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The Disaster-Resilient Smart City in Malaysia: The Use of Technology in Flood Management

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Abstract
Growth in metropolitan areas is occurring at a rate never seen before in human history. Almost two-thirds of the world's population is expected to reside in cities by the year 2050, up from a current percentage of more than half. Floods provide new risks and uncertainties at a time when growing urbanization is already putting a strain on finite resources and infrastructure. With the rise of smart cities as a solution to urban problems like flooding, many nations have made their largest cities more advanced than before. This study has accomplished its goal of generating interest in smart cities as a research topic by examining the use of smart city applications on flood management in Malaysia. It is hoped that this research would help policymakers develop a meaningful public policy and program to enhance smart city technologies, particularly for flood management.
Keywords: Climate Change, Smart City, Flood, Flood Management, Information and Communication Technologies (ICT).

Introduction

Floods are the most common natural disasters worldwide, accounting for 40% of all-natural disasters (Munawar et al., 2019). The annual cost of damage caused by floods is in the hundreds of millions of dollars, and thousands of lives have been lost (Arrighi et al., 2019). Economic losses from floods are substantial and include not only human lives but also infrastructure, buildings, fields, crops, and livestock; in this age of sustainability and smart cities, these losses must be reduced to a minimum (Qayyum et al., 2021; Ullah et al., 2021).

Recently, Malaysia was hit by an enormous downpour. Klang Valley, which includes the cities of Kuala Lumpur and Selangor, experienced significant rains on the 17-19th of December 2021. The maximum 1-day rainfall recorded at the Jalan Benteng Kapar rainfall station was 316.5 mm, which is greater than a 100-year average. Rainfall totals of above 200 mm over two days were also reported in the other locations. More than 70,000 people had to be relocated due to the Klang River flood, 50 individuals were killed, and 5 are still missing. The high tidal level has left an area in Taman Seri Muda, Selangor, inundated to a depth of more than 3 meters, and the flood water has been ponding there for 3 days (Liu et al., 2022).

Lives are lost because relief and recovery services are not delivered in time because of the late identification of floods and the lack of accurate and rapid technologies that might automatically detect the onset of flooding in a region. People need cutting-edge digital tools to pinpoint the locations of flood damage as soon as possible so that rescue efforts can get underway (Low et al., 2020; Ullah et al., 2020). According to Atif et al (2021), early detection of floods is critical for properly planning relief missions and rescuing the trapped individuals, which in turn reduces economic damages and mortality.

It is crucial to set up some kind of early warning system to let people know what to expect in the event of a flood. Numerous technologies exist that can be used for foresight and avoidance. Most people in the country probably have access to electronic devices like tablets and smartphones. During floods, the Internet of Things (IoT) flood monitoring system plays an important role by providing accurate data that can be used by authorities to better assist victims of flooding and mitigate the disaster's impact (Zahir et al., 2019). This has been recognized as having significant promise by Khan et al (2021) for remaking non-smart cities into such. There is an urgent need for emergency response systems, and research communities all around the world are hard at work deploying a wide variety of smart city services. One problem with the way cities have traditionally handled emergencies is a lack of coordination, a breakdown in communication, a lack of preparation, a poor reaction time, and a disorganized recovery process (Rijwan Khan et al., 2021).

Research into the concept of a "smart city" as it pertains to climate change adaptation is essential since adaptive decision-making must be both intelligent and proactive (Nicholls, 2007). Yau et al (2014) argue, however, that there has been a paucity of research in the context of most developing nations, Malaysia included, and that this requires a local study on the smart city to address the local problem, especially floods. There is a growing amount of work on climate change adaptation and mitigation, but so far there has been little effort to integrate this knowledge with the technologically-based study on smart cities (Obringer & Nateghi, 2021).

Research objective: To examine the use of smart city applications in flood management in Malaysia.

Subsequent sections of this article explore several smart city definitions and concepts. The article then moves on to detail the progress of smart cities in Malaysia. Our discussion then turns to how a smart city can aid in flood prevention and management. Finally, this article explores how smart cities can aid in disaster response in Malaysia. The conclusion section will be presented at the end of this paper.

Smart City

There has been a push to establish the smart city concept as the new ethos for city planning (Yigitcanlar et al., 2019; Figueiredo et al., 2019). Communities that utilize information and communication technologies to improve livability, productivity, and sustainability are referred to as smart cities (The International Capital Market Association (ICMA), 2016). According to Patro et al. (2020), smart city projects aim to tackle urbanization's complexities from a fresh perspective and provide interdisciplinary answers to urban issues.

"Faith in technology" and "techno-urban development" (two key tenets of the Smart City movement) may have their roots in Francis Bacon's New Atlantis (1627), as claimed by Cugurullo (2018). However, there appears to be no agreement on the definition of a smart city at that time (Kummitha & Crutzen, 2017; Caird & Hallett, 2019; Mora et al., 2019). The usage of Information and Communication Technologies (ICT) is frequently mentioned (Bifulco et al., 2016; Bibri & Krogstie, 2020). While the concept of a smart city has been around for over 20 years, scientists are still debating what it entails (Neirotti et al., 2014). Though there is no consensus on what constitutes a smart city, most academics agree that ICT is essential to the development of such communities (Albino et al., 2015; Bibri & Krogstie, 2017). To be more precise, there are many examples in the written word when technology alone is sufficient to create a smart city (Obringer & Nateghi, 2021).

Giffinger & Gudrun's (2010) idea of smart cities encompasses several of the most critical facets of urban improvement, including smart economics, smart people, smart governance, smart mobility, smart environment, and smart living. Increased attention has been paid to the concept of smart cities in recent years, both as a field of study and as a framework for public policy. However, there has been no unified understanding of what characteristics constitute a smart city. In the real world, smart cities are often celebrated as a way to modernize cities while also aiding in sustainability efforts.

The environmental, infrastructural, public health, accessibility, and equity effects of smart cities, as well as the ramifications of producing and utilizing "big data," must be taken into account. Due to the interconnected nature of climate change and the rise of smart cities, research in these two fields must be brought together (Obringer & Nateghi, 2021). This technologically-motivated smart city movement is predicated on the extensive use of ICT, Big Data, Artificial intelligence (AI), the IoT, algorithms, and automation to provide utopian answers to urban issues and improved municipal administration (Zheng et al., 2020; Kummitha & Crutzen, 2017). In light of the foregoing, it seems reasonable to define a smart city as one that employs several technological tools, including Big Data, Artificial Intelligence (AI), and the Internet of Things (IoT), to effectively handle municipal issues and further the city's sustainable development goals.

The Development of Smart City in Malaysia

Some see smart cities as a new urban development approach, and they are becoming increasingly popular in emerging nations (Mendes, 2022). Malaysia has accepted various national and international goals as guides for smart city projects, including the Sustainable Development Goals, the New Urban Agenda, the Twelfth Malaysia Plan, the National Physical Plan 3, and the National Urbanization Policy 2. Cities in Malaysia are starting to deploy the technology necessary to become smart and sustainable through their respective Local Authorities (Lim et al., 2021). Several urban areas in Malaysia have become pilot cities, which would be later developed into smart cities, such as Kuala Lumpur, Johor Bahru, Cyberjaya, and Putrajaya. Among the criteria for becoming a smart city in Malaysia are Smart Governance, Smart People, Smart Digital Infrastructure, Smart Economy, Smart Mobility, Smart Living, and Smart Environment (PLANMalaysia, 2019).

Knowledge-based urban planning ideas have been used to create space and location for smart urban communities in Malaysia ever since the 1996 Multimedia Super Corridor Malaysia initiative (Yigitcanlar & Sarimin, 2015; Yigitcanlar & Dur, 2013). Besides that, the Malaysian government unveiled the Malaysia Smart City Framework (MSCF) in September 2019 (Loo, 2019). The MSCF framework was created to serve as a unified policy blueprint for smart city development in all of Malaysia's governments and regions. The term smart city was first coined by the Municipal Services and Construction Fund (MSCF) and refers to municipalities that employ ICT and technological progress to better the lives of their citizens, increase economic growth, create a more sustainable and secure environment, and foster more effective urban (MSCF, 2019).

When planning and building smart cities in Malaysia, the MSCF is used as a guide and reference by Local Authorities city managers, state governments, federal ministries and departments, industry actors, academics, and other stakeholders. A smart city, in the eyes of the Malaysian government, is a future approach to urban planning, development, and management that can provide solutions to urban challenges like the inefficient delivery of urban services, environmental pollution, and traffic congestion, thereby improving the quality of life for people who live in cities. CCTV, intelligent traffic management systems, smart parking, cashless payments, air quality indicators, and water quality indicators are just some of the digital services being implemented as part of the Selangor Smart City program to improve the quality of life for city residents (Effendee et al., 2022).

Smart City and Flood Management

With the help of data sources including Unmanned Aerial Vehicle (UAV), remote sensing, online news media, and CCTV cameras, the disaster-resilient smart city concept aims to provide the benefits of both technologies for preventing, evacuating from, monitoring, and early warning the public about catastrophic events (Shah et al., 2019; Hadi et al., 2020; Grasic et al., 2018). Numerous researchers rely heavily on artificial intelligence and geographic information systems when mapping out the distribution of flood risks and vulnerable areas (Arinta & Andi, 2019; Chen et al., 2020). For effective and timely hazard preparedness and flood crisis management, a Geographic Information System (GIS) can be used to input, store, integrate, manage, and transmit spatial data for strategic planning and real-time decision-making (Abid et al., 2021).

A real-time flood control system that can detect flooded areas immediately and begin relief efforts as soon as feasible is urgently required. Since current imaging systems rely on satellites, which have proven to have limited precision and delayed reaction, they are unreliable and impracticable for use in emergency responses to natural disasters like flooding (Munawar et al., 2021). Since the advent of the cloud computing era, ICT has been undergoing continuous modifications and improvements. Database management, knowledge-based data mining, and data storage are three areas where the cloud shines. It is for the best that this innovation is integrated into smart city initiatives. GreenCloud is pushing some cool stuff for smart city growth. This is especially true in the event of a natural disaster, such as a flood, that the smart city must respond to (Yusoff et al., 2015).

There has been a lot of momentum in recent years to promote eco-friendly technology as a means of fostering smart city growth. As part of the effort to promote environmentally friendly practices, even the field of cloud computing developed the GreenCloud simulator. The primary goal of GreenCloud is to reduce network energy consumption by optimizing cloud computing system output processing (Kliazovich et al., 2013). Utilizing the GreenCloud facility has numerous advantages, including energy and power savings, and an improved Intelligent System of flood detection and early warning system (Yusoff et al., 2015).

Also, any flood monitoring system needs real-time monitoring enabled by the Internet of Things (IoT) to aid in early warning if it is to be useful in providing flood forecasts (Chen et al., 2022). Using technologies like Radio-frequency identification (RFID), sensors, actuators, and mobile phones, the IoT allows for the interconnection of disparate devices that generate and/or collect data (Giusto et al., 2010). Real-time Internet of Things (IoT) flood detection systems evacuate victims and lessen the disaster's devastating effects. Time is widely considered the most important aspect in all these contexts. That is why it is important to use these technologies for advanced identification and reporting of accurate data to research centers, where it can be thoroughly analyzed for its domain, rationale, and impact to halt any more negative outcomes (Khan et al., 2021).

Quickly collecting, filtering, processing, and analyzing the data allows for the construction of flood-ready infrastructure. Preparations are made in advance, including the establishment of medical camps and emergency shelters in the area that may be affected by the event, in case the area lacks basic precautions like anti-flood facilities. The priority in such a situation must be saving people's lives rather than repairing the property that will soon be flooded (Ackere et al., 2019). The Internet of Things (IoT) is helpful in several ways, including the early detection of floods and other calamities and the investigation of the causes of rapid climatic changes and their effect on the agriculture sector. The Internet of Things-based emergency management system can foresee a flood and promptly warn those in the area. The current system uses a sound buzzer and human monitoring at the dam wall to notify the appropriate parties of an impending flood (Khan et al., 2021).

The Internet of Things Early Flood Detection & Avoidance System is a smart system that monitors several environmental indicators to foresee the onset of a flood, at which point we can take preventative measures to lessen the extent of the disaster. Since the system is Wi-Fi enabled, the data it collects may be accessed from anywhere via the Internet of Things. This system will leverage the ubiquitous Internet of Things (IoT) to publish readings of the water level on a website. A user with a laptop or mobile phone and an internet connection can check the water level from any location in the event of persistent heavy rain. Additionally, this high-tech setup allows for wireless management of the warning signal and the gate that opens when water levels get too high. Sending citizens an SMS as a warning signal who haven't subscribed to mobile data or don't have internet access is one way to make the system even better (Kumaria et al., 2020).

Smart City and Flood Management in Malaysia

In terms of global averages, Malaysia has some of the greatest yearly precipitation. To help with flood planning, prevention, and post-event reaction, the Malaysian government enlisted the help of British technology firms to create an integrated environment dashboard system (Department for International Trade, 2021). The government of Malaysia has launched its first smart city project called Kemaman Smart Community (KSC). The primary goal of the KSC programs is to promote the widespread adoption of ICT by the local government and communities as a means of improving the quality of life and expanding economic prospects. Community Internet Centre, Kemaman Innovation Centre (KIC), mobile application development competition, Flood Management System and Malaysia's Flood Warrior are the six flagship initiatives available through the KSC program. The purpose of this program is to help the community be ready for another devastating flood like the one in 2014. All of the infrastructures were made possible thanks to funding from Malaysia's Ministry of Communications and Multimedia (MCMC) (Mohd Satar et al., 2020).

Several steps have been launched by major entities such as the Penang State Department of Irrigation and Drainage (JPS), the City Council of Penang Island (MBPP), and the Seberang Perai Municipal Council (MPSP) in response to flood occurrences in Penang.

Throughout flood-prone areas of Penang, 25 siren stations have been installed as part of the Joint Protection Scheme (JPS). Eleven of these are located on the island itself, while the remaining 14 are located on the mainland. MBPP installed water-level sensors in 10 flood-prone regions, while MPSP installed water-level monitoring and alert warning systems in 12 places with pump houses (Inn, 2019).

CCTV stations have been widely established among Typhoon Committee (TC) Members in recent years for use in river monitoring, water level measurement, flood modeling, and emergency management connected to flooding. There are more than 300 CCTV stations in Thailand, around 1400 in the Republic of Korea, and 25 in Malaysia, all according to 2017 data from the Ministry of Land, Infrastructure, and Transportation (MLIT) of Japan (Liu et al., 2022). Recently, the preexisting CCTV networks never interacted with one another. Now with more than 5,000 cameras, the city has a centralized observation to better monitor crime, traffic, and natural disasters like flash floods. The ability of city governments to provide and manage data sets will be strengthened thanks to this project. From the perspective of law enforcement, this will create a secure and streamlined setting in which officers can do their jobs and respond rapidly to situations. Effective monitoring and analytics will be possible with the help of AI and other predictive systems (Department for International Trade, 2021).

The Kuala Lumpur City Council has begun installing and upgrading smart CCTV cameras across the city as part of the Safe City Program. Some of these cameras have video analytics-enabled software. The integration of surveillance footage into the control room should make it easier to keep an eye on things like traffic, potential criminal activity, and sudden weather changes (Department for International Trade, 2021). Businesses focused on smart city technology in the United Kingdom (UK) and Malaysia are teaming together to serve the needs of both domestic and international clients. As an additional result of the collaboration, a cutting-edge smart city solution for predicting and controlling flash urban floods in Malaysia would be made available (Yusof, 2022).

Since flash floods can erupt in an instant in Kuching, having more time to respond means more people will be able to be warned, evacuated, and have floodgate management activated. Over 300 telemetry stations will be used in Kuching's planned response system, alerting authorities and citizens to impending danger as soon as possible. As part of the flood detection and warning system, four Intelligent Gauges (IG) have been built in Kuching 112's most flood-prone regions; these gauges measure the height of the water in these places and send out early warning messages via sound and light to the local populace. Once the water reaches the maximum level, the device sounds an alarm. Information is transmitted to the mobile devices of Department of Drainage (DID) officers in such a case. On the iHydro website, people can view preexisting IG data to keep tabs on potential floods (Department for International Trade, 2021). iHydro is an online telemetry web-based system made to help relevant agencies and the general public with flood monitoring and early flood preparation planning; it displays data from the four Intelligent Gauges. Data is updated every 15 minutes and includes things like rainfall totals and river levels in Sarawak. iHydro can show readings from 109 water level telemetry stations and 250 rainfall telemetry stations across the State (S-Sarawak, 2022).

There are now 161 cameras in operation in Johor Baru, all of which are located within the Johor Bahru City Council's jurisdiction. The installation of a CCTV system was crucial to realizing the vision of a "smart city," wherein information technology is used to collect and analyze data to improve urban planning and quality of life. In addition to supporting law enforcement with traffic-related incidents and criminal investigations, the Johor Bahru City

Council is also capable of pinpointing the locations of flash floods and determining the root causes of traffic jams (Shah, 2022). In Malacca, the flood problem is being addressed by the Melaka Smart City Advisory Council (SCAC), which is developing the Melaka Smart River as a monitoring technology (Yaacob, 2019).

Conclusion

Floods, an excess of water, are one type of natural disaster that can cause widespread destruction to both people and infrastructure. Most often, this is the result of excessive precipitation and subsequent dam overflow. Since it has such a profound impact on the lives and land of the people in the region, the government will need to allocate additional funds to rebuild. Because of this, it is essential to create a flood warning system that alerts the public about impending flooding in high-risk areas (Khan et al., 2021).

The fourth industrial revolution (4IR) of today necessitates an openness to the practical implications of recent developments in computing (Samsurijan et al., 2022). Data analytics tools and AI are being used by emerging technologies like the Internet of Things to predict and warn of potential disasters. In addition to saving lives, these technologies have been essential in locating missing persons, restoring damaged structures, and carrying out effective rescue operations. With the use of IoT data, the authority can save enough lives in advance to make a difference. Real-time Internet of Things (IoT) flood detection allows for timely evacuations, lessening the disaster's devastating effects (Khan et al., 2021).

Malaysia is still moving forward with its smart city effort, but changes to the plan are needed to improve the efficiency and efficacy of execution. As previously said, Malaysia began its quest to construct smart city projects in the 1990s. The government had developed many public policies linked to this initiative to transform cities into smart cities. Several smart city projects in Cyberjaya, Putrajaya, Selangor, Malacca, Penang, Sabah, and Sarawak provide evidence (Ridzuan et al., 2021). However, more outstanding efforts must be made to ensure that smart city projects significantly help the government plan and mitigate flood issues. In this instance, internet coverage and speed must be increased to maximum levels to stimulate the use of technology in cities. In addition, smart city development needs to be carried out equally across the country and not just concentrated in big cities like the Klang Valley. This is felt to be necessary to achieve balanced development, in line with the government's desire to empower the implementation of Shared Prosperity Vision 2030.

This article's overarching goal is to encourage the provision of smart city services in urban areas of Malaysia to lessen the destructive effects of flooding. The high technological cost of development poses a problem for Malaysia as it attempts to fully adopt smart city technology. Some smaller local authorities in Malaysia lack the resources to implement electronic technologies necessary for smart city initiatives, particularly those relating to flood management. The local government may have difficulties in flood monitoring if there are not enough qualified people to utilize smart city technology. Technical and Vocational Education and Training (TVET) is the greatest way for Malaysia to prepare a new generation of professionals to address the challenges posed by floods and other natural disasters.

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