies. On the other hand, opportunities to strengthen urban resilience are open through the application of smart city technology and ecosystem-based approaches. Collaboration between governments, the private sector, and communities is essential to design sustainable solutions. With the right policies, cities in Indonesia can become more resilient to disasters as well as environmentally friendly and more able to adapt to increasingly real climate change [28,29].

In the future, the application of green cities and environmentally friendly technologies will be an important step to improve resilience and quality of life in Indonesian cities. As part of its global commitment to sustainability, Indonesia has great potential to develop cities that are not only resilient to disasters but also environmentally sustainable, providing economic, social, and environmental benefits for the community [30].

3.2. Implementation of the Green City Concept in Indonesia

A green city is a concept of urban development that integrates aspects of environmental sustainability with resilience to disasters. This concept prioritizes efficient natural resource utilization, carbon emission reduction, and the preservation of natural ecosystems. Implementing green city initiatives in Indonesia is crucial for addressing climate change challenges while enhancing the quality of life for local communities. The main characteristics of a green city include adequate green open space planning, energy efficiency, and sustainable water management systems. By prioritizing sustainability, green cities function to improve air quality, reduce pollution, and strengthen resilience to disasters such as floods and landslides [31].

The immediate benefits of implementing green cities are evident in their contribution to urban resilience against disasters. The integration of blue–green infrastructure, which combines green open spaces with an environmentally friendly water management system, serves as an effective approach. For example, the implementation of green open spaces in several major cities in Indonesia has succeeded in increasing water absorption capacity so that it can reduce the risk of flooding. This is also supported by the implementation of an ecosystem-based drainage system that lowers surface flow during high rainfall [32]. In addition, the management of coastal ecosystems based on green cities plays an important role in reducing the risk of abrasion and high waves in coastal areas.

In the context of climate change, the implementation of green cities also supports the reduction in carbon emissions. This effort can be seen in the development of green infrastructure in big cities such as Jakarta, Surabaya, and Bandung. Measures such as greening building facades, planting trees, and building urban parks contribute to improving air quality and reducing the effects of urban warming due to urbanization [33]. Furthermore, these efforts are in line with the need to create a healthier environment, not only in terms of the physical but also the mental well-being of the community.

Ecosystem protection is also an important component in the concept of a green city. Healthy ecosystems contribute to increasing rainwater absorption, flood prevention, and drought management. For example, green open spaces in Surabaya have been used as a buffer for urban ecosystems that increase food security through urban agriculture [34]. This shows that green cities not only support environmental sustainability but also resilience to diverse disaster risks.

The social benefits of implementing green cities cannot be ignored. Green open spaces provide space for physical activity, socialization, and relaxation, which are important

in building social resilience. Research shows that green spaces contribute to improving people's mental and physical well-being, which in turn strengthens people's adaptive capacities in dealing with disasters [35]. Community involvement in the management of green space is also the key to the success of the green city concept.

In facing the challenge of climate change, green cities can also reduce the risk of disasters caused by extreme weather. The application of environmental sustainability principles in infrastructure, such as efficient drainage systems and environmentally friendly technology in building construction, is a very important step. Cities such as Jakarta and Banda Aceh, which are prone to disasters, need proactive policies to optimize the potential of green spaces as a solution to adapt to extreme weather [36].

However, although the potential for green cities is quite large, its implementation in Indonesia faces various challenges, especially limited land in densely populated cities. Rapid urbanization often hampers efforts to expand green open spaces. In addition, the lack of public awareness and local government policy support is also a major obstacle [37]. Addressing these challenges requires a holistic approach that involves governments, the private sector, and communities in the planning and implementation of green cities.

As a strategic step, Indonesia needs to continue to prioritize the application of the concept of green cities in urban planning. Green cities emphasize not only environmental sustainability but also disaster resilience. Ecosystem-based approaches and environmentally friendly technologies can create cities that are more adaptive to climate change. In addition, policies that support the development of green cities must be strengthened, and the community needs to be actively involved in the process of urban planning and management [38]. With these steps, Indonesia can realize a safer, more resilient, and sustainable future for future generations.

3.3. Increasing Disaster Resilience in Banda Aceh City

Banda Aceh, a city located in the coastal region of Aceh, Indonesia, has a long history related to natural disasters, especially the major tsunami that hit on December 26, 2004. This disaster not only caused tremendous physical damage but also destroyed the social and economic life of the community [39]. Post-tsunami, urban recovery planning is based on the need to strengthen disaster resilience, which includes the development of more disaster-resilient infrastructure and sustainability-based environmental management [40]. This reflects a combined approach between disaster direct impact mitigation and future risk reduction.

Banda Aceh's efforts to increase disaster resilience emphasize the development of earthquake-resistant and environmentally friendly infrastructure. Given the city's geographical location prone to earthquakes and tsunamis, the construction of public facilities is carried out according to stricter earthquake-resistant construction standards, which is in line with global experience in disaster risk mitigation in coastal areas [41]. In addition, green open spaces (GOSs) are expanded by adding ecological functions to improve air quality, reduce flood risk, and maintain soil carrying capacity. Other studies emphasize that GOSs can also help address the problem of subside-prone soils in coastal areas [42], which poses an additional threat to Banda Aceh.

Greening policies in Banda Aceh also play a key role in strengthening urban resilience. This strategy includes tree planting, urban park development, and coastal ecosystem restoration. The ecological contribution of this greening not only helps with disaster mitigation but also improves the overall quality of the environment. In addition, ecosystem-based coastal management, such as mangrove planting and natural embankment construction, has proven to be effective in reducing the impact of coastal abrasion and high waves, while providing additional benefits in the form of increasing local biodiversity [43].

However, major challenges still face Banda Aceh in implementing the concept of a green city and disaster resilience. One of the main challenges is the limitation of resources, both in terms of budget and technical capacity. Land limitations in urban areas, as experienced by other coastal cities, pose a challenge to the expansion of ideal green open spaces [44]. On the other hand, rapid urbanization increases pressure on infrastructure and natural resources. This indicates that mitigation and adaptation measures require a more integrated approach between governments, communities, and the private sector to create sustainable solutions.

Opportunities for cross-sector collaboration provide great hope for Banda Aceh to strengthen the city's resilience. Communities that are actively involved in the planning and management of green spaces have the potential to accelerate the implementation of sustainability policies. In addition, the use of technology such as geographic information systems (GISs) to monitor the dynamics of the urban environment and identify high-risk areas can improve the efficiency of mitigation programs [45]. However, it is important to recognize that GISs are just one of many technologies crucial for achieving urban sustainability and resilience. Other key technologies include the Internet of Things (IoT), artificial intelligence (AI), renewable energy sources, and smart grid technologies. This approach allows for the optimization of data-driven strategies to improve disaster preparedness and development policy efficiency.

In conclusion, Banda Aceh has the opportunity to become a resilient coastal city model through the application of green city principles and the strengthening of ecosystem-based infrastructure. Strengthening progressive environmental policies, empowering communities, and investing in environmentally friendly technologies are key to facing future challenges. With this approach, Banda Aceh can not only reduce disaster risk but also create a healthier, more livable, and sustainable environment.

3.4. Challenges of Disaster Resilience in Jakarta City

Jakarta, the capital city of Indonesia, faces major challenges related to natural disasters due to its geographical location on the coast and high population density [46]. Flooding is one of the main problems, especially during the rainy season, due to poor drainage systems that are unable to accommodate high rainfall. On the other hand, worsening coastal abrasion also threatens coastal areas, while air pollution worsens the quality of life of residents. This challenge requires Jakarta to overcome the impact of existing disasters while preparing itself to face future threats through a more comprehensive approach [47].

In response to this challenge, Jakarta has initiated steps to create a sustainable and disaster-resilient green city. One of its main efforts is the improvement of green open spaces (GOSs), which aims to lower the temperature of the city, control flooding, and improve air quality. Studies show that the existence of GOSs provides ecological benefits while providing a space for social interaction that is important for the health of urban communities [48]. In the context of Jakarta, planting trees in public areas and building city parks are strategic steps that support adaptation to climate change while reducing flood risk.

In addition, more efficient waste management has become a top priority, considering that the accumulation of waste that is not managed properly is the main cause of the clogging of waterways. The Jakarta government together with various community organizations has made efforts to increase recycling rates and reduce the use of single-use plastics, in line with reducing greenhouse gas emissions [49]. This move not only reduces the negative impact on the environment but also supports Jakarta's vision as a cleaner and greener city.

Strengthening the drainage system is also the main focus to reduce flood risk. New drainage infrastructure improvement and construction projects have been undertaken to deal with the high rainfall that occurs frequently. This effort is combined with the construction of sea embankments and coastal maintenance to overcome abrasion in coastal areas. This strategy is in line with the approach implemented in other coastal cities to increase resilience to climate change and flood risk.

However, major challenges remain, especially related to high population density, which limits the availability of land for the development of green infrastructure and GOSs. Rapid urbanization and a lack of integrated urban planning often hamper greening efforts and better drainage management. In addition, air pollution caused by motor vehicles and industrial activities worsens the quality of life of Jakarta residents, which indirectly affects efforts to improve the city's resilience to disasters [50].

Natural resource management that is not fully sustainable is also a major obstacle. Although emission reduction and waste management policies have begun to be implemented, there are still many challenges in terms of implementation and enforcement. Unsustainable development projects in some urban areas show the need for more integrated planning to reduce ecosystem damage and increase resilience to disasters.

Despite these challenges, there is a great opportunity to improve Jakarta's resilience through collaboration between the government, the private sector, and the community. For example, developers can be invited to build new green areas and improve existing infrastructure, while the community can actively participate in maintaining environmental cleanliness and supporting greening and emission reduction policies [51]. This collaborative approach can also accelerate the city's adaptation to climate change and increase community resilience in the face of disasters.

In the future, Jakarta needs to strengthen more progressive environmental policies and increase the participation of various parties in the development of green cities. Raising public awareness of the importance of sustainability and disaster preparedness is also key to creating resilient and sustainable cities. By consistently implementing the concept of green city development, Jakarta can improve environmental quality, increase disaster resilience, and ensure a better future for future generations.

3.5. Challenges of Disaster Resilience in the City of Surabaya

Surabaya, Indonesia's second-largest city, faces major challenges due to climate change, disaster resilience, and a typical hot climate. The high temperatures that last throughout the year, especially during the dry season, negatively impact the quality of life of residents and increase their burden in carrying out daily activities. In addition, high rainfall often causes flooding due to the limited capacity of drainage channels. In this context, water management efficiency and adaptation to extreme weather are key to facing these challenges [52]. Therefore, Surabaya needs to develop integrated solutions that are not only able to reduce the impact of climate change but also increase disaster resilience.

In response, Surabaya has launched various green city initiatives to reduce the impact of climate change and improve the city's resilience to disasters. One important step is a mass tree planting program aimed at lowering city temperatures, absorbing carbon dioxide, and improving air quality. A well-managed GOS provides ecological benefits while providing a space for social interaction for the community. In addition, this measure contributes to flood control through increased water absorption in urban areas [53]. However, the effectiveness of this program is still limited because some areas of the city have experienced land conversion which reduces space for reforestation.

Environmentally friendly transportation is also an important component of Surabaya's green city initiative. The development of public transportation modes, such as electric

buses and bicycle lanes, aims to reduce dependence on private vehicles, which are major contributors to air pollution. This strategy is in line with the sustainable approach implemented in other cities to reduce carbon emissions and create a greener transportation system [54]. However, the sustainability of these initiatives requires close collaboration between the government, the private sector, and the community to ensure changes in transportation habits.

In addition to greening and environmentally friendly transportation, Surabaya also applies the concept of a "compact city" to maximize the use of vertical space and reduce horizontal urban expansion. This strategy is designed to reduce vulnerability to flooding and make efficient use of urban space. With the development of environmentally friendly infrastructure, Surabaya can reduce the impact of unplanned urbanization, which is often the main cause of environmental damage in major cities.

However, various challenges still hamper Surabaya's efforts to improve disaster resilience. Extreme weather, especially high temperatures during the dry season, remains a difficult problem to overcome due to its direct impact on people's quality of life. Drainage management is also a major issue, as limited capacity is often inadequate to deal with higher rainfall intensities due to climate change. In addition, rapid urbanization has led to the conversion of green land into residential and commercial areas, which significantly reduces the carrying capacity of the city's environment [55].

To address these challenges, a more integrated approach to urban planning is needed, including investments in disaster-resilient infrastructure and the implementation of policies that support the management of green open spaces. For example, data-driven urban planning can help identify priority areas for more efficient green infrastructure development. In addition, stronger efforts in waste management and recycling can help improve the overall quality of the environment [56].

Surabaya has great potential to become a model sustainable green city in Southeast Asia. Collaboration between the government, the private sector, and the community is key to capitalizing on this opportunity. For example, the city can expand greening programs in residential and commercial areas and increase innovation in waste management and green transportation. With a more collaborative and integrated approach, Surabaya can be a pioneer in facing the challenges of climate change and disasters, as well as an inspiration for other cities in the Southeast Asian region [57].

Overall, despite the many challenges Surabaya faces, the initiatives that have been undertaken show a positive direction towards sustainability and disaster resilience. With consistency in the implementation of policies and innovations, Surabaya has a great opportunity to create a greener, cleaner, and more resilient city in the future.

4. Discussion

Indonesia faces major challenges in improving the resilience of cities to disasters. Inadequate infrastructure, such as poor drainage systems and disaster-resistant buildings, increases its vulnerability to natural disasters such as floods, earthquakes, and landslides. Many regions in Indonesia still rely on outdated infrastructure, while rapid urbanization is putting enormous pressure on existing infrastructure, exacerbating urban resilience issues. Furthermore, limited budgets for infrastructure construction and maintenance hinder timely repairs, while the unpredictable nature of climate change, characterized by intense rainfall, droughts, and rising sea levels, further compounds these challenges, forcing cities to adapt rapidly [58]. This necessitates stronger efforts to enhance physical and systemic resilience to future disasters.

However, despite the considerable challenges faced, Indonesia also has significant opportunities to strengthen the resilience of cities to disasters. One of the main opportuni-

ties is closer collaboration between the central and regional governments. A coordinated approach can ensure policies and programs implemented at the local level are aligned with national goals to reduce disaster risk and strengthen urban resilience. Local governments play an important role in designing policies that suit local needs, while the central government can provide support in the form of funding, regulations, and supporting technology. Community empowerment is also a great opportunity to increase urban resilience because active community involvement in disaster mitigation can strengthen local resilience to disasters [59]. Experience in several Indonesian cities shows that the active role of communities in sustainable urban planning can accelerate the achievement of higher resilience to disaster risks [60].

The application of environmentally friendly technology can strengthen the city's resilience to disasters. Technology can help Indonesian cities manage natural resources more efficiently, reduce carbon emissions, and improve early warning systems [61]. Innovations such as satellite-based disaster monitoring systems or sensors allow for faster and more effective responses. The concept of smart cities, which integrate big data and the Internet of Things (IoT), can also help Indonesian cities plan and manage their infrastructure more efficiently, reducing their vulnerability to disasters [62].

Increasing public awareness of climate change and disasters also plays an important role in building urban resilience. By increasing awareness of the impacts of climate change, communities can change their behavior, such as reducing energy and water consumption and increasing their participation in disaster mitigation activities. Education and training on disaster preparedness can strengthen community resilience in the face of disasters, ensuring that the necessary information and resources are available to those who are most vulnerable [63].

International cooperation also offers great opportunities to strengthen the city's resilience to disasters. Collaboration between ASEAN countries and international institutions provides access for Indonesia to share knowledge, technology, and funding related to disaster resilience. This partnership allows Indonesia to adopt best practices from other countries that have experience in green and sustainable urban planning. Funding for sustainable development projects is essential to strengthen urban resilience, including the development of green infrastructure such as green open spaces and better drainage systems, which can reduce the impact of natural disasters [64,65].

The findings of He et al. [66,67] have significant implications for Indonesian cities, particularly Jakarta, which is experiencing rapid urbanization and is highly vulnerable to flooding and other extreme weather events. The study highlights the need to consider the compounding effects of multiple hazards and to develop urban planning strategies that mitigate these risks.

Overall, although the challenges faced by Indonesia in improving the resilience of cities to disasters are considerable, the opportunities are significant. Through collaboration between the government, communities, and the private sector, as well as the use of technology and international funding, Indonesia can build cities that are more resilient to disasters and climate change. With a strong commitment from all relevant parties, Indonesia has the potential to become a leader in the development of sustainable and disaster-resilient green cities in Southeast Asia [68].

5. Conclusions

This study concludes that the primary challenges in improving urban resilience to disasters in Indonesia include inadequate infrastructure, rapid urbanization, budget constraints, and the increasing complexity of climate change management. Limited infrastructure weakens a city's ability to mitigate disaster impacts, while rapid urbanization

places additional strain on existing systems, increasing vulnerability. Additionally, financial constraints and limited government capacity to manage climate-related risks further hinder urban resilience.

Despite these challenges, significant opportunities exist to enhance urban resilience through multi-stakeholder collaboration, technological innovation, and strategic policy development. Strengthening coordination between central and local governments, empowering communities in disaster mitigation efforts, and integrating adaptive urban planning can significantly improve disaster preparedness and response. International cooperation also provides valuable access to expertise, technology, and funding for sustainable and resilient urban development.

To address these issues, this study recommends the following key actions:

a. Invest in resilient infrastructure: develop climate-adaptive infrastructure, including sustainable drainage systems, flood control mechanisms, and green open spaces to mitigate disaster risks and urban heat effects.
b. Strengthen cross-sector collaboration: enhance cooperation between government agencies, the private sector, and local communities to improve policy effectiveness, resource allocation, and disaster response mechanisms.
c. Leverage smart city technology: utilize digital innovations, real-time early warning systems, and environmentally friendly urban solutions to enhance disaster preparedness and adaptive urban management.
d. Promote adaptive urban planning: integrate green city principles into development strategies, ensuring that land-use policies, zoning regulations, and infrastructure projects incorporate sustainability and disaster resilience considerations.
e. Increase public awareness and community empowerment: conduct educational programs and disaster preparedness initiatives to strengthen community engagement in risk reduction and response efforts.
f. Secure sustainable funding and international cooperation: develop financing strategies that support long-term urban resilience projects, leveraging both domestic and international partnerships for knowledge sharing and investment in sustainable urban development.

By implementing these measures, Indonesian cities can enhance their ability to withstand and recover from disasters while fostering long-term urban sustainability. A coordinated and comprehensive approach, integrating social, economic, and environmental dimensions into urban planning, is crucial to creating safer, more resilient, and future-ready cities.

Author Contributions: Conceptualization, M.F.; methodology, M.F. and B.; formal analysis, M.F., B. and M.A.K.; investigation, M.A.K. and M.R.F.; data curation, M.R.F. and A.T.; writing—original draft preparation, M.F.; supervision, B.; writing—review and editing, B. and A.T.; visualization, M.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

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