Urban resilience to floods in parts of Makassar, Indonesia

Meydelin Isani Thoban and *Dyah Rahmawati* Hizbaron*

Departement of Environmental Geography, Faculty of Geography, Universitas Gadjah Mada, Yogyakarta, Indonesia

Abstract. Makassar – the largest and fastest growing area in eastern Indonesia – experienced significant number of damages and losses due to recurrent floods. In early 2019, the flood disaster exposed the urbanized area and inundated 1,658 houses and caused 9,328 impacted population. These figures imply that Makassar needs to create concerted efforts to improve its currently low resilience to floods. This study was designed to assess the urban resilience to floods in Makassar to provide the government with reference for evaluation and identify the most contributing factors to the resilience. In this context, resilience was assessed in four urban systems, namely physical, social, economic, and institutional, in every unit of analysis, i.e., flood-affected districts. The research data included building density, green open space, population density, the number of economically disadvantaged households, community's subsistence funds, and the availability of early warning systems and disaster emergency stations. The physical, social, economic, institutional, and equal scenarios of resilience were modeled using the Spatial Multi-Criteria Evaluation (SMCE). The results showed that the districts in Makassar were moderately resilient to floods and that the resilience of each urban system shaped the overall resilience. Tamalate and Rappocini sub districts had the lowest resilience values, whereas Manggala was estimated as the most highly resilient district in several scenarios.

1 Introduction

Urbanization gives a sufficient boost to multiply the number of populations in urban areas, leading to increased demand on, particularly, residential land. With the limited availability of inhabitable space, population growth causes the shift in land utilization and the use of i.e. riverbanks for settlements. This illegal land transformation entails environmental changes that may lead to adverse impacts, including more frequent occurrences of floods in large urban areas in floodplains and lowlands [1] [2].

The City of Makassar, the capital of the Sulawesi Selatan Province, plays a crucial role in the growth of the eastern side of Indonesia. It lies directly adjacent to the Makassar Straits and, for this reason, becomes one of the busy trade routes in Asia and the primary entrance to the eastern part of the country. As a result, uncontrolled urbanization persists and triggers various problems, such as floods. Floods hit the city every year; also, based on the National Disaster Management Agency (BNPB) data in 2019, their impact has been quite extensive in the last few years, as shown in Table 1.

Table 1. Flood impacts at the City of Makassar

Years	Casualties	Damaged and inundated houses
2019	9328	9328
2017	17376	2924
2015	2085	417
2013	5753	288

The Government of the Makassar City has made several efforts to deal with floods, namely, establishing emergency stations, providing assistance for evacuations, deploying evacuation teams, and, for mitigation purposes, normalizing channels that are often clogged and overflow. Nevertheless, in 2017 and early 2019, these efforts remained ineffective to prevent flooding in the city, leading to even higher losses. Floods are natural events that cannot be predicted its magnitude; therefore, the strategies required must be useful not only for flood prevention but also impact reduction. One strategy that has been considered to lower flood risks is to build disaster-resilient cities. A resilient city is part of the sustainable city development program used by the government to deal with current city development and climate change issues [3]. Resilience occurs if a city can maintain its condition even when under outside/inside pressure and can restore its function immediately [4]. A resilient city describes a city that is sustainable and livable for the community [5].

Continuously expanding urbanization in Makassar leads to elevated flood hazard and risk. From 2010 to 2019, the increasing trend of flood-related losses in the city warrants the need for realizing a resilient city. Parts of the process include evaluating the current resilience to produce guidelines for resilience enhancement planning.

1.1. Literature Review

Resilience is perceived as a concept that can build a better city by factoring in disaster impacts and raising the capacity of its residents to adapt to and deal with uncertain risks in the long term. In the context of sustainable city,

* Corresponding author: dyah.hizbaron@ugm.ac.id

this concept is of vital importance because it focuses on disruptions induced by humans, which are deemed responsible for the emergence of global impacts [6],[7]. Urban resilience also defines the ability of a city as a whole to maintain its previous functions and the ability of urban systems to adapt in the face of disturbances or changes [8] The resilience concept takes form following the uncertainty of pressures or shocks that may arise at any time, and in response to this, a robust resilience system is required Apart from the scale, the likely impact of floods is also unpredictable. Floods are part of environmental dynamics, meaning that flood control is unnecessary.

Urban resilience assessment is an essential step in realizing better preparedness in overcoming, mitigating, and adapting to disturbances that threaten the urban system. It can also help understand the complexity of an existing system within the city and investigate the different impacts felt and exerted by every environmental, social, economic, physical, and institutional element. In the context of floods, this assessment integrates three aspects, namely, response to floods, adaptation taken immediately after a flood event, and recovery to previous functions [9]. Also, it covers three capacities that compose the definition of resilience, i.e., absorptive, persistent, and adaptive-recuperative. These three capacities illustrate each part of the disaster cycle, as seen in Figure 1. In this study, the urban resilience assessment of Makassar is based on the resilience of urban systems, which can be differentiated into physical, economic, social, and institutional resilience, to illustrate the three capacities in the resilience concept.

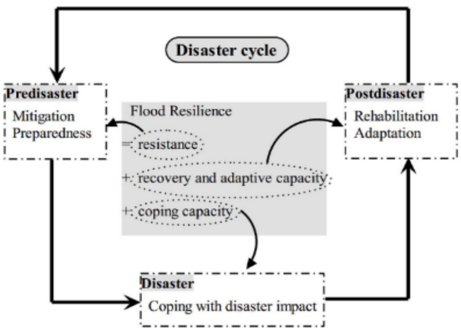

Fig. 1 The position of the resilience concept in the disaster cycle. Source: [10]

2 Research Method

2.1 Data Collection

The research area depicted in the following map (Figure 2). The study used primary data, which were collected by interviews, and ancillary data drawn from related agencies (Table 2).

As shown in Table 2, these data were analyzed to measure the resilience of four urban systems to floods, i.e., physical, social, economic, and institutional resilience. The respondents were selected by purposive sampling techniques with frequently affected districts as reference. There are seven districts with this criterion, namely, Biringkanaya, Tamalate, Tamanlanrea, Manggala, Panakukang, Tallo, and Rapocinni, as presented in Figure 2.

Fig. 2 Maps of Study Area

Table 2. Data Source

Variables	Data Source	Data Acquisition Methods
Physical Resilience		
The proportion of green open space	Spatial Plans and Land Use Maps from the regional government	Secondary
Building density	Spatial Plans from the regional government and OSM data	Secondary
Percentage of built-up areas on riverbanks	Spatial Plans and Land Use Maps	Secondary
Institutional Resilience		
Existence of an early warning system	Interviews	Primary
Availability of flood hazard maps	Interviews	Primary
Economic Resilience		
Number of economically disadvantaged households	Publications of BPS-Statistics Indonesia	Secondary
Community's subsistence funds	Publications of BPS-Statistics Indonesia	Secondary

Revenues from the Land and Building Tax	Publications of BPS-Statistics Indonesia	Secondary
Total members of agricultural cooperatives (farmers' co-ops)	Publications of BPS-Statistics Indonesia	Secondary
Social Resilience		
Population Density	Publications of BPS-Statistics Indonesia	Secondary
Total under-five population	Publications of BPS-Statistics Indonesia	Secondary
Total elderly population	Publications of BPS-Statistics Indonesia	Secondary
Level of community's participation and enthusiasm in dealing with floods	Interviews	Primary
Number of disaster emergency stations	Interviews	Primary

2.2 Data Processing

The research data were processed by SMCE (Spatial Multi-Criteria Evaluation), which is an approach used for simultaneously analyzing spatial and statistical data that have varying values and types. This method serves to assist in the decision-making process, especially in terms of planning, because it considers the influence of the variables assessed [11]. SMCE processing has four stages, namely, problem tree analysis, standardization, weighting scenarios, and scenario building [12]. The problem tree analysis describes any factors that affect resilience, as depicted in Figure 3.

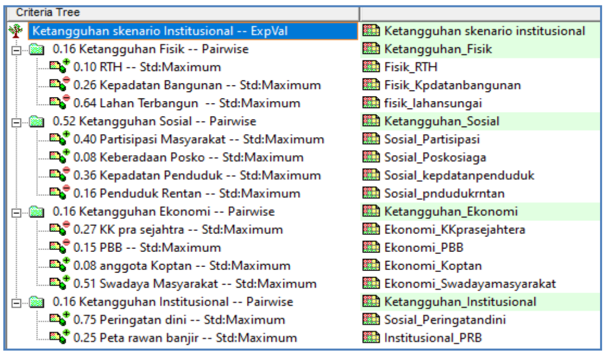

Fig. 3. The Criteria Tree

Most of the time, the variables observed are represented by a different range of values; hence, the second stage, standardization, aims to equalize these values. Because this study expressed resilience as values ranging between 0 (not resilient) and 1 (highly resilient), the standardization applied the same range to all variables (0-1). This process was based on how the variables influenced or contributed to urban resilience, which can be differentiated into negative (-) and positive (+). Figure 4 shows an example of standardization for the variable "the proportion of green open space" in determining the physical resilience. Green open space plays a crucial part in preventing floods: the more extensive the green open space is, the higher the physical resilience of the city will be. Considering this correlation, the standardization of this variable used the maximum scheme by taking into account its positive influence (+) to urban resilience. Therefore, a broader green open space was given a value closer to 1.

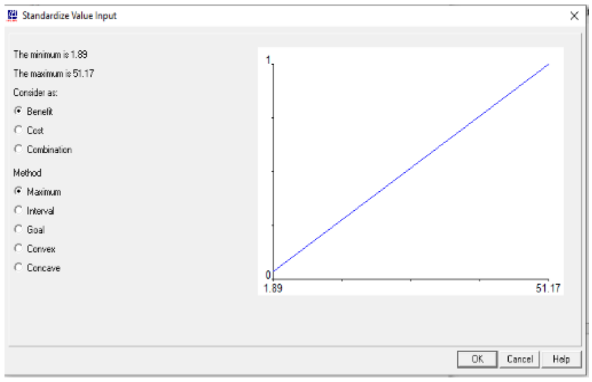

Fig. 4. The standardization of the variable "the proportion of green open space"

After the standardization, all variables were weighted. With pairwise weighting, the importance values of all variables were compared, as illustrated in Table 3. The importance value was determined by referring to the results of previous studies and factoring in the conditions of Makassar. For instance, the variable "percentage of built-up areas on riverbanks" that affects physical resilience was given a relatively high weight value. According to Rachmat and Pamungkas [13] and based on the results of interviews with several district governments, the substantial amount of loss is attributable to the burgeoning construction of settlements on riverbanks and the habits of disposing of waste into the rivers, increasing the sediment volume in the channels and potential occurrences of overflows. Compared to the proportion of green open space, population density has a higher weight because green open space in Makassar will increasingly decrease as the population grows and the development of facilities and infrastructure increases [14]. In other words, green open space is likely to shrink due to population density. The weighting results of all variables are presented in Table 4.

The weights of all variables of urban systems were presented in maps of physical, economic, social, and institutional resilience. Each of these maps was subjected to another weighting process to produce total resilience with several scenarios, as summarized in Table 5. These scenarios were used to identify the spatial pattern of each resilience when one system was given the highest weight, while the others were assigned with the same weight value.

Table 3. Standardization and Weighting

Variables	Standardization	Considerations	Weights
Physical Resilience			
Percentage of built-up area on riverbanks	Maximum	negative (-)	0.64
Building density	Maximum	negative (-)	0.26
The proportion of green open space	Maximum	positive (+)	0.10
Economic Resilience			
Number of economically disadvantaged households	Maximum	negative (-)	0.27
Community's subsistence fund	Maximum	positive (+)	0.51
Revenues from the Land and Building Tax	Maximum	Negative (-)	0.15
Total members of agricultural cooperatives (farmers' co-ops)	Maximum	positive (+)	0.08
Social Resilience			
Level of community's participation and enthusiasm in dealing with floods	Maximum	positive (+)	0.40
Number of disaster emergency stations	Maximum	positive (+)	0.08
Population density	Maximum	negative (-)	0.36
Total vulnerable or elderly population	Maximum	negative (-)	0.16
Institutional Resilience			
Existing early warning systems	Maximum	positive (+)	0.75
Availability of flood hazard maps	Maximum	positive (+)	0.25

Table 4. The weighting process for all variables in scenarios of resilience

Urban Resilience	Weighting (%)			
	Physical	Economic	Social	Institutional
Physical Scenario	52	16	16	16
Social Scenario	16	16	52	16
Economic Scenario	16	52	16	16
Institutional Scenario	16	16	16	52
Equal Scenario	25	25	25	25

3 Results and Discussions

Physical resilience describes the ability of a city to prevent floods. The variables used in this resilience are building density, the percentage of built-up areas on riverbanks, and the proportion of green open space. Riverbanks were determined by creating buffer areas parallel to both sides of the river channels, and the width was set at three meters for rivers with artificial banks in urban areas and 15 meters for rivers without artificial banks in urban areas, as specified in the Government Regulation No. 38 of 2011 on Rivers. . The three variables above were selected from several variables discussed in Cutter *et al*. [15] and Li *et al*. [10] that can be used to measure physical resilience and represent the conditions of the study area. Rachmat and Pamungkas [13] claim that building density and the proximity of buildings to the river are two of many factors contributing to the high flood risk in one of the districts in Makassar.

Green open space is part of green infrastructure development, which is a fundamental step to increase the resistant capacity of an urban area. The function of the green open space is to store rainwater and, consequently, reduce surface runoff. The more extensive the available green open space, the higher the resilience of the city [10]. Uncontrolled development that causes the conversion of protected areas to buildings also takes part in diminishing the resistant capacity, especially when it sprawls to riverbanks. The building density, % built-up area, and the proportion of green open space in the study area are shown in Table 5.

Table 5. The Variables of the Physical Resilience

Districts	**Building density (units/ha)**	**Built-up areas on riverbanks (%)**	**Green open space (%)**
Biringkanaya	8.77	71.02	8.67
Manggala	11.28	91.73	7.53
Panakkukang	13.75	63.67	30.77
Rappocini	26.69	97.89	1.89
Tallo	34.08	78.35	51.17
Tamanlanrea	9.28	54.38	17.53
Tamalate	15.93	96.45	3.44

Based on the data analysis results, the physical resilience of Makassar to floods is depicted in Figure 5. It ranged between 0.5 and 0.9, which fell into the category of moderate. Four districts were found to have low resilience, namely Tamalate, Tallo, Rappocini, and Manggala. These districts had a vast built-up area and high building density. Many areas in the other districts were also widely covered with buildings, but they had low building density and ample green open space that contributed to a better resilience than the four districts. An extensive built-up area on riverbanks is another major factor of the relatively low resilience of the four districts. These districts are designated as integrated settlement, business, and trade areas to encourage their development; however, this has created an imbalance between land availability and demands and initiated developments in protected areas, such as riverbanks, instead. Panakukang had the highest resilience value because it had the lowest percentage of built-up areas on riverbanks and high availability of green open space. This finding is attributable to the designation of Panakukang as the central office district for the Province of Sulawesi Selatan.

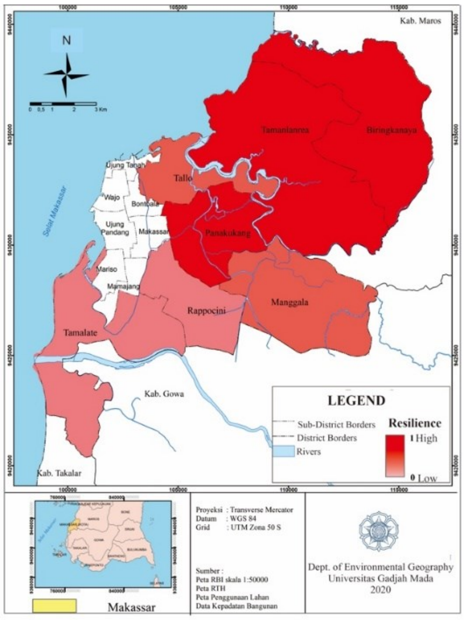

Fig. 5. Map showing the distribution of physical resilience in parts of Makassar
Source: Office of Public Governments (2017), Office of Spatial Plan (2017)

Social resilience describes the ability of a system to deal with and respond to floods (coping capacity). It was assessed using several variables, namely population density, vulnerable population (%), community participation, and the existence of disaster emergency stations. Population density and vulnerable population were calculated based on the data issued in the document District in Figures published by the Statistics Indonesia (BPS), while information on community participation and the number of disaster emergency stations was collected through interviews. These four variables were selected based on Li's research, [10] Erlani and Nugrahandika's research [16], and the conditions in the field.

Makassar is not only the capital city of Sulawesi Selatan but also one of the central and busy gates to the eastern regions of Indonesia. Owing to this situation, rapid population growth in the city is inevitable. Unfortunately, this also means that the number of people affected by floods multiplies. Population density thereby reflects how resilient the population is to a disturbance. Vulnerable populations include all residents who cannot evacuate by themselves: the larger the share of the vulnerable population, the lower the social resilience of a city. Community participation and disaster emergency stations define how the community deals with floods and receives relevant information. Higher community participation and more available disaster emergency stations mean that the people are more unlikely to be affected by floods because these two variables show that they have been vigilant since the early phase of the disaster cycle [10].

Based on the data analysis results, some parts of Makassar had different social resilience to floods, as seen in the distribution pattern in Figure 6. The social resilience varied between 0.6 and 0.9, and the lowest value was identified in Tallo and Rappocini Districts. As seen in Table 7, large population size and density are believed to have caused this condition. Compared to other districts, Tallo and Rappocini had a relatively smaller area. As a result, higher population density potentially increases the number of people affected by flooding and, more often than not, slows down the evacuation process. Nevertheless, the social resilience of the two districts was classified as moderate due to the influence of high community participation in dealing with floods and the existence of disaster emergency stations.

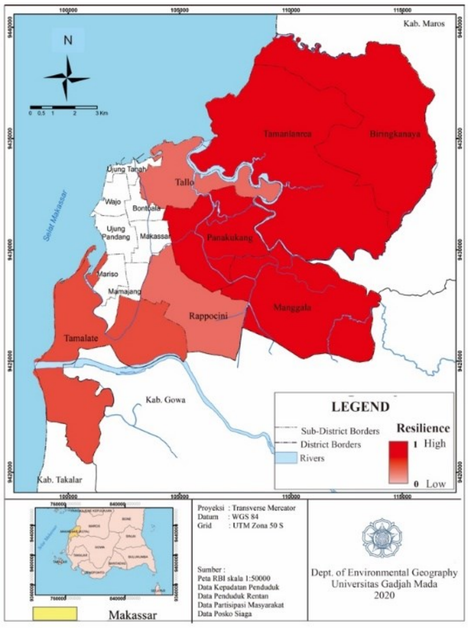

Fig. 6. Map showing the distribution of social resilience in parts of Makassar
Source: The Statistics Indonesia (BPS) for the City of Makassar (2018), Interviews (2019)

Moderate to high social resilience in the study area is shaped by not only high community participation but also a low proportion of the vulnerable population in each district, i.e., <20%, as presented in Table 6. According to Li's research [10], vulnerable communities are considered less capable of dealing with disasters individually; they need help from others and potentially slow the evacuation process. Apart from the low percentage of the vulnerable population, high community participation is also a major factor that enhances the social resilience of Makassar.

Economic resilience is the ability of a city to restore its urban system. Floods are known to cause damages to residential buildings and loss of property. For economically disadvantaged households, recovering from these impacts poses a significant challenge, particularly when access to food, clothing, and shelter is limited in the first place. The Land and Building Tax imposed on an area can define the potential losses caused by floods. City residents (individuals and entities) that have ownership rights of land and buildings must pay a specified amount of money for this tax [17]. Therefore, in the wake of a disaster, higher revenue from the Land and Building Tax means a greater potential loss.

Table 6. Population density and percentage of vulnerable population

Districts	Population Density (people/ha)	% Vulnerable Population
Biringkanaya	43.2	10.6
Manggala	58.9	11.6
Panakkukang	87.1	11.5
Rappocini	180	13.9
Tallo	239	11.0
Tamanlanrea	35.6	19.0
Tamalate	98.1	14.9

Community's subsistence funds are also a variable in economic resilience because the development of sub-districts and villages cannot solely rely on the relatively small funds allocated by the government but has to use some additional funding that the community organizes. These can also be used as a source of funding in the case of emergency; for instance, to help restore flood-affected public facilities. Besides affecting buildings on riverbanks, floods also submerge agricultural land downstream, causing losses of income. Although the City of Makassar has a narrow farming area, agricultural cooperatives can significantly help farmers to recover from such losses. For this reason, the economic resilience of the city partly depends on the number of agricultural cooperative members.

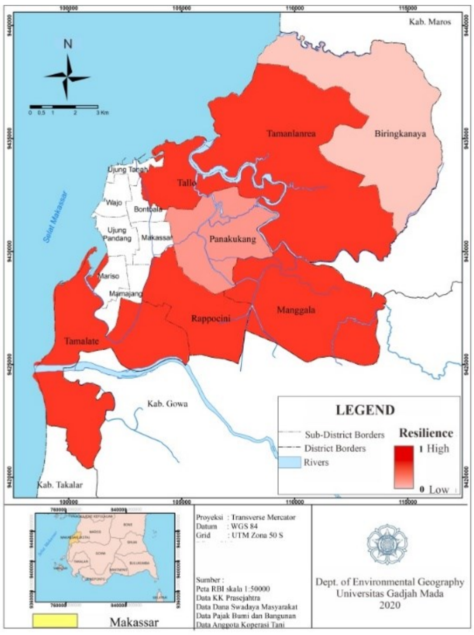

Fig.7. Map showing the distribution of economic resilience in parts of Makassar
Source: The Statistics Indonesia (BPS) for the City of Makassar (2018)

Based on the four variables above, the economic resilience of Makassar ranged between 0.3 and 0.8 (Figure 7), with the lowest resilience found in Panakukang and Biringkanaya District. Panakukang and Biringkanya had the lowest resilience due to the high share of economically disadvantaged households that, more often than not, experienced slow recovery after floods. Apart from the severely lucking financial assistance from its government, Biringkanya also had very little community's subsistence funds compared to the other districts (Table 8). Unlike Biringkanya, Panakukang had low economic resilience, chiefly because of the high Land and Building Tax. In other words, the district is exposed to a greater loss because there is a large number of buildings and land potentially affected by floods. The Land and Building Tax is a source of regional income used to finance physical and non-physical community services. At the same time, if an object is affected by a disaster, its tax levy will be reduced. In other words, more flood-induced losses reduce regional income and hamper the local economic

Table 7. The Variables of Economic Resilience

Number of economically disadvantaged households	Community's subsistence funds (million rupiah)	Revenues from the Land and Building Tax (million rupiah)	Total members of agricultural cooperatives
Biringkanaya			
5430	5,814	16,824	20892
Manggala			
2491	24,78	4,977	9275
Panakkukang			
4929	14,164	23,811	22063
Rappocini			
2670	12,697	14,29	15417
Tallo			
4014	12,029	I6,187	19428
Tamanlanrea			
1276	10,905	19,211	7245
Tamalate			
8543	34,343	17,219	55420

Taken from an economic perspective, Manggala, Tamanlanrea, and Rappocini Districts are highly resilient. This finding is attributable to the designation of these three districts as an integrated settlement area (Manggala and Rappocini) and an integrated educational and industrial area (Tamanlanrea) [18]. An integrated settlement area means that the dwellings are well laid out and equipped with integrated facilities and infrastructure, while an integrated educational and industrial area is prepared for educational development and has complete facilities. As evidenced by the small number of economically disadvantaged households and a high amount of community's subsistence fund, these two integrated areas are generally inhabited by people with high economic status and easy access to basic needs. Therefore, in the case of floods, the residents can recover faster.

Institutional resilience was measured using two variables: the availability of flood hazard maps and an early warning system, which describe the ability of a city to adapt to flood events. An early warning system helps people to be ready and on alert so that in the event of flooding, they will be able to evacuate faster and, as a result, incur fewer losses [10]. Flood hazard maps can assist the government in planning for development and reducing flood-related losses. The institutional resilience of the study area ranged between 0.5 and 0.9 or fell into the category of "high" (Figure 8). Interviews with stakeholders in each district revealed that the districts in question did not have flood hazard maps and only relied on the maps issued by the Regional Disaster Management Agency (BPBD) for the City of Makassar. Despite the absence of a digital map, each stakeholder could pinpoint the most frequently affected areas. For instance, Manggala and Tallo Districts own historical data on flood locations and have manually generated some maps to anticipate flood occurrences in the rainy season. Accordingly, both districts were categorized as highly resilient in terms of institutions and governance.

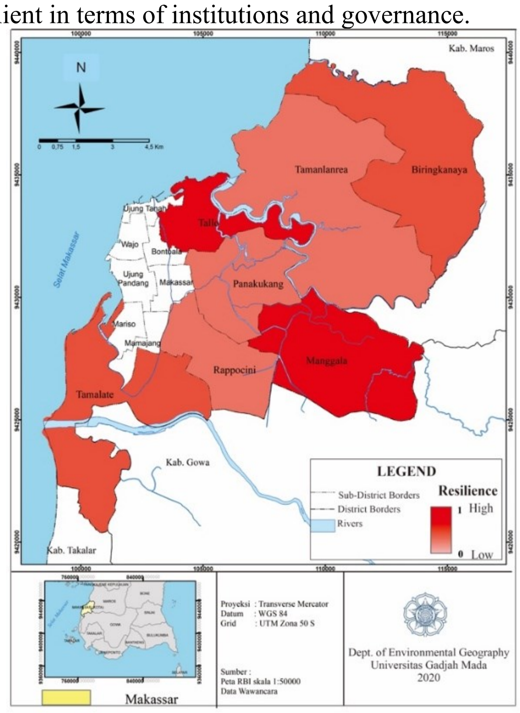

Fig. 8. Map showing the distribution of institutional resilience in parts of Makassar
Source: Interviews (2019)

During the rainy season, the governments in several flood-prone districts (i.e., Tallo, Tamalate, Manggala, and Biringkanaya) actively organize public dissemination in villages. An early warning system is not only assessed from the existing technology but also less technologically sophisticated technique, such as public dissemination [19]. An early warning system broadcasts an alert signal, and when combined with public dissemination, it warns people to be vigilant during the rainy season. These conditions primarily contribute to the high resilience of Tallo and Manggala.

Resilience has three concepts, namely, infrastructure, ecology, and social ecology. The three concepts cannot be separated when discussing the resilience of cities because an urban system is a complex product of physical, social, economic, and institutional elements. The concept of infrastructure and ecological resilience determines urban resilience from the physical system, while the social-ecological resilience factors in social, economic, and institutional systems. These four systems are integrated because they have inter-relationships and influence one another. Accordingly, urban resilience assessment cannot be observed merely from one side but must factor in all four systems [8],[20].

The total resilience of Makassar was determined from the four components of the city, namely physical, social, economic, and institutional resilience. The resilience of each component was displayed five different scenarios that were designed with different weight values to be able to identify the effects of resilience in each urban system. In the economic resilience scenario, the economic variables were assumed dominant and given the highest weight value (Figure 9). The same case applied to physical (Figure 10), institutional (Figure 11), and social scenarios (Figure 12), with dominant or highest weight value assigned to their respective variables. As for the equal scenario (Figure 13), the resilience variables were given the same weight value.

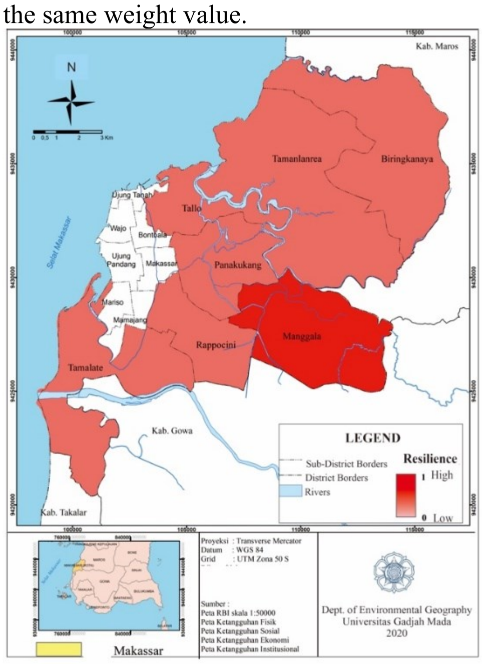

Fig. 9. Map of Economic Resilience Scenario

The economic scenario is considered as the worst because Manggala was the only district projected with high resilience. Except for Manggala, all variables in the study area had low values, particularly the large share of the economically disadvantaged population. Compared to the other districts, Manggala had a higher economic resilience owing to its substantial amount of community's subsistence fund and low revenues from the Land and Building Tax. Apart from Manggala, there were other districts with high resilience, namely Tallo, Tamalate, Tamanlanrea, and Rappocini. However, in the economic scenario, these four districts showed a decrease in their resilience values. This finding indicates the influence of the resilience of other urban systems.

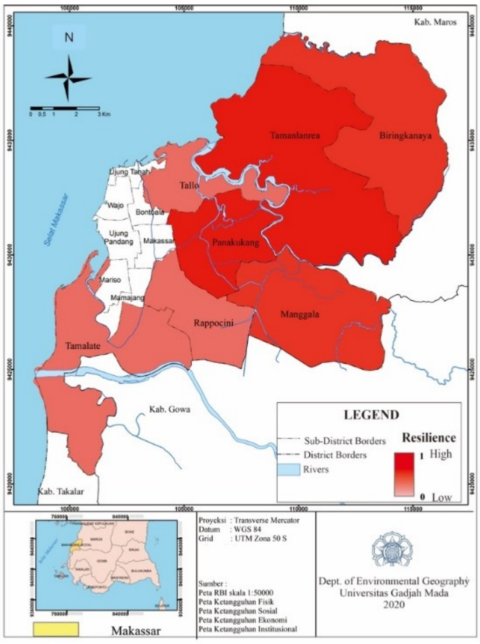

Fig. 10. Map of Physical Resilience Scenario

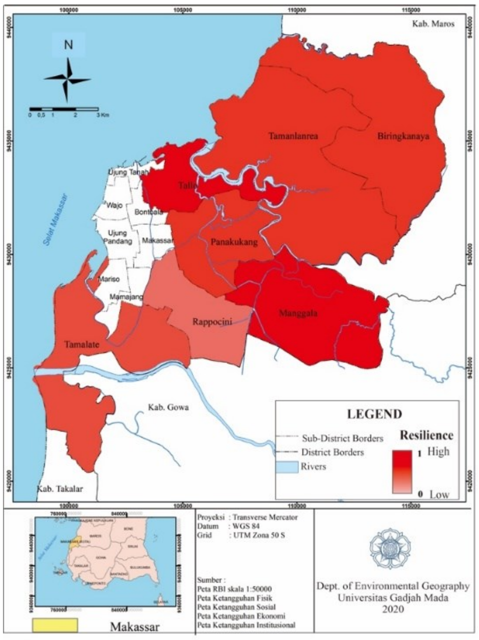

Fig. 11. Map of Institutional Resilience Scenario

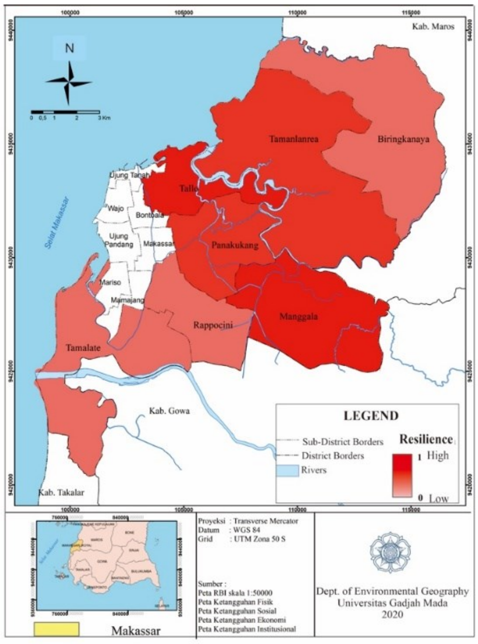

Fig. 12. Map of Equal Resilience Scenario

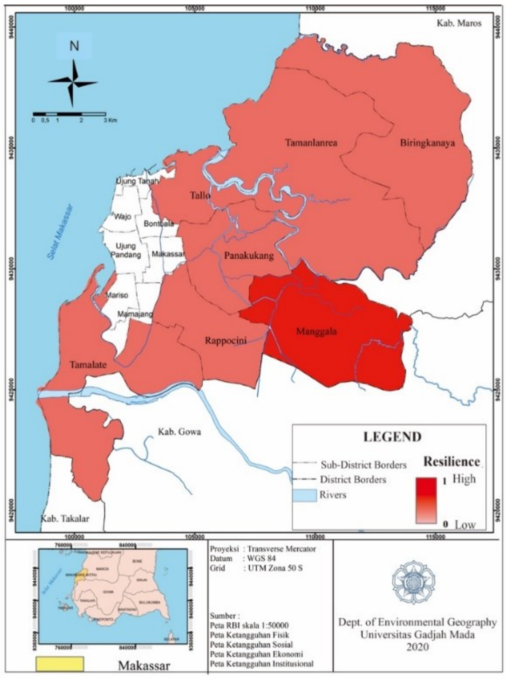

Fig. 13. Map of Social Resilience Scenario

The social resilience scenario produced the best distribution pattern of resilience, with values ranging between 0.51 and 0.89. In this scenario, Manggala had the highest value, while Rappocini was the opposite. In Manggala, the community participation was high, the population density was fairly scarce, and a disaster emergency station was available and was even monitored specifically by the BNPB. On the contrary, Rappocini had a high population density and abysmal community participation.

Based on the scenario, social factors or variables are concluded as having the most significant role in increasing the resilience of parts of Makassar. Nevertheless, the government is not recommended to solely rely on this scenario for evaluation because low resilience estimates were identified in Tallo and Rappocini. Tallo had the highest resilience value in institutional and equal scenarios, while Rappocini was highly resilient in the equal scenario. These results prove that focusing on enhancing only one factor can increase the disaster resilience of some districts but diminish the resilience of some others. In conclusion, urban resilience cannot be merely perceived and assessed from one system; instead, it must incorporate the other urban systems. Changes in the resilience of several districts in different scenarios demonstrate how increased resilience can be realized when the contributing variables in every urban system involved are improved accordingly because the resilience of the urban system in every district tends to vary. This finding is consistent with Fu and Wang's research [21] i.e., that conceptually the assessment of urban resilience cannot be separated from the complexity and variety of urban systems.

This concept believes that equal scenario produces resilience values that best describe the conditions of each district because it gives all urban systems an equal weight value. In this study, the equal scenario produced a nearly similar pattern to the results of the social, physical, and institutional scenarios. The difference lies in, among others, the estimated resilience of Rappocini. In other scenarios, this district had the lowest resilience, but in the equal scenario, it was classified as highly resilient, as seen in Figure 14. Changes in the distribution pattern of resilience values in all districts can be useful for the government to determine priorities in development. For instance, Manggal requires immediate improvements because the physical scenario showed that it still had extensive residential areas on the riverbanks and a low percentage of green open space, all of which contribute to its low physical resilience.

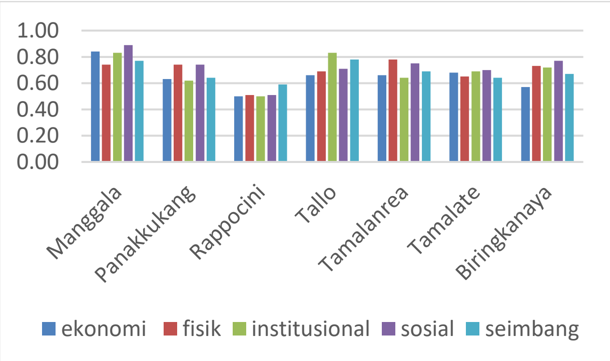

Fig. 14. Changes in the flood resilience values of some parts of Makassar based on five scenarios

4 Conclusion

Physical, social, economic, and institutional urban systems define to what extent some parts of the City of Makassar are resilient to floods. Each district has different resilience for each system. Rappocini District has the lowest resilience in all systems, whereas Manggala is the most highly resilient district to floods. However, in all of the districts observed, the ability to recover after floods is deemed weak because the number of their economically disadvantaged households is categorically large. Also, for some districts located adjacent to the rivers, the banks are increasingly occupied by residential buildings, contributing to low physical resilience. These conditions are potentially attributable to the lack of available data, which leads to low government's attention to flood-prone areas. Nevertheless, community participation in increasing social resilience is very high. Based on the results of the scenarios, the City of Makassar can be resilient to floods depending on the resilience levels of every urban system involved. For this reason, improvement in all urban systems is imperative, with priorities set according to the conditions of each district.

References

1. S. Putro., & R. Hayati. Dampak Perkembangan Permukiman Terhadap Perluasan Banjir Genangan Di Kota Semarang. *Jurnal Geografi: Media Informasi Pengembangan dan Profesi Kegeografian*, **4**(1). (2007). In *Bahasa*
2. S. P. Nugroho. *Analisis Curah Hujan Penyebab Banjir Besar di Jakarta pada Awal Februari 2007*. Jurnal Air Indonesia, **4**(1). (2018). In *Bahasa*
3. Kementrian Pembangunan Perencanaan Nasional. *Pengembangan Kota Cerdas di Indonesia*. In Papers presented in Conference on e-Indonesia Initiative dan Smart Indonesia Initiatives Forum ke-1 (Vol. **15**). (2015). In *Bahasa*
4. R. Setiadi, & F. Wulandari. *Memadukan Strategi, Mewujudkan Ketahanan: Sebuah Pembelajaran Dari Pengembangan Strategi Ketahanan Kota Di Semarang*. Jurnal Pengembangan Kota, **4**(2), 95. (2016). In *Bahasa*
5. UNISDR. *Disaster Resilience Scorecard for Cities Detailed level assessment*, 118. (2017).
6. L. Chelleri. *From the Resilient City to Urban Resilience. A review essay on understanding and integrating the resilience perspective for urban systems*. Documents DAnálisi Geográfica, **58**(2), 287–306. (2012)
7. J. Normandin, M.C. Therrien, & G. Tanguay. *City Strength in times of turbulence*, 445–448. (2009)
8. S. Meerow & J. P Newell. *Urban resilience for whom, what, when, where, and why? Urban Geography*, 00(00), 1–21. (2016)
9. K. H. Liao, T. A. Le, & K. V. Nguyen. *Urban design principles for flood resilience: Learning from the ecological wisdom of living with floods in the Vietnamese Mekong Delta*. Landsc. Urban Plan., **155**, 69–78. (2016)
10. Z. Li, X. Zhang, Y. Ma, C. Feng, & A. Hajiyev. . "*A multi-criteria decision making method for urban flood resilience evaluation with hybrid uncertainties*." nt. J. Disaster Risk Reduct. **36**. (2019).
11. A. K. Choirunisa, & S. R. Giyarsih. "*Kajian Kerentanan Fisik, Sosial, dan Ekonomi Pesisir Samas Kabupaten Bantul Terhadap Erosi Pantai.*" Jurnal Bumi Indonesia **5.4** (2016). In *Bahasa*
12. D. R. Hizbaron, D. S Hadmoko, E. T. W Mei, & S .H Murti. "*Towards measurable resilience: Mapping the vulnerability of at-risk community at Kelud Volcano, Indonesia*." Appl. Geogr. **97**, 212-227 (2018)
13. A. R. Rachmat, & A. Pamungkas. "*Faktor-Faktor kerentanan yang berpengaruh terhadap bencana banjir di Kecamatan Manggala Kota*

Makassar." Jurnal Teknik ITS 3. C178-C183 (2014). In *Bahasa*
14. S. Rijal. "*Kebutuhan ruang terbuka hijau di Kota Makassar tahun 2017*." Jurnal Hutan dan Masyarakat **3.**1, 8219 (2008). In *Bahasa*
15. S. L Cutter, C. G. Burton, & C. T. Emrich. "*Disaster resilience indicators for benchmarking baseline conditions*." J. Homel. Secur. Emerg. Manag. **7**.1 (2010)
16. R. Erlani, & W. H Nugrahandika. "*Ketangguhan Kota Semarang dalam Menghadapi Bencana Banjir Pasang Air Laut (Rob)*." Journal of Regional and Rural Development Planning **3.1,** 47-63 (2019). In *Bahasa*
17. R. Adelina. "*Analisis Efektifitas dan Kontribusi Penerimaan Pajak Bumi dan Bangunan (PBB) terhadap Pendapatan Daerah di Kabupaten Gresik*". Jurnal Akuntansi AKUNESA **1.2** (2013).
18. M. M. Tahir. "*Good urban governance: Peran pemerintah dalam pembangunan wilayah kecamatan di Kota Makassar*." Government: Jurnal Ilmu Pemerintahan **8.1,** 9-16. (2015). In *Bahasa*
19. N. Syam. "*Arahan Penanganan Kawasan Rawan Banjir Berbasis Gis (Geography Information System) Di Kecamatan Tamalate Kota Makassar*." Plano Madani: Jurnal Perencanaan Wilayah dan Kota **4.2,** 42-48. (2015). In *Bahasa*
20. K. H. Liao. "*A theory on urban resilience to floods—a basis for alternative planning practices*." Ecol. Soc. **17.4** (2012).
21. Fu, Xin, & X. Wang. "*Developing an integrative urban resilience capacity index for plan making.*" Environ. Syst. Decis. **38.3**, 367-378. (2018