Urban Area Design in the Arrangement of Smart Drainage Systems with IoT Technology (IoT) to Overcome Flooding in Urban Areas

Ruth Riah Ate Tarigan[1*], Supiyandi[2], Najla Lubis[3], Muhammad Hasanuddin[4], Siti Khodijah[5], Cindy Atika Rizki[6]

[1]Department of Urban and Regional Planning, Postgraduate Program, Universitas Pembangunan Panca Budi, Medan, Indonesia
[2,5,6]Faculty of Computational Science and Digital Intelligence, Information Technology, Universitas Pembangunan Panca Budi, Medan, Indonesia
[3]Department of Master of Agricultural Sciences, Postgraduate Program, Universitas Pembangunan Panca Budi, Medan, Indonesia
[4]Master of Information Technology, Postgraduate Program, Universitas Pembangunan Panca Budi, Medan, Indonesia
E-mail: [1*]truthtrg@yahoo.com, [2]supiyandi@dosen.pancabudi.ac.id, [3]najlalubis@dosen.pancabudi.ac.id, [4]muhammadhasan20feb@gmail.com, [5]sitikhodija31@gmail.com, [6]cindyatika100egmail.com
*E-mail Corresponding Author: truthtrg@yahoo.com

Abstract

Flooding is a major problem that frequently occurs in Medan City due to high rainfall, dense settlements, and limited drainage system capacity. Conventional drainage planning still faces obstacles in real-time monitoring of channel conditions, resulting in less than optimal flood management responses. This study aims to examine the use of Internet of Things (IoT) technology in planning a smart drainage system as a flood mitigation effort in Medan City. The research method was carried out through literature review, conceptual modeling, and analysis of IoT infrastructure needs, including water level sensors, data communication devices, and integration with geographic information systems (GIS). The results of the study indicate that the implementation of an IoT-based drainage system can improve the effectiveness of water flow monitoring, support rapid decision-making in flood control, and provide accurate spatial data for urban spatial planning. In conclusion, the use of IoT has great potential to support the development of a smart drainage system in Medan City, thereby reducing flood risk and increasing the resilience of urban infrastructure in a sustainable manner.

Keywords— *Internet of Things; smart drainage; flooding; Medan City; urban planning*.

I. INTRODUCTION

Medan City is the largest metropolitan city outside of Java Island and serves as the center of economic, social, and cultural growth in the North Sumatra region(Swandhani, 2024). With the population continuing to increase every year and urban areas expanding further, the challenges in managing urban infrastructure are also becoming more complex(Connolly et al., 2021). One of the main problems still faced by Medan City today is flooding(Saragih, 2023). Almost every rainy season, several areas in Medan experience flooding of varying depths, which not only disrupts community activities but also causes significant economic, social, and environmental losses(Samosir et al., 2025). This phenomenon shows that the flooding problem in Medan is not just a seasonal issue, but has become a structural problem that needs to be addressed systematically and sustainably(Muliadi et al., 2024).

Flooding in Medan City is triggered by various interconnected factors(Fitria et al., 2022). High rainfall in a short period often exceeds the capacity of available drainage channels(Bertels & Willems, 2022). Additionally, the high rate of urbanization leads to a decrease in water absorption areas due to land conversion into residential, commercial, or industrial areas. Another problem that further exacerbates this condition is the suboptimal waste management(Saukenova et al., 2022). Drainage channels in several areas are often blocked by domestic waste and plastic trash, which hinders water flow and accelerates flooding. The existing drainage infrastructure is also relatively old and poorly maintained, so its capacity to handle water flow is no longer adequate(Ma et al., 2022). These factors indicate that the flooding problem in Medan is a combination of

natural, technical, and human behavioral aspects(Saragih, 2023).

The efforts that the Medan City government has made so far in dealing with floods have generally been physical and conventional(Syahputra & Sugiarto, 2024). For example, the construction of new drainage channels, river widening, dredging of sedimentation, and the normalization of main canals. These steps are indeed important, but they tend to require significant costs, a long time, and often face social constraints such as land acquisition. Additionally, conventional drainage systems lack the adaptive capacity to respond dynamically to changing conditions. For example, there is no real-time monitoring mechanism that can provide early warning when water flow increases drastically, so handling decisions are often delayed. This indicates the need for an innovative approach that can complement physical strategies with data-driven technology.

The development of digital technology, particularly in the field of the Internet of Things (IoT), offers new opportunities to address these challenges. IoT is a concept where physical devices such as sensors, cameras, or measuring instruments can connect to the internet to automatically send, receive, and process data. In the context of drainage systems, the application of IoT allows for the installation of water level sensors at various points in the channels, which are then connected to a control center via a data communication network(Yasin et al., 2021). The collected information can be visualized in a geographic information system (GIS), making it easier to map flood-prone areas and predict potential flooding in the future. With this approach, the city government not only has historical data but also real-time data that can be used for quick decision-making(Adepoju et al., 2022).

Various previous studies have shown that the use of IoT in flood management can improve the effectiveness of urban water management (Veerappan, 2024). For example, in some major cities in Asia and Europe, IoT-based sensors have been used to detect rising river water levels, automatically control floodgates, and provide early warnings to the public thru digital applications. As a result, flood losses can be reduced, and emergency responses can be carried out more quickly. The application of a similar concept in Medan City is highly relevant, considering the relatively flat topography, high rainfall intensity, and increasing pressure due to urbanization(Veerappan, 2024).

Besides supporting technical aspects, the implementation of IoT in drainage systems also provides added value in terms of urban governance(Gade, 2021). The collected data can be used to develop evidence-based long-term planning. For example, the city government can prioritize the construction of new drainage based on data on the most frequent flooding, or design public education programs in the areas most prone to flooding. Thus, IoT not only serves as a monitoring tool but also as a strategic instrument for more sustainable urban planning.

However, of course, the implementation of this technology also faces challenges(Sharma & Bumb, 2021). The readiness of digital infrastructure in Medan City, budget limitations, and the need for human resources who understand IoT technology are factors that need to be considered. Additionally, sustainability aspects must also be considered, including sensor maintenance, data security, and integration with existing systems. Therefore, a comprehensive study on the application of IoT for drainage systems in Medan City needs to be conducted, not only from a technical perspective but also from social, economic, and institutional aspects.

Based on this background, this research aims to analyze the potential use of the Internet of Things in planning an intelligent drainage system in Medan City. The study focuses on identifying technological infrastructure needs, integrating with geographic information systems, and the potential benefits that can be obtained in flood mitigation efforts. This research is expected to make a tangible contribution to the development of flood mitigation policies in Medan City, while also strengthening the city's position as one of the pioneers in the application of digital-based urban technology in Indonesia. With this new approach that combines IoT technology and regional planning, it is hoped that the flooding problem in Medan City can be addressed more effectively, efficiently, and sustainably.

II. RESEARCH METHODOLOGY

This research uses a descriptive-qualitative approach with literature studies and conceptual modeling, supported by secondary data analysis on drainage conditions and flood events in Medan City. This approach was chosen because the research focus is not only on the technical measurement of the field, but also on exploring the potential application of Internet of

Things (IoT) technology in supporting smarter urban drainage system planning.

a. Types and Research Approaches

This type of research is applied research with a focus on planning solutions. The research was conducted thru: Literature study, which involved reviewing theories, concepts, and previous research findings related to urban flooding, drainage planning, and the implementation of IoT in various cities. Descriptive analysis, to describe the existing conditions of the drainage system in Medan City and identify its main problems. Conceptual modeling, to design an IoT-based innovative drainage system framework relevant for implementation in Medan.

b. Location and Research Objects

The research location is focused on Medan City as a case study. The study object is the urban drainage system and existing channel network, particularly in areas prone to flooding such as Medan Marelan, Medan Maimun, and Medan Perjuangan. The location selection is based on annual flood data reported by the Medan City Government and the Regional Disaster Management Agency (BPBD).

c. Data and Data Sources

The data used consists of:

Primary Data (Conceptual): IoT sensor requirements, technical specifications, and system integration design with GIS (obtained thru literature studies and technology documentation).

Secondary Data: including Medan City drainage maps, rainfall data, flood inundation data, BPBD reports, and city spatial planning documents (RTRW and RDTR).

d. Data Collection Techniques

Some data collection techniques used in this study include: Literature review of journals, books, proceedings, and technical reports related to IoT implementation in flood management in other cities. Documentation and review of secondary data from relevant agencies such as the Medan City Public Works Department, BMKG, and BPBD. Limited field observation (if possible) to review drainage conditions and flood-prone areas.

e. Tools and Technology Used

In the design of an intelligent drainage system, this research examines relevant IoT devices, including:

1. Ultrasonic or pressure-based water level sensors.
2. Flow quality sensors to detect blockages.
3. Wi-Fi/LoRa-based communication gateway for sending data to the control center.
4. Cloud-based dashboard monitoring connected to a Geographic Information System (GIS).

f. Data Analysis Techniques

Data analysis was conducted in three main stages:

1. Analysis of existing conditions: identifying drainage limitations in Medan City based on secondary data.
2. Analysis of technology needs: determining the most relevant IoT devices to support drainage monitoring in Medan.
3. Conceptual modeling: developing a design for an IoT-based smart drainage system, including sensor workflows, data communication systems, integration with GIS, and usage scenarios for flood mitigation.
4.

g. Conceptual Validation

To ensure the plan's feasibility, the modeling results were compared with literature and case studies from other cities that have already implemented IoT in their drainage systems. This validation is conducted comparatively and descriptively to assess the extent to which the proposed concept can be adapted to the conditions of Medan City.

III. RESULTS AND DISCUSSION

a. Existing Drainage Conditions in Medan City

Medan City has a drainage network consisting of primary, secondary, and tertiary channels. However, several reports indicate that the channel capacity is no longer sufficient to accommodate the water flow during heavy rainfall. Additionally, drainage maintenance is not optimal, compounded by the frequent problem of waste blockages that obstruct water flow. Data from the Medan City Regional Disaster Management Agency (BPBD) shows that flood-prone areas are scattered across several sub-districts, especially in areas with low topography.

Table 1. Existing Drainage Conditions and Problems in Medan City

No	Main Drainage Problems	Impact Caused

1	Channel capacity is insufficient.	Flooding occurred in densely populated areas.
2	Blockage due to garbage.	The water flow is obstructed, triggering local flooding.
3	Old/poorly maintained drainage infrastructure.	Reduced carrying capacity and channel damage.
4	Conversion of absorption land.	Increased rainwater runoff.
5	The lack of a real-time monitoring system.	The government's response was slow when the flood occurred..

From the table, it can be seen that the flooding problem in Medan City is not only due to natural factors (high rainfall), but also due to limitations in technology and drainage management.

b. Potential for Internet of Things (IoT) Integration

IoT can be an innovative solution in building smart drainage systems. By installing sensors at various points in the channel, the government can monitor drainage conditions in real-time. Data from the sensors is transmitted to the control center via a communication network and then visualized in a geographic information system (GIS). This allows for mapping flood-prone areas and early detection of potential blockages.

Table 2. The Concept of IoT Integration in the Drainage System of Medan City

IoT Technology Components	Main Function	Relevance to the Field
Water level sensor	Measuring channel water elevation	Early detection of rising water levels in flood-prone areas.
Flow quality sensor	Monitoring flow velocity & potential blockages	Identifying channels blocked by garbage.
Communication gateway (LoRa/Wi-Fi)	Sending data from sensors to the server	Supporting integrated monitoring in the city center
Cloud server & dashboard	Storing and displaying real-time data	Providing data access for the Public Works and Disaster Management Agency
GIS integration	Spatial visualization of sensor locations & flooding	Assisting in long-term drainage planning.

This IoT integration allows Medan's drainage planning to be based not only on assumptions but also on actual, continuously updated data.

c. Benefits of IoT Implementation in the Medan Drainage System

Based on the analysis, the implementation of IoT in the drainage system can provide several strategic benefits for Medan City:

1. Increased monitoring capacity: channel conditions can be monitored in real-time.
2. Early flood detection: water level sensors can provide rapid warnings to both the government and the public.
3. Spatial data management: Integration with GIS allows for flood point analysis for long-term planning.
4. Cost efficiency: Compared to building new drainage systems, which requires significant investment, using IoT is relatively more economical in the medium term.
5. Increased public participation: open data can be accessed by the public to raise awareness about maintaining channel cleanliness.

Table 3. Comparison of Conventional Drainage Systems and IoT-Based Smart Drainage

Comparison Aspects	Conventional System	IoT-Based Smart Drainage System
Monitoring.	Manual, not real-time.	Automatic, real-time, sensor-based.
Flood response.	Slow, according to	Fast, based on live data.

	citizen reports.	
Operational costs.	High (repeated physical development).	Relatively more efficient (initial cost + sensor maintenance).
Data accuracy.	Low, limited to field inspection.	High, based on digital sensors.
Long-term planning.	Based on assumptions.	Based on spatial & historical data.

d. Discussion

The analysis results show that the conventional drainage system in Medan City has significant limitations, particularly in terms of capacity, maintenance, and monitoring. Without innovation, the flooding problem is expected to worsen as cities grow.

The application of IoT offers more efficient, accurate, and adaptive solutions. This technology not only serves as a monitoring tool but also as the basis for developing data-driven regional planning policies. With real-time data, the government can determine priority areas for channel improvements, allocate budgets more accurately, and provide early warnings to the public.

However, the implementation of IoT is not without its challenges, including the need for digital infrastructure, the availability of competent human resources, and the budget for sensor installation and maintenance. Therefore, the implementation of IoT in Medan City's drainage requires collaboration between the government, academics, the private sector, and the community.

With the right strategy, IoT can be the foundation for building a sustainable smart drainage system, significantly minimizing flooding problems in Medan City.

IV. CONCLUSION

Flooding in Medan City remains a serious problem, triggered by limited drainage capacity, channel blockages due to waste, reduced absorption areas, and the absence of a monitoring system capable of providing rapid and accurate information. Conventional approaches used so far, such as physical construction and channel normalization, have proven insufficient in reducing flood risk, especially because they are not accompanied by technology that adapts to the dynamics of the urban environment. This study shows that implementing Internet of Things (IoT) technology can be a strategic step in building an intelligent drainage system in Medan City. By installing water level and flow sensors connected to a data communication network and integrated with a Geographic Information System (GIS), channel conditions can be monitored in real-time. The availability of accurate and up-to-date data allows the government to make faster decisions in the face of potential flooding, while also providing a strong foundation for developing evidence-based long-term drainage plans. Overall, the use of IoT in Medan City's drainage system has the potential to improve monitoring effectiveness, speed up responses to flood threats, and support more adaptive and sustainable regional planning. With this innovation, the risk of social, economic, and environmental losses due to flooding can be minimized, while urban governance can be directed toward the concept of a resilient city that aligns with digital technological developments. Implementing this concept will certainly require consistent policy support, digital infrastructure readiness, and the involvement of all stakeholders to ensure that the expected benefits can be realized optimally.

V. REFERENCES

Adepoju, A. H., Austin-Gabriel, B., Hamza, O., & Collins, A. (2022). Advancing monitoring and alert systems: A proactive approach to improving reliability in complex data ecosystems. *IRE Journals*, *5*(11), 281–282.

Bertels, D., & Willems, P. (2022). Climate change impact on salinization of drinking water inlets along the Campine Canals, Belgium. *Journal of Hydrology: Regional Studies*, *42*, 101129.

Connolly, C., Keil, R., & Ali, S. H. (2021). Extended urbanisation and the spatialities of infectious disease: Demographic change, infrastructure and governance. *Urban Studies*, *58*(2), 245–263.

Fitria, R., Rahmayanti, H., & Sumargo, B. (2022). The causal loop diagram model of flood management system based on eco-drainage concept. *Sustinere: Journal of Environment and Sustainability*, *6*(3), 185–196.

Gade, D. S. (2021). Reinventing smart water management system through ICT and IoT driven solution for smart cities. *International Journal of Applied Engineering and Management Letters*,

5(2), 132–151.

Ma, Y., Cui, Y., Tan, H., & Wang, H. (2022). Case study: Diagnosing China's prevailing urban flooding—Causes, challenges, and solutions. *Journal of Flood Risk Management*, *15*(3), e12822.

Muliadi, M., Lubis, S. N., Harahap, H., Slamet, B., & Lubis, A. A. R. D. (2024). Sustainable food systems and regional development: Analyzing food security in Medan City's underprivileged areas, Indonesia. *Journal of Ecohumanism*, *3*(6), 529–537.

Samosir, F. N., Susilawati, S., Amelia, A., Qur-Ani, O. H., Paramitha, L., & Andwina, A. (2025). Socio-Economic Impact Analysis of Rob Flooding at Kuala Dewi Indah Beach, Pantai Cermin Sub-District. *PROMOTOR*, *8*(3), 408–412.

Saragih, D. (2023). Problems and Solutions for the Flood Control Program in Medan City and its Surroundings. *Journal of the Civil Engineering Forum*, *9*(1), 47–58.

Saukenova, I., Oliskevych, M., Taranic, I., Toktamyssova, A., Aliakbarkyzy, D., & Pelo, R. (2022). Optimization of schedules for early garbage collection and disposal in the megapolis. *Eastern-European Journal of Enterprise Technologies*, *1*(3), 115.

Sharma, S., & Bumb, A. (2021). The challenges faced in technology-driven classes during COVID-19. *International Journal of Distance Education Technologies (IJDET)*, *19*(1), 66–88.

Swandhani, A. R. (2024). Analysis of Social Perspectives in Reconstructing the History of Urbanization in Medan City. *Jurnal Geografi*, *16*(2), 325–337.

Syahputra, D., & Sugiarto, A. (2024). Flood Management Solutions at Panca Budi School in Medan. *Journal of Information Technology, Computer Science and Electrical Engineering*, *1*(3), 403–412.

Veerappan, S. (2024). Edge-enabled smart storm water drainage systems: A real-time analytics framework for urban flood management. *Journal of Smart Infrastructure and Environmental Sustainability*, *1*(1), 52–59.

Yasin, H. M., Zeebaree, S. R., Sadeeq, M. A., Ameen, S. Y., Ibrahim, I. M., Zebari, R. R., Ibrahim, R. K., & Sallow, A. B. (2021). IoT and ICT based smart water management, monitoring and controlling system: A review. *Asian Journal of Research in Computer Science*, *8*(2), 42–56.