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Manage Flood Risk with the Digital Instruments, Community and Officers' Participation

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Abstract

Flood hydrology is a phenomenon that occurs due to insufficient capacity of the drainage system and environment factors. This survey research was conducted in Medan Municipality to seek the human interaction with digital instruments and participation of community and local government officers to control flood. With survey and observation, it found local government has connected to the digital instruments of National Board of Meteorology and Geopgysics and local systems to dectect the rainfall and flood. The problems that resulted in from the buiding development with concrete has made the flooding appears when heavy rain 2-3 hours in urban areas of Medan Municipal. Digital tools have helped the mitigation and public policy. Additionally, it can be said that 77.7% variation in the dependent variable includes the mitigation of floods, community participation, institutional coordination, the risk of flooding, and land use, thus other comprises 23.3 %. But the problems are coming from the volume of incoming water has the higher size than the absorbed capacity of the soil due to uncontrolled building construction with the small tunnels to flow the water and the illegal buildings near the streams.

Keywords: *digital; participation; officers; community; flood control*

1. Introduction

Floods are natural events that can occur at any time and often results in loss of life, property, and objects. Flooding is a global phenomenon that can cause widespread suffering, economic damage and loss of human lives. Flooding is a presence of water exceeds normal limits in areas that are usually dry. Flooding caused by a combination of heavy rains that caused the river or sea flows into the house, which can occur at any time of year, not only in the winter. Flooding is generally grown for several days, when there is too much rain. However, they can happen very quickly when a lot of heavy rain fell during a short period of time (When et al., 2015). It notes the flood would significantly interfere with the activity of man and society (Jonkman and Kelman, 2005). Since the relatively quickly of modernization with concrete buildings many areas in urban spaces are flooded in heavy rain. Furthermore, the phenomenon of flooding that occurred in various areas of Medan municipality. Initial data basically showed a strong indication of the use of space of urban area of Medan Municipality; it is due to a mismatch between man and nature as well as between economic interests with environmental preservation. Medan city traversed by Watershed Deli and Babura River which now are not able to accommodate the flow of water; so this city is often flooded by the imbalance of land use and environmental management. Location of Medan is the lowland area and flat with a height of 2.5 meters to 40 meters above sea level and the slope covers 0-4% is a low-lying topography which tends ramps to the north and it becomes the meeting place of two rivers; namely Deli and Babura Rivers. Medan is one of the flood-prone areas. Flood condition almost always occurs in certain areas, especially during the rainy season, this condition is a problem that needs to be considered because it is very detrimental to society.

Tingsanchali (2012) explained that the impact of the flood disaster is one of the most significant in the world. Thus, Haghebaert (2007) argued that the disaster risk reduction is a top-down, and it often fails to overcome the particular vulnerabilities, needs and demands of society at risk. The government's plan without involving the public in flood mitigation is very difficult to achieve, which is often government policy in flood mitigation unwanted by society. Arnstein (1999) argued there are eight stairs force participation rate is based on the levels of society in influencing the planning. Institutional interpreted as restrictions are made to form a pattern of a harmonious interaction between individuals in political interaction, social and economic. Thus, Schmid (1972) put forwards the institutions as a number of regulations in a society, group or community, which regulates the rights, obligations, responsibilities, both as individuals or as a group. Therefore, Schotter (1981) considered the institutional regulation of human behavior that is agreed upon by all members of the community and is a stylist interaction in a particular repeated situation. According Krasovskaia (2001) the knowledge gained in community participation approach can be used to develop a coordination policy that emphasizes community participation.

The digital tools for the dectection of high rate rainfall and huge damage of flood lead the Medan Municaplity has connected to the instruments of the National Board of Meteorology and Geophysics and local system warning. It makes link to the offices and local districts heads. Like the Servir which has been used to map floods in Africa and predict forest fires in the Himalayas, Medan also links to digital instrument. It is known that Wu, et al (2014) had offered the digital tool to make the estimation of flood via satellite-based precipitation. Digital detection with Satellite like the anticipation of flooding, it notes that NASA already used a technology called the Global Flood Monitory System (GFMS). In the official website of NASA mentioned that the system is similar to what we know as *Google Maps*. The difference, GFMS is a disaster map that maps floods on a global scale. The obtained data in real-time via satellites are owned by NASA. Thus, Wu H. et al (2012) discussed the global satellite for helping the detection of rainfall. Therefore, NASA GFMS makes the data received is then processed in such a way and displayed through a map that can be used by policy makers to anticipate flooding. Also there is a Servir, a device or computer that carries out analysis. Servir receives supporting data through satellite imaging; then it analyzes the data obtained through the assistance of technological sophistication owned by NASA (https://www.nasa.gov/mission_pages/servir/overview.html).

Based on the above views, this research was conducted to seek the data of flood mitigation that involves digital tool, participation of community and public policy of local government of Medan Municipality. It collected the data through a survey research and observation in the field. It took 21 districts of Medan Metropolitan area of Indonesia.

II. Research Design

The research applied a survey method which conducted in the city of Medan, Indonesia. This location is the Capital of North Province which geographically total area of Medan is 26 510 km$^{2.}$ Data of average of rain, digital forcast, land use of settlements in 18126.8 acres; 159.06 acres to the company, industry and services counted as 559.62 acres and the remaining 359.06 acres devoted to agriculture were used to calculate in seeking the flood factors. An observation was also carried out to know the community and local officers participation to control the flood that makes the vulnerability of people living in the flood prone settlement Medan also used to count the preparedness in face annual flood.Data also covered the discussion of vulnerability of the region's economy which is dominated by business location or lots of factory located near streams. Following Wu H.,et al (2012) ideas of revers networking with digital tool and Servir, this study seek the data of Medan Municipal which has used some digital instruments to help the districts officers and community to anticipate highg rate rainfall which results in the flood.

This research analyzed obtained data of an overview of the policy of Medan in flood mitigation. Public Policy of Medan Government in mitigation takes a systematic effort to reduce disaster risk structurally through the development of physical infrastructure and non structural through legislation and training institutions. Basically disaster mitigation includes preparedness; it is the effort made to anticipate disasters, through organizing, appropriate steps effectively and efficiently. Preparedness means to prevent and mitigate disasters, take steps to reduce the impact caused by the disaster and make sure everyone is on alert if a disaster occurs.

III. Findings

Based on survey and field observation; the flooding is due to two categories: natural and flooding due to human activities.Fist, naturally affected by flooding due to high average of rainfall in Medan City of North Sumatra from October to April each year, the two rivers capacity, and overflow of drainage as well as tidal factor in Northen area of Medan City. Secondly, flooding due to human activities caused by human activities that lead to environmental changes such as: changes in the condition of the Watershed, residential areas around the banks, destruction of land drainage, flood control building damage, destruction of forests (natural vegetation), and planning flood control system that is not right. Emergency response with regard to what happens during and after a disaster to save lives, reduce suffering and dealing with the impact of the direct impact of the disaster.

Data obtained displays the climate data of Medan in 2015-2017:

Table1.Avarage Climate Data of Medan (2015-2017)

Month	Temperature (°C)	Humidity (%)	Wind Velocity (Knot)
January	29,02	93,31	6,82
February	29,06	90,94	6,93
March	29,11	90,75	7,15
April	29,10	91,49	6,93
May	29,15	91,50	7,04
June	29,12	91,51	7,48
July	29,10	91,52	7,59
August	29,10	91,53	7,15
September	29,03	91,54	7,59
October	29,03	91,55	7,26
November	29,04	91,56	7,04
December	29,03	91,58	6,93
Average	29,07	91,56	7,16

Source: the Board of Meteorology and Geophysics of Medan 2015- 2017

The following table (2) shows the calculation results of modeling the risk of flooding in Medan Municipality:

Table 2.Results of Flood Risk Modeling Calculationin Medan

No	**District**	**Broad area at the risk of flood (M^2)**					**Sum**
		Very Low	**Low**	**Medium**	**High**	**Total**	Family No (000)
1	Medan Maimun	0	0	3,873,825	235,354	4,109,179	18.62
2	Medan Area	0	0	6,942,578	659,877	7,602,455	37.314
3	Medan Helvetia	62,951	510,419	15,568,135	1,659,837	17,801,342	47.733
4	**Medan Polonia**	**0**	**0**	**10,236,225**	**2,039,094**	**12,275,319**	**18.64**
5	Medan Kota	0	0	5,970,214	1,463,653	7,433,867	32.138
6	Medan Denai	130,287	293,489	9,981,519	2,104,887	12,510,182	51.234
7	Medan Timur	2,170	2,299	9,629,464	2,769,476	12,403,409	38.412
8	Medan Tembung	113,956	548,692	8,726,506	1,936,264	11,325,418	48.538
9	Medan Baru	0	0	5,944,340	1,917,759	7,862,099	17.544
10	MedanPerjuangan	0	0	5,030,402	1,812,215	6,842,617	39.467
11	Medan Selayang	22,163	1,650,278	14,440,421	3,671,099	19,783,961	33.141
12	Medan Johor	69,743	4,789,228	16,690,325	2,014,731	23,564,027	41.342
13	Medan Barat	4,461	1,587	6,448,915	3,082,491	9,537,454	27.8

14	MedanTuntungan	325,124	8,611,309	25,988,738	4,720,428	39,645,599	26.52
15	Medan Amplas	181,547	4,276,987	9,716,519	1,074,743	15,249,796	38.904
16	Medan Petisah	0	0	4,505,224	3,256,126	7,761,350	24.862
17	Medan Sunggal	49,036	88,664	11,795,312	9,280,100	21,213,112	40.82
18	Medan Deli	141,713	251,134	11,685,885	17,873,768	29,952,500	47.749
19	Medan Marelan	247,021	1,406,042	6,622,561	23,037,346	31,312,970	36.65
20	Medan Labuhan	260,879	874,206	4,342,600	15,271,780	20,749,465	33.747
21	Medan Belawan	167,599	64,983	3,692,145	21,624,524	25,549,251	31.184

From Table 2 above, it shows an average growth rate of 1.95% per year and the average density of 11,127 inhabitants per Km. It could be seen that most districts that have high levels of flood risk is highest in the district of Medan Polonia.

Table 3 .Results of Stastical Calculation of Community Participation

Test	Variable	Flood mitigation	Public Participation	Institutional coordination	Flood risk	Land Use
Pearson Correlation	Flood mitigation	1.000	.714	.762	.800	.847
	Public Participation	**.714**	1.000	.825	.701	.688
	Institutional coordination	**.762**	.825	1.000	.737	.680
	Flood risk	**.800**	.701	.737	1.000	.864
	Land Use	**.847**	.688	.680	.864	1.000

Based on calculations from Table 3 it can be seen that the correlation coefficient (r_{xy}) is equal to 0.714. Looking at the above calculation can be concluded the relationship between participation and flood mitigation in Medan strongly correlated. The strength of these relationships can be stated that if the participation is increasing the impact on the improvement of flood mitigation efforts in the city of Medan. For institutional coordination correlation results revealed strong, very strong flood risk and land use are also very strong.

able 4. Results of Product Moment Correlation Local Government

Variable	Flood mitigation	Public Participation	Institutional coordination	Flood risk	Land Use
Flood mitigation	1.000	.722	.820	.764	.800
Public Participation	**.722**	1.000	.767	.694	.706
Institutional coordination	**.820**	.767	1.000	.743	.691
Flood risk	**.764**	.694	.743	1.000	.849
Land Use	**.800**	.706	.691	.849	1.000

Based on the correlation values of Table 4, it is known that the correlation value for public participation is lower than for local government participation.

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IV. Discussion

It notes that the factors causing flooding, among others: (1) geomorpologis conditions, eg flood-prone areas, the condition of the basin areas and low-lying areas such as the city of Medan. (2) climate conditions can not be predicted. (3) activity and human actions such as population growth, human moral hazard such as taking out the trash in the river, changing the various types of land for various purposes. Maryono (2005) also revealed the presence of flooding caused by several factors, namely rain, destruction of retention factors Watershed, the error factor of development planning of rivers, river depth factor and factor grammar mistakes region and infrastructure development.
Recovery after a disaster, such as an attempt to restore the original situation or might be better before the disaster occurs by way of rebuilding the community; it can be through appropriate which means and estimate the risk of future disasters. Haldar et al. (2015) stated that flooding can also be a serious problem for the plant. Therefore, some solution must be found for the settlement of the existing problem. With the digital tools the anticipation of rainfall and flood can be done. Flood protection is generally provided by structural measures such as the reservoir, dike or a combination of both. In this case, it is a wise thing to find a suitable size for flood mitigation through the application of digital system (Matondang, et al 2020) and modeling.

It obtained that the Institutional forms of government in flood mitigation has been established as National Disaster Management Agency (BNPB), National Search and Rescue Agency (Basarnas). Institutional forms of community that is a member of Family Planning (RUK) and Planned Activity Group (RKK). Institutional form in the mitigation has not been coordinated with BNPB and SAR which has been established by the government. Further institutional public participation activities conducted by members of the public who is responsible for carrying out the activities of government programs. Members of the public attended the meeting planning, implementation and review of the project even though only as listeners only. Community members are actively involved in making decisions about how to implement a project and participate to provide assistance and materials needed for the project. Community members are actively involved in all stages of the decision-making process that includes planning, supervision, and monitoring. Raungratanaamporn et al. (2014) proposed that the coordination between the government and the community is an important factor in disaster management, which can be addressed as a professional approach as emergency response. Institutional coordination for community values lower than the institutional coordination for local government, community flood mitigation correlation value is greater than the value of flood mitigation for local government, the value of land for public use was higher than for local government land use.

Table 5: Participation of Community and Officers

Criteria	Community		Govt Officers	
	Frequency	Percentage	Frequency	Percentage
1	16	4.6	16	16.7
2	7	2.0	7	7.3
3	23	6.6	8	8.3
4	161	46.4	38	39.6
5	140	40.3	27	28.1
Sum	347	100.0	96	100.0

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The above data shows that community participation in the flood mitigation planning meeting covered 161 respondents (46.4%), the 38 local government officers (39.6%).

These results are indicative of awareness of society to participate in the prevention of flooding in the city of Medan. It found the correlation values of 0.882 local governments. Taken together community participation, institutional coordination, the risk of flooding, land use able to mitigate flooding in a close and positive level. The coefficient of determination (R^2) is 0.777. It covered 77.7% of portion in the dependent variable of the mitigation of floods. Those variables are community participation, institutional coordination (officers), the risk of flooding, land use, the rest 23.3%. Based on calculations in Table 5 can also be seen that the correlation coefficient (r_{xy}) is equal to 0.722.

Digital instruments, participation are two correlated variables in manage the flood risk. Reducing the losses caused by flooding, it is necessary flood mitigation measures in the flood damage mitigation; both physical (structural measures) as ameliorative measures are natural and non-physical (non-structural measures) because it is the mitigation of disaster / loss (Purbawijaya, 2011). Specialized in natural flood prevention policy is now more emphasis on mitigation / avoidance flood-prone area. One form of non-structural flood mitigation is public participation. Community participation is a technical process to provide opportunities and wider authority to the community collectively solves problems.
Looking at the results of inferential relationship between community participation and flood mitigation in Medan which is strongly correlated, public participation which aims to find solutions to problems better in a community with open more opportunities for people to participate in activities contributing to the implementation of more effective, efficient, and sustainable. The strength of these relationships can be stated that if the participation is increasing the impact on the improvement of flood mitigation efforts in the city of Medan. For institutional coordination correlation results expressed most powerful, very powerful flood risk and land use are also very strong.

V. Conclusions

1. Data analysis gives two conclusions; The use of digital tools for the dectection of high rate rainfall and huge damage of flood, it found that the Medan Municaplity has connected its policy and teamworks for flood with the instruments of the Board of Meteorology and Geophysics and local system warning to the offices and local districts heads.

2. Participation: Community participation and understanding of the risk of flooding is able to support the implementation of effective institutional coordination. Community has actively participated in institutional coordination structure with reason to know the risks faced by communities in flood mitigation. These results are indicative of awareness of society to participate in the prevention of flooding in the city of Medan. It found the correlation values of 0.882 of local governments participation in the flood mitigation and institutional coordination, the risk of flooding, land use able to mitigate flooding in a close and positive level. The coefficient of adetermination (R^2) is reached 0.777.

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