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# System of urban flood control: A Comparative Study between Kanagawa Prefecture and Makassar City

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**Abstract.** Flooding is a water event inundation the land area due to the overflow of water from rivers or rainwater runoffs with high intensity. Kanagawa Prefecture is a country of Japan that has overcome flood events with a simple and high-tech flood control system. The conservation of watersheds and green open spaces as water catchments and the use of naturally occurring and artificial rivers and ponds show the simplicity of the flood control technology adopted by the Kanagawa Prefecture government. Subsurface drainage is a high-tech flood control system that is connected to surface drainage and guttering system in resident's housing. Based on the Kanagawa experiences, this study is an effort to apply the concept for the Makassar City of Indonesia, which the flood still occurs. Data collection methods were conducted with direct observation in the field and were described qualitatively based on the facts and literature approaches. The results of the analysis indicate that the type of flood control such as Miyagase dam in Kanagawa prefecture is the same as the Bili-Bili dam on Jeneberang River as flood control in Makassar City. The high-tech flood control type in Kanagawa Prefecture is sub-surface drainage that has not been applied in Makassar. This research is expected to be a reference for the Government of Indonesia, especially the City of Makassar in formulating policy concerning solving the problem of flooding.

## 1. Introduction

Every region needs to make a good and efficient flood control system, taking into account the existing conditions and development of future water resources utilization. Flood control system planning should take into account all aspects from upstream to downstream of the river to produce a good planning document. Aspects of review and assessment of flood control plans include technical, economic, social, cultural, legal, institutional and environmental aspects [1].

While according to the technical handling of flood control can be divided into two namely: technical flood control and non-technical flood control [1]. Reservoir or basin as one of the structural methods for



water reservoirs used to control flooding. Flood control with reservoirs must know the relationship between the water surface with the holding capacity and the relationship between the water surface and the flood discharge [2].

Flood disaster is one of the most dangerous disasters in the world. As flood events become common, awareness of the risks of flooding and flood prevention increases. The highly changing climate also has an impact on floods, such as the rising rainfall that causes of flooding. Flooding will occur when the watershed system receives an unusually high rainfall intensity or prolonged incidence of rainfall so that the flow rate exceeds the channel and water capacity is difficult to flow in urban areas[3][4][5].

Generally, the cause of flooding is illegal logging without reforestation/land use changes can impact on flood discharge [6], slums along the river, random garbage disposal, unqualified drainage of water (dams and water structures), poor embankment construction, shortening of streams or inadequate river capacity, the erosion and sedimentation, the physiographic / geophysical effects of the river, the decline of land, rivers or lakes overflowing and inundating land, seawater inundated by tidal, and disturbance of the hydrological cycle [7].

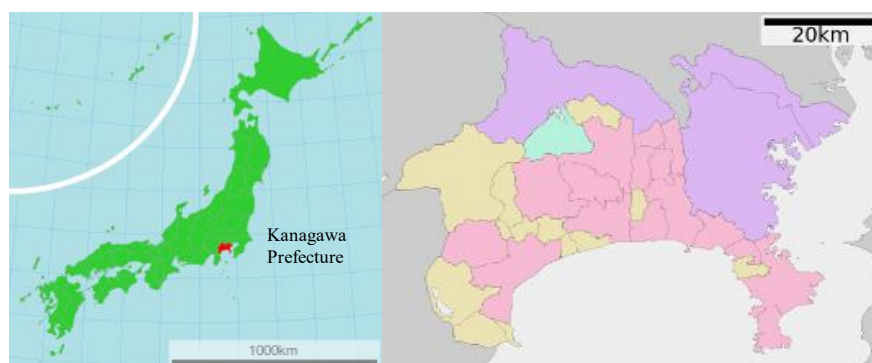
The societal benefits of the use of our rivers are profound, including irrigation, transportation, flood control, power generation and recreation [8]. This study aims to investigate flood control techniques in Kanagawa Prefecture of Japan as a reference for implementation in Makassar City.

## 2. Research Methods

The research method used was qualitative, based on complex paradigm philosophy, where researchers are as a key instrument, data collection techniques conducted by observation, data analysis was descriptive qualitative.

### 2.1. Study Area.

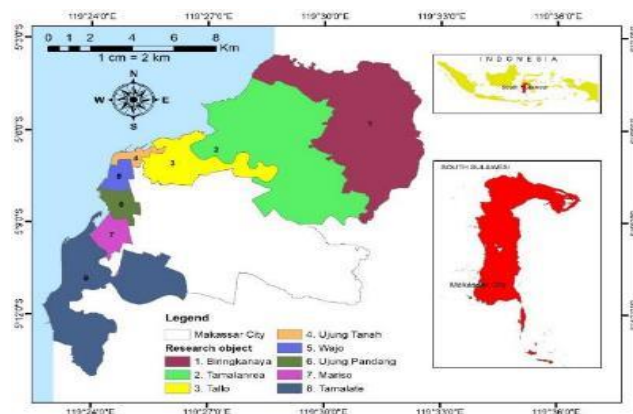
Kanagawa Prefecture is a relatively small prefecture located at the southeastern corner of the Kantō Plain wedged between Tokyo on the north, the foothills of Mount Fuji on the northwest, and the Sagami Bay and Tokyo Bay on the south and east. The eastern side of the prefecture is relatively flat and heavily urbanized, including the large port cities of Yokohama and Kawasaki. The southeastern area nearby the Miura Peninsula is less urbanized, with the ancient city of Kamakura drawing tourists to temples and shrines. The western part, bordered by Yamanashi Prefecture and Shizuoka Prefecture on the west, is more mountainous and includes resort areas like Odawara and Hakone. The area, stretching 80 kilometers (50 mi) from west to east and 60 kilometers (37 mi) from north to south, contains 2,400 square kilometers (930 sq mi) of land, accounting for 0.64% of the total land area of Japan. Nineteen cities are located in Kanagawa Prefecture, i.e. Atsugi, Ayase, Chigasaki, Ebina, Fujisawa, Hadano, Hiratsuka, Isehara, Kamakura, Kawasaki, Minamiashigara, Miura, Odawara, Sagami-hara, Yokohama (capital), Yokosuka, Zama and Zushi, Map of Kanagawa Prefecture as shown in figure 1.



**Figure 1.** Research object in Kanagawa Prefecture, Japan.

## 2.2. Implementation Area.

Makassar City, geographically, Makassar is located between 119°24'17'38" EL and 5°8'6'19" SL. Regarding administrative position, Makassar City has boundaries as follows: North-Maros Regency; South-Gowa Regency; West-Makassar Strait; East-Maros Regency. The area of Makassar is 175,77 square km2 which include 14 districts. In Administrative, Makassar Municipality has 14 districts; these include Mariso, Mamajang, Tamalate, Rappocini, Makassar, Ujung pandang, Wajo, Bontoala, Ujung Tanah, Tallo, Panakukkang, Manggala, Biringkanaya, and Tamalanrea District. In 2015, the city had 143 wards, 996 RW and 4968 RT [9]. Research object in Makassar City as shown in figure 2.



**Figure 2.** Research object in Makassar City, Indonesia.

## 3. Results and Discussions

In November 2017, a field observation focusing on flood control has been done in Kanagawa Prefecture. There was a River basin, Tsurumi river basin, Miyagawa dam, Aratamgawa river, open space, and also the drainage system. Following are the details:

### 3.1. River Basin.

Doshi-mura River Basin, the Doshi-mura river basin has been a forest water resource since 1897 and had an area of about 2,780 hectares [10]. Based on topography, Doshi-mura is an upstream area of Kanagawa Prefecture. Land use arrangements in the watershed are intended to improve the hydrological conditions of the watershed [1]. Land use affects water absorption into the soil during rainfall. The surface runoff then influences the flood discharge of a watershed, so it can be stated that a good watershed ecosystem will have implications for flood control [11]. The preservation of the Doshi-mura river area is so good that it produces drinkable water that can be consumed directly by the local community, the area being one of the flood control techniques in Prefecture Kanagawa. Field study in Doshi-mura river as shown in figure 3.



**Figure 3.** Field study in Doshi-mura River Basin

Tsurumi River Basin, located on the administrative area of Tokyo Metropolis, Machida City, Inagi City, Kanagawa Prefecture, Yokohama City, Kawasaki City. The watershed reaches 235 km<sup>2</sup>, the length of the river is 42.50 km, the population reaches 1,950,000 people, the topography is grouped into 2 categories: hills about 70 percent and alluvial plains 30 percent, 85 percent of Tsurumi river basin is built up area. The Tsurumi river basin map is shown in figure 4.

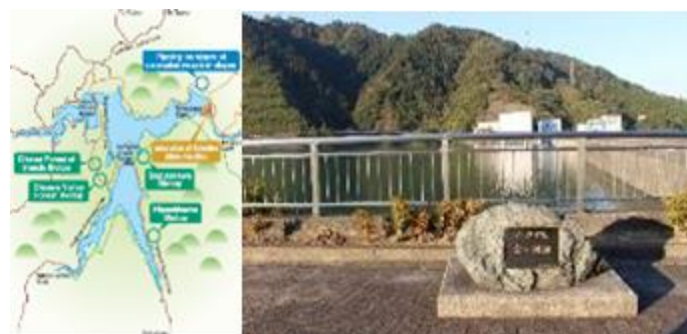


**Figure 4.** Tsurumi River Basin

In the case of Makassar City which is located in Jeneberang watershed, Tallo, Maros, Gowa-Takalar and non-watershed areas, Jeneberang watershed is the largest and located in the upper reaches of Makassar City. Currently, the use of land in the Jeneberang watershed has been exploited into settlements and agricultural cultivation areas that result in infiltration of water into the soil is reduced so that the flow of the surface increases. Tallo watershed, Maros, Gowa-Takalar and non-watershed are a watershed in urban areas of Makassar whose land use is dominated by settlements, offices and public facilities. One of the efforts to control floods in Makassar City is by controlling the use of river basin in the upstream city and river borderline. Proper watershed management can give economic value to a region by utilizing watershed as a source of drinking water for the population.

### 3.2. Miyagase Dam.

In (*Miyagase Dam*, n.d.) explained that Miyagase Dam, one of the largest dams in the Tokyo Metropolitan area, was completed in 2001 on the Nakatsugawa river, a branch of Sagami-gawa river system. The dam is located about 50 kilometers from central Tokyo and about 40 km from the urban districts of Yokohama and Kawasaki. The dam plays a large role in our life. As well as keeping us safe from flooding associated with typhoons and heavy rainfall, it provides us with an indispensable source of drinking water and generates the electricity necessary for our daily lives. The location and Miyagase dam are informed in figure 5.



**Figure 5.** Miyagase Dam [12]

In the case of Makassar, there is a Bili-Bili dam that functions as flood control and drinking water source for residents of Gowa Regency and Makassar City. Some areas of Makassar City are Jeneberang watershed which leads into District Tamalate.



Dam is generally built for the development of river water resources. Besides, the dam is usually built for several benefits called multi-function, for example for flood control, irrigation, water supply (raw water), power plant, etc. Flood control with dams can only be done on the upstream, so downstream can benefit from flood discharge management with flood control gate on dam [1].

### 3.3. Rivers.

Aratamagawa River is one of the rivers that pass in the City of Yokohama along the 1,8 km. It is explained that the method of flood control structures for river network systems is the improvement of rivers, embankments, crosses, floodways, and special drainage systems [1]. The river improvement system is conducted primarily closely related to flood control which is an attempt to increase river flow capacity. This is intended to accommodate the flood discharge that occurs to flow downstream or sea so that no runoff occurs. The Aratamagawa River is shown in figure 6.



**Figure 6.** Aratamagawa Rivers

In Makassar City, there are two rivers namely Jeneberang River and Tallo River. Also, canals such as the Pampang Canal and the Jongaya Canal also serve as the main tracts that drain water into the sea. The river as one of the flood controllers has been implemented in Kanagawa and Makassar City.

### 3.4. Open Space.

Himenoshima Park is an open space located in front of AEON Kanazawa Hakkei and Yokosuka road. Open space as a social function is used for pedestrians, performances of traditional activities [13]. Also, open space can also serve as a means of flood control. Rainwater that falls on the vegetated soil surface is more easily infiltrated into the soil. Infiltration is the flow of water into the soil through the soil surface [14]. Himenoshima Park is shown in figure 7.



**Figure 7.** Himenoshima Park

In Makassar City, there are some green open spaces such as Taman Macam, Pakui Park, Maccini Sombala Park and urban forest at Hasanuddin University Tamalanrea. The existence of green open

spaces and urban forests for Regency / municipal administration in Indonesia is determined at 30 percent of the total area, which functions for ecological balance and water absorption during rainfall. The concept of exploiting green open space as water absorption area has been applied in Kanagawa Prefecture and Makassar City.

### 3.5. Drainage System.

Failure of urban drainage capacity to flow surface runoff due to rainfall is possible to be a factor from many other factors causing a flood in urban areas [15]. In this study, the classification of drainage is divided into 3 categories, *ie.* guttering system, surface drainage, and subsurface drainage:

**3.5.1. Guttering System.** Serves to drain the water that falls on the surface of the roof to the subsurface drainage so that water is not abundant above the soil surface that can cause flooding. The gutters system applied to buildings in Kanagawa Prefecture is shown in figure 8.



**Figure 8.** Guttering System

In the case of Makassar City, the gutter system in residential and governmental offices has not been connected with the drainage system. The situation causes rainwater that falls on the surface of the roof will flow on the surface of the soil as the flow of the surface that resulted in flooding. In the context of the gutter system, there is a difference between Kanagawa Prefecture and Makassar City.

**3.5.2. Surface Drainage.** Serves to discharge surface runoff due to rainwater through holes prepared on the side of the road. The form of surface drainage on Kanjonigo Road of Isogo City is shown in figure 9.



**Figure 9.** Surface Drainage (street inlet)

In Makassar City, open drainage is divided into 2 (two) categories, secondary and tertiary drainage. Secondary drainage is built on the side of the arterial road to drain water into rivers and canals while tertiary drainage is built on housing and local roads. The surface drainage system between Kanagawa

Prefecture and Makassar City is very different, in Kanagawa using closed drainage while Makassar City uses open drainage.

**3.5.3. Sub Surface Drainage.** In largely urbanized areas space is scarce and the construction of a regular floodway is mostly impossible. In Japan, artificial underground channels are used to solve this problem. An artificial underground channel has similar principles as a floodway. The channel increases the discharge capacity of the main river course thus creating a lower water level of this main river resulting in less flooding [4]. Subsurface drainage in Japan as shown in figure 10.



**Figure 10.** Sub Surface Drainage

In Makassar City has not been implemented subsurface drainage system that can function as a primary channel. Currently, the existence of the Jeneberang River, Tallo River, and Pampang Canal has not been sufficient to accommodate the volume of surface flow during rainfall.

### 3.6. Pond.

Stormwater management ponds come in many different shapes and sizes, but all have an embankment (dam) to hold back runoff that enters the pond and a control structure that releases the runoff at a rate designed to prevent downstream erosion and flooding. There are two general types of stormwater ponds: wet ponds and dry ponds [16].

**3.6.1. Wet Pond.** Have a permanent pool of water. Runoff from each storm enters the pond and partially displaces the water from previous storms. They provide improved water quality and can be used for flood control. The pool prevents re-suspension of sediments and other pollutants deposited during prior storms [16][17]. The Futatsu wet pond as shown in figure 11.



**Figure 11.** Futatsu pond

In the City of Makassar, several locations function as a wet pond that is a reservoir waiting for Pampang, pond of Hasanuddin University Tamalanrea and Antang lake. The wet pond capacity has not been able to accommodate the runoff of rainwater causing flooding.



**3.6.2. Dry Pond.** Is designed to hold water for a short period before allowing the water to discharge to a nearby stream. Dry ponds control peak flows of runoff, help improve water quality and lessen the effects of erosion. When rain events, a dry pond looks like a large, grassy low area. When it rains, the pond fills with water. They hold water for 48-72 hours to allow sediment and pollutants to settle out. Because the detain for a brief time before allowing it to flow out, dry ponds are also called detention ponds [17]. Figure 12 shows the Nissan Stadium dry pond.

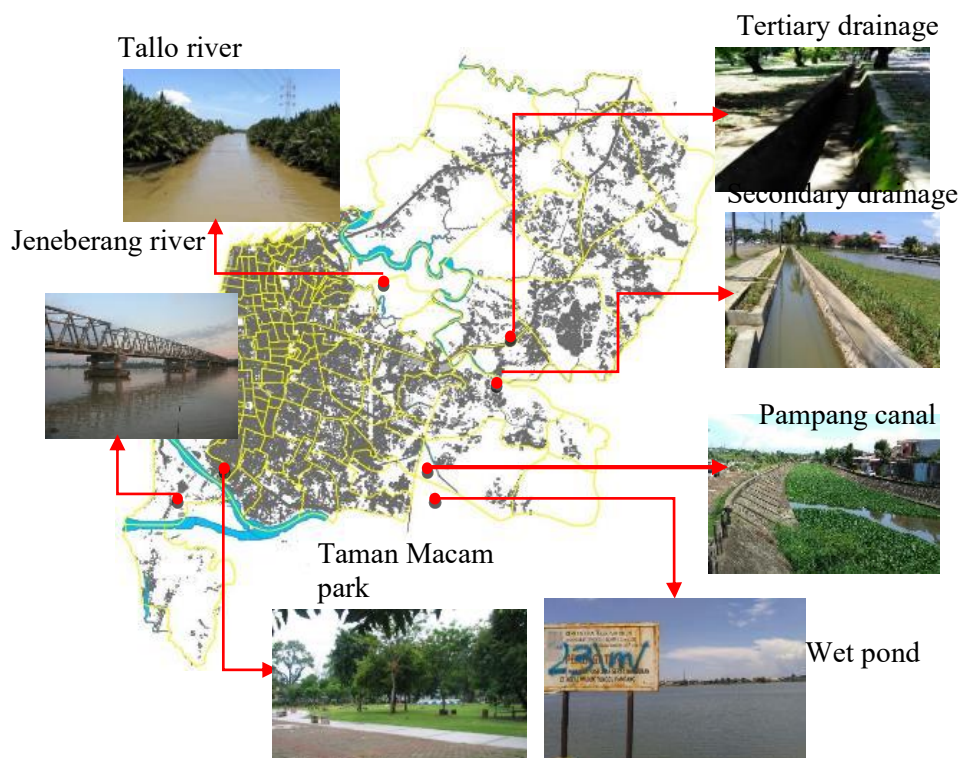


**Figure 12.** Tsurumi Pond integrated Nissan Stadium

In Makassar City, there is no dry pond integrated with public facilities such as sports stadium, playground and green open space.

#### 4. Existing Flood Control in Makassar City

The existence of the current drainage system of Makassar City has not been able to overcome the runoff of surface water when it rains, causing some points in the area of Makassar City experiencing flooding. Existing condition of flood control system in Makassar City is shown in figure 13.



**Figure 13.** Flood Control of Makassar City

## 5. Implementation in Makassar City

Based on the analysis of the results of the investigation of flood control techniques in Kanagawa Prefecture can be implemented in Makassar City as follows:

- Control of land use in watershed areas such as Jeneberang, Maros, Gowa-Takalar watershed in the upper reaches of Makassar City so that infiltration capacity of water into the soil can be maintained and suppress surface runoff during rainfall;
- Enforcement of regulation on river borderline;
- Expansion of green open space as water absorption;
- The use of guttering systems in residential and government offices connected to surface drainage and sub-surface drainage systems to eliminate flooding;
- Construction of subsurface drainage connected with a surface drainage system to solve flood problem.

## 6. Conclusions

The results showed that the type of flood control in Kanagawa Prefecture such as the preservation of Doshi-mura river basin and Tsurumi river basin, Miyagase Dam, Aratamagawa rivers, open space (Himenoshima Park), gathering system, surface drainage, subsurface drainage, wet pond, dry pond very effective to overcome the flood problem. Some types of flood control already exist in the upstream and in the city of Makassar but have not been able to overcome the problem of flooding at the time of rain with high intensity such as the presence of Jeneberang watershed, Bili-Bili Dam, Jeneberang River and Tallo River, Taman Macam park, drainage system (secondary and tertiary), and the waiting dumplings. It is necessary to control the use of land in watersheds that cause flooding in Makassar City, enforcement of river boundary regulation, increased river capacity, expansion of green open space as water absorption, subsurface drainage development, reservoir capacity development and construction of new reservoirs.

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