Flood Risk Analysis in Denpasar City, Bali, Indonesia

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Abstract. Denpasar city is a Capital City of Bali Province and one of the leading tourist destinations in Indonesia. Denpasar area is relatively flat with high rain fall intensity with the domince of settlement. This makes Denpasar City becomes prone area of flood.
The aim of this research is to find out the spatial distribution flood hazard and the risk of population which are affected to the flood hazard. Weighting, scoring and overlaying method were used in this research. Six indicators were used to analyze the flood hazard: landuse, rainfall, type of soil, slope, altitute and drainage density. The vulnerability is analyzed per Desa or Kelurahan (Rustic/ Neighborhood) with the indicator of age, education and population density. Risk was calculated by multiplied hazard with vulnerability and divided with coping capacity. In this research, coping capacity is determined by the amount of internal budget for each *Desa* or *Kelurahan* for development purpose. Flood risk in Denpasar city is divided into five classes, very low risk, low risk, medium risk, high risk and very high risk. Total population with very high risk reached 202478 people or 13.16% of total population. The total area is 780.7 ha or 16.02% from total settlement in Denpasar city. Total population with high risk reached 202478 people or 13.16% of total population. The total area is 780.7 ha or 16.02% from total settlement in Denpasar city. The number of population with medium risk reached 202478 people or 33.51% of total population which occupied 22.95% of total settlements or 1118.18 ha. The total number of population with low risk reached 79435 people or 13.14% of total population with area of low flood risk is 716.89 ha or 14.71% of total settlements in Denpasar City. Very low flood risk with total population at risk reached 19184 people or 31.74% of total population and occupied 2003.54 areas or 41.12% of total areas of settlements.

Keywords: Flood Hazard, Flood Risk, Population

1. Introduction

Denpasar City is capital city of Bali Province, Indonesia. Beside its administrative function, Denpasar City is also the heart of tourism, education, economy, trade and services in Bali Province. Denpasar city consists of 4 districts and 43 Villages. The number of population in Denpasar always increases every year. The latest data in 2015 population of Denpasar City as much as 880,600 people [1]. This condition cause the need for land becomes increasing and eventually triggers landuse change.

Denpasar City is located in a flat until undulating topography which bordered by Lombok Strait in the south. Denpasar City is a downstream area for three major river in Bali, Ayung River, Mati River and Badung River. The physical conditions makes Denpasar City becomes prone area to flood. Not to mention that Denpasar City has high rainfall intensity. This condition and the existence of many

buildings and impermeable layers due to the development of the City itself makes Denpasar City become prone area to flood.

Flood is a water runoff that exceeds the normal water level, so that the runoff from the riverbed causing a puddle on the low land on the side of the river [2]. There are two type of flooding events, the first flooding event occurring in an area that usually does not flood and both flood events occur because the flood discharge is greater than the existing drainage capacity of the river [3]. The occurrence of flooding is also caused by low soil infiltration capability, thus causing the land to be unable to absorb water [4–7].

Based on data obtained from the Regional Disaster Management Agency of Bali Province, it is said that there are some flood events occurs due to heavy rain. Several areas which at that time were submerged by the flood were Padang Sambian Village, Panjer Village, Penatih Village, Pengecutan Kelod Village and Sambian Kaja Village. In 2015 again floods occured in the area of Monang-Maning and surrounding areas, causing the death toll due to drag currents in Tukad Mati. The trigger of the flood at that time due to the amount of garbage clogging drainage channels [8]. The occurrence of floods in Denpasar City in addition to causing losses in terms of material, also makes population becomes exposed to flood hazard. The aim of this research is to study the floods risk to the population in Denpasar City.

2. Literature Review

Risk is defined as the probability of the danger or expectation of losses (death, property damage) resulting from the interaction between natural disaster and vulnerability. The purpose of risk assessment is to determine the nature and extent of risk by analysing the potential hazards and evaluating the existing conditions of vulnerability. One method of risk assessment was the qualitative method. Qualitative methods describe risks at levels such as "very high", "high", "medium", "low" and "very low". Qualitative methods were used in conditions that required rapid, precise and cost-free assessments. This method used a matching and scoring approach that emphasized the quantitative assessment of risk components. Hazards, vulnerabilities and coping capacities were the key concepts in risk assessment. Hazard as probabilities of natural events that harm and cause victims and vulnerability as the level of damage or casualties when the incident struck. While capacity was the ability of the community in tackling the dangers of natural disasters. The concept leads to an understanding of risk as the product of two concepts, namely the probability of occurrence and the intensity of the disaster event [8].

The same hazard events can result in different risk analysis due to differences in vulnerability of risk elements. For example, assessing the hazard risk of similar flood events in two different cities may result different values depending on the factors that contribute to the vulnerability and resilience of the population. Risk analysis can be used to identify locations and populations that may be affected by disaster events. This information is very important when preparing a disaster mitigation plan. A disaster mitigation plan is a dynamic process built on the practical assessment of past and current information to anticipate future hazards and provide meaningful strategies for addressing potential impacts and identified needs. The main objective of the hazard mitigation plan is to reduce vulnerability and increase community resilience, thereby reducing the potential risks [9].

3. Methodology

3.1. Area of Study

Denpasar city consists of 4 districts, and 43 sub-district. The area of Denpasar City has total area of 127.98 km^2. The area of Denpasar City is generally a relatively flat area with a slope of 0-8% and the altitude is less than 75 meters above sea level. Land use is dominated by buildings.

3.2. Tools and Materials

The tools used in this study include were: a unit of laptop with QGIS software, and writing utensils. The materials used in this study were: Denpasar City administrative map from Planning Agency of Denpasar City, Landuse Map from National Land Agency of Denpasar City, Soil Type Map from Faculty of Agriculutre of Universitas Udayana and Altitude Map, based on contour line, obtained from Planning Agency of Denpasar City, annual rainfall data in Denpasar obtained From Meteorological and Geophysical Agency, Region III of Denpasar City, and Slope Map and River Map obtained from Balai Wilayah Sungai Bali-Penida of Bali Province.

3.3. Research Implementation

The methods in this research were based on the risk equations as formulated in equation (1) [8].

$$Risk = \frac{Hazard\,x\,Vulnerability}{Coping\,Capacity} \quad ...(1)$$

Disaster risk is the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. Hazard is a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Meanwhile vulnerability is the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards. And coping capacity means the combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience [10].

This research used the variable of flood hazard, population vulnerability to flood and institutional coping capacity which was the amount of Village's budget for development purpose. Flood hazard used matching and scoring methods, population vulnerability was analyzed by using with the indicator of age, education and population density.

3.3.1. Flood Hazard

At this stage, an analysis that requires data input from the six parameters are suspected to be the cause of flood, ie landuse, slope, altitude, soil type, rainfall and drainage density. Each parameter was given the weight and score that has the greatest influence on the flood. Table 1 listed the score and weight for each parameter [11].

Table 1. Score and Weight for Each Flood Parameter

No	Parameter	Score	Weight	Max. Score
1	Landuse	1 – 5	2	10
2	Altitude	1 – 5	1	5
3	Drainage Density	1 – 5	1	5
4	Slope	1 – 5	3	15
5	Soil type	1 – 5	2	10
6	Rainfall Intensity	1 – 5	3	15

The hazard class was divided into 5 classes. The hazard class calculation was performed by dividing the value of each parameter into equal class interval calculated according to equation (3) [11] then summed up each class of each parameter to reach the final score. The division of hazard into 5

classes resulted in 5 classes of hazard, namely very high hazard, high hazard, medium hazard, low hazard and very low hazard.

$$Class\ Interval\ = \frac{N\ maks - N\ min}{Class\ Number} \ldots (2)$$

With N max: Highest population density
N min: The lowest population density

After the weighting and scoring, then the process continued with overlay for the six parameters. Any graphical data that will be overlaid by using a UTM coordinate system to make it easier to know the unit width in meters. The purpose of doing overlay was to obtain new information that has a mapping unit of the combined graphics data. To calculate the level of flood hazard is calculated by using equation (3) as follows [8]:

Flood Potential Score = (2 x LanduseScore) + (1 x Height Score) + (1 x Drainage Density Score) + (3 x Slope Score) + (2 x Land Type Score) + (3 x Rainfall Score*) ...(3)*

3.3.2. Vulnerability

Vulnerability in this research used population's vulnerability to flood hazard by analyzing the parameter of age, education and population density with data obtained from Central Statistical Bureau of Denpasar City. Age level was calculated by grouping age level into two groups namely productive (15-64 y.o) and unproductive (0-14 y.o and >64 y.o). Level of education was calculated by dividing the population by their highest level of education, ie not attending school, finishing elementary school, finishing middle school, finishing high school, finishing vocational school, finishing university degree, meanwhile population density was calculated by dividing number of population by the area of the settlements [11].

Each indicator will be scored to create vulnerability level to each parameter then summed up to resulting a total score. Vulnerability in this research was calculated per settlements at village boundary level. And the analysis was conducted per Village.

The vulnerability class was divided into 5 classes. The vulnerability class calculation was performed by dividing the value of each parameter into equal class interval calculated according to equation (3) [11] then summed up each class of each parameter to create total vulnerable value. The division of vulnerability into was divided into5 classes that resulted in 5 classes of vulnerability, namely very high vulnerability, high vulnerability, medium vulnerability, low vulnerability and very low vulnerability.

3.3.3. Coping Capacity

The coping capacity in this research used the availability of development budget for each village to conduct disaster mitigation until post-disaster reconstruction and rehabilitation. The number of budget was then divided into equal class interval calculated according to equation (3) [11]. The division of coping capacity into 5 classes resulted in 5 classes, namely very high coping capacity, high coping capacity, medium coping capacity, low coping capacity and very low coping capacity.

3.3.4. Risk Analysis

Risk analysis was calculated by using equation (1) [8]. The division of risk was divided into 5 classes that resulted in 5 classes of risk, namely very high risk, high risk, medium risk, low risk and very low risk.Number of population at risk within a village is calculated with assumption that the

population in a village was distributed evenly within village settlements using equation (4). This equation used mainly if there was more than one risk class within one village.

$$Population = \frac{Settlement\ Area}{Total\ settlement\ area} x\ total\ village\ population \ldots (4)$$

4. Result and Discussion

4.1. Flood Hazard

The area of flood hazard in Denpasar City was divided into three classes, medium hazard, high hazard and very high hazard. Denpasar City that has medium flood hazard is the area of South Denpasar and East Denpasar Sub-district, with a total area of 251.73 ha (2.09%). Based on the calculation of the total score, it can be predicted the dominant parameter that causes this area which has medium level of hazard is slope of 0% to 3% until 3%-8% with relatively flat to undulating topography. In addition, the dominant landuse is irrigated rice fields. In some areas of the water will be difficult to flow so that in some areas there will likely be inundated.

The area of Denpasar City which has high level of hazard is found in a small part of North Denpasar, West Denpasar and most of East Denpasar and South Denpasar, with total area of 4686.70 ha (38.91%). Based on the results of the calculation that cause this region has a high level of vulnerability is the average annual rainfall is quite high reaches 1982 mm. Land use is dominated by settlements and building with low to medium density. Due to the lack of natural land cover, when the condition of excess water then itcannot be absorbed by the soil.

The area of Denpasar City that has very high hazard is found in a small part of East Denpasar, partly in West Denpasar and mostly in South Denpasar, with total area of 7107,08 ha (59%). Based on the calculation of the total score, it can be predicted that the dominant parameter that cause very high hazard is the use of land dominated by settlements and building which is intended for housing, offices, trade and housing with high density. Landuse affects the amount of rainfall runoff that has exceeded the infiltration rate, resulting in the occurrence of inundation and runoff in areas that are mostly covered by buildings. The minimal natural land cover that exists in this region indicates the absence of a source of infiltration which can lead to inundation.

Denpasar City area consisting of 43 villages have varying physical conditions between villages with each other. This causes each region to have a different distribution of flood hazard. Flood hazard that occurred in Denpasar City starts from the low to very high level. Areas with low to moderate flood hazard spread over most of Peguyangan Kaja area with an area of 97.45 (33.48%) ha of total area. The village that has the widest area with high flood hazard is PemoganVillage with an area of 344.84 ha (35.76%) of the total area. While the village that has the most widespread areas with very high flood hazard is Sesetan with an area of 479.71 ha (91.1%) of the total area. Overall flood spreads with high levels of hazard are located in almost every village but with varying percentages based on the area of each village.

The secondary data of flood events of 2013-2015 floods are still frequent and spread at some point location in Denpasar City such as Padang Sambian Village, Panjer Village, Penatih Village, Pemecutan Kelod Village and Sambian Kaja Village [12,13]. There are 12 points of flood-prone locations, where 10 points are included at the result of this research. The research results are at very high flood hazard (83.3%) and the other 2 points are at high hazard (16.6%). From the data, it can be concluded that the existing research results are appropriate and can represent the conditions that occur in the field.

Seeing the occurrence of floods are still common in Denpasar City, the mitigation efforts that can be done by the government are: improving drainage channels, inviting the community to participate in maintaining environmental hygiene by not littering in the river or in other drainage channels, and making absorption wells in each house to reduce the inundation in the presence Excess water conditions. The results of the flood hazard analysis are presented in Table 2. Flood hazard spread throughout the city of Denpasar with different levels of hazard due to the physical condition of each area. Flood hazard map can be seen in Figure 1.

Table 2. Flood Hazard Class

No	Hazard Class	Area (Ha)	Percentage (%)
1	Medium	251,73	2,089
2	High	4686,70	38,91
3	Very High	7107,08	59,00

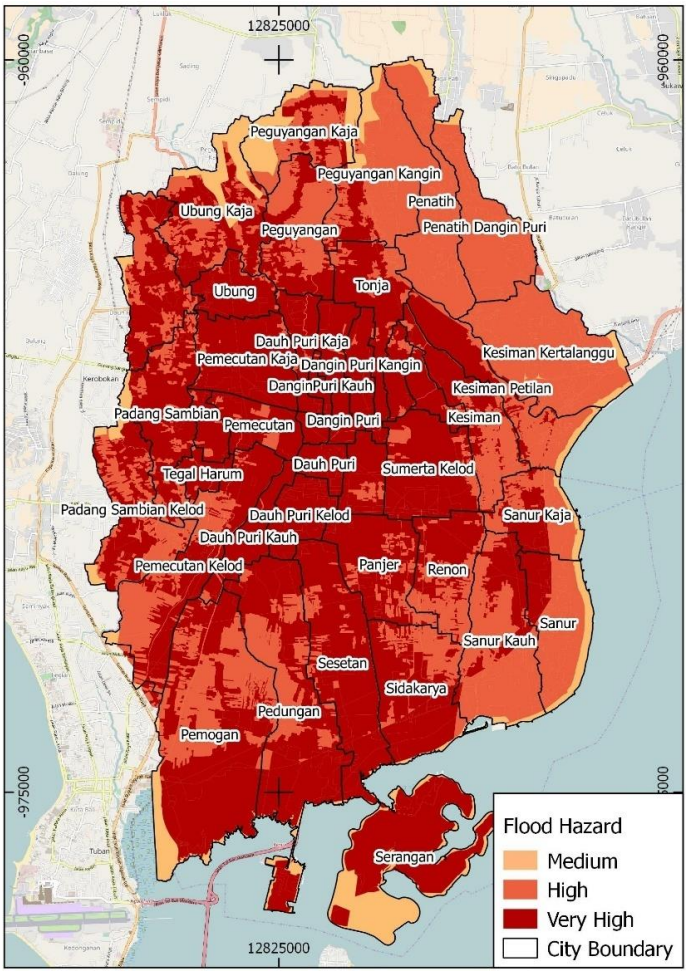

Figure 1. Flood Hazard Map.

4.2. Vulnerability

Vulnerability of population which expose to flood hazard is calculated by using age level, level of education and population density as parameter to create vulnerability class. The vulnerability of population in Denpasar city can be divided into four classes, namely very low, low, medium and high vulnerability. High vulnerability is located at high population density with low education and high

unproductive age. High vulnerability with total of 19091 population located in Kelurahan Kesiman and Ubung Village. Medium vulnerability in total of 241303 population located in 19 villages in 4 Sub-district, i.e. South Denpasar, East Denpasar, North Denpasar and West Denpasar. Meanwhile, total 229043 of population are included in low vulnerability class which located in 11 villages over 3 Sub-districts, South Denpasar, North Denpasar and West Denpasar. Very low vulnerability are people located in 6 Villages over 3 Sub-districts, South Denpasar, North Denpasar and West Denpasar with total population reached 81851 people.

High vulnerability only happens on two villages of East Denpasar and North Denpasar, which is Kesiman and Ubung Village. Meanwhile medium vulnerability mainly distributed in East Denpasar Sub-district with 10 villages, meanwhile north Denpasar and West Denpasar only have 3 villages and 5 villages that categorized as medium vulnerability. Low vulnerability are distributed in South Denpasar, North Denpasar and West Denpasar sub-district with 5 villages and 6 villages each. Very low vulnerability is distributed mostly in South Denpasar with 3 villages, meanwhile North Denpasar and West Denpasar sub-district only have 2 villages and a village that categorized as very low vulnerability. Table 3 list the number of population who is vulnerable to flood hazard. Figure 2 (a) shows the vulnerability map to flood hazard in Denpasar City.

Table 3. Vulnerabilty to Flood Hazard

No	Sub-district	Village	Vulnerability	Population[1]
1	East Denpasar	Kesiman	High	9999
	North Denpasar	Ubung		9029
2	South Denpasar	Pemogan (1)	Medium	22811
	East Denpasar	Sumerta Kelod, Sumerta Kaja, DanginP uri, Kesiman Petilan, Dangin Puri Kangin, Dangin Puri Kelod, Sumerta, Sumerta Kauh, Kesiman Kertalangu, Penatih (10)		84514
	North Denpasar	Tonja, Dangin Puri Kaja, Pemecutan Kaja (3)		56931
	West Denpasar	Tegal Kertha, Dauh Puri, Dauh Puri Kelod, Dauh Puri Kauh, Pemecutan (5)		77047
3	South Denpasar	Sidakarya, Renon, Sanur Kaja, Panjer, Pedungan (5)	Low	65501
	North Denpasar	Dauh Puri Kaja, Ubung Kaja, Peguyangan Kangin, Penatih Dangin Puri, Dangin Puri Kauh (5)		66094
	West Denpasar	Dauh Puri Kangin, Dauh Puri Kauh, Padangsambian, Tegal Harum, Pemecutan Kelod, Padangsambian Kaja (6)		97448
4	South Denpasar	Sanur, Sanur Kauh, Sesetan (3)	Very Low	43062
	North Denpasar	Peguyangan, Peguyangan Kaja (2)		18624
	West Denpasar	Padangsambian Kelod (1)		20165

[1]population data was taken from center statistical bureau of Denpasar City [10]

4.3. Coping Capacity

The coping capacity for each village in Denpasar city was calculated by using the number of Village development budget which allocated for development. This budget will affect the preparation for each village if flood is coming. The availability of budget for development itself is different for each village, ranging from IDR 304,900,000.00 (USD 22,886) until IDR 9,627,400,000.00 (USD 722,663) [8]. From 43 villages, villages with the highest budget are Kesiman, Ubung Kaja,Sumerta Kaja, Padang Sambian Kelod, Kesiman Kertalangu, Sesetan, Pedungan, Dauh Puri Kaja, Penatih, Peguyangan Kangin, Pemogan and Sidakarya with total budget of more than one billion rupiah or

more than 75,000 US Dollars. The highest budget that included in very high capacity is the budget from Peguyangan Kangin, Pemogan and Sidakarya Village, meanwhile the very low capacity which indicate villages with low budget for development purpose are Dangin Puri Kangin, Dangin Puri Kauh, Padangsambian, Dauh Puri Kauh, Dauh Puri, DanginPuriKaja, Penatih Dangin Puri, Tegal Harum, Panjer, and Renon.Figure 2 (b) shows the capacity for each village in Denpasar City.

4.4. Flood Risk

Flood risk analysis in this research was done by using the variable of flood hazard, population vulnerability and institutional coping capacity which was the amount of Village's budget for development purpose. Flood risk in Denpasar city was divided into five classes, very low risk, low risk, medium risk, high risk and very high risk. Very high risk areas are located in 4 villages, Dangin Puri Kangin, Dangin Puri Kaja, Dauh Puri and Dauh Puri Kauh. Total population was at risk at 50981 people or 8.43% from total population in Denpasar City with total area of 252.81 ha or occupied 5.19% of total settlements in Denpasar City. The population which risk to flood is very high is located in the middle of Denpasar City where very high hazard are located. Vulnerability in this area is medium to low with medium to low capacity as well. This indicates that the high risk is resulted by the high flood hazard but with medium to low coping capacity.

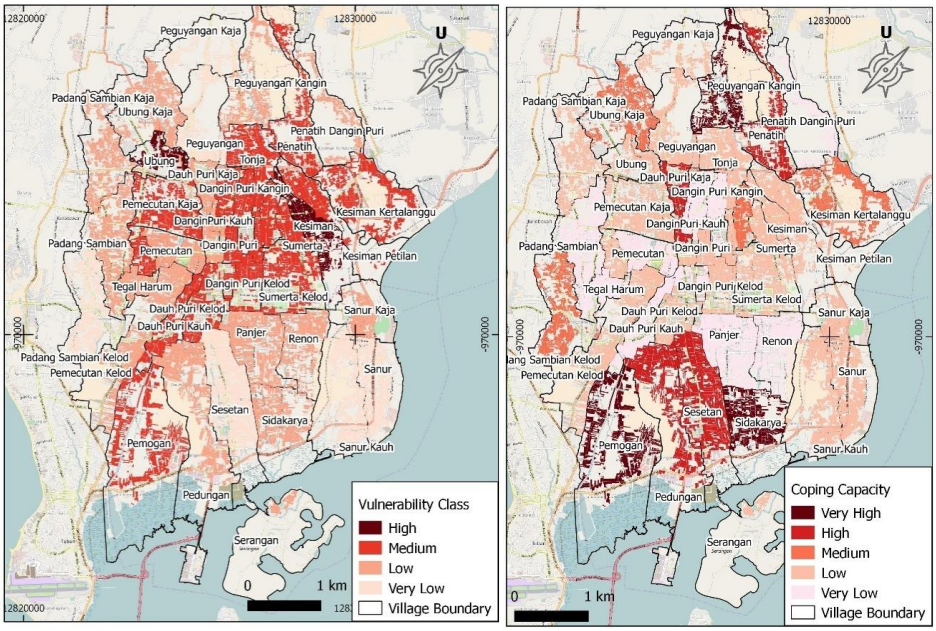

Figure 2. (a) Vulnerability Map and (b) Coping Capacity Map to Flood of Denpasar City

High flood risk areas are located in Kesiman, Ubung, Renon, Dangin Puri Kauh, Padangsambian, Panjer and Tegal Harum Village. Total population was at risk reached 202478 people or 13.16% of total population. The total area is 780.7 ha or 16.02% from total settlement in Denpasar city. The population with high flood risk located in the middle to south area of Denpasar city. The hazard in that areas are high to very high with medium to low vulnerability and very high to low coping capacity which indicates the role of hazard in building the risk value in that villages.

Medium flood risk located in 12 villages, Kesiman Village, Renon, Padangsambian, Panjer, Penatih Dangin Puri, Sumerta Kelod, Dangin Puri, Kesiman Petilan, Tonja, Dangin Puri Kelod, Sumerta, Sumerta Kauh, Tegal Kertha, Pemecutan Kaja, Dauh Puri Kelod, and Pemecutan Village. The number of population at risk is quite high, reached 202478 people or 33.51% of total population. Medium risk occupied 22.95% of total settlements which reached 1118.18 ha of total settlements in Denpasar city. Population who has medium flood risk is one of most common risk classes in Denpasar

city which occupied the center of the city area. The hazard in this area is high to very high but with medium to low vulnerability and medium to very low coping capacity.

Low flood risk is located in 10 villages in Denpasar City, namely Serangan village, Sanur Kaja, Dauh Puri Kangin, Pemecutan Kelod, Padangsambian Kaja, Sumerta Kelod, Sumerta Kaja, Kesiman Petilan, Tonja and Kesiman Kertalangu Village. The total number of population at risk reached 79435 people or 13.14% of total population with area of low flood risk is 716.89 ha or 14.71% of total settlements in Denpasar City. Population with low risk to flood is spatially distributed on the side of Denpasar City. The hazard in the area are mainly medium to high hazard with medium to very low vulnerability ad high to very low coping capacity.

Very low flood risk with total population at risk reached 19184 people or 31.74% of total population and occupied 2003.54 areas or 41.12% of total areas of settlements. Very low flood risk has the highest percentage of population at risk along with medium risk. Population with very low flood risk spatially distributed on the north side and south side of Denpasar City with high to very high hazard. The very low flood risk is result from the high coping capacity and low vulnerability which caused the risk value decreasing. Table 4 listed the flood risk class in Denpasar City

The physical condition of Denpasar City makes Denpasar has flood hazard and maximum the population is exposed to risk. Spatial distribution of very high to medium risk generally located in the center of Denpasar city. Figure 3 shows the flood risk map of Denpasar City.

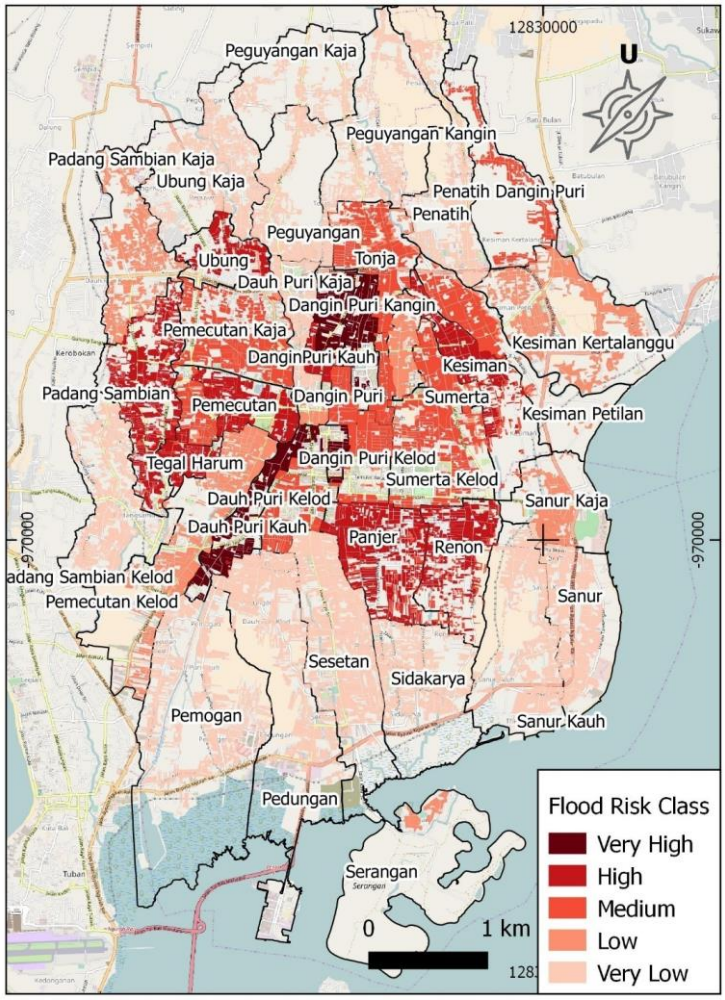

Figure 3. Flood Risk of Denpasar City

Table 4. Flood Risk in Denpasar City

Village	Settlement Area (Ha)	Population at Risk	Village	Settlement Area (Ha)	Population at Risk
Very Low Risk:			**Medium Risk (continuation):**		
Sidakarya	144.93	13590	Padangsambian	20.76	2148
Dauh Puri Kaja	68.72	18830	Panjer	23.57	2325
Pedungan	206.69	13086	Penatih Dangin Puri	72.68	5608
Ubung Kaja	157.45	24053	Sumerta Kelod	144.85	11063
Peguyangan Kangin	129.02	9951	Dangin Puri	36.71	7078
Penatih	132.66	7642	Kesiman Petilan	83.13	6508
Pemogan	218.52	22811	Tonja	127.71	13080
Sanur	146.33	9401	Dangin Puri Kelod	65.61	5843
Sanur Kauh	168.03	7724	Sumerta	56.11	7740
Peguyangan	124.18	12828	Sumerta Kauh	37.52	6932
Sesetan	270.59	25937	Tegal Kertha	50.72	15615
Padangsambian Kelod	161.83	20165	Pemecutan Kaja	164.74	29084
Peguyangan Kaja	74.59	5796	Dauh Puri Kelod	88.32	15049
Total	***2003.54***	***191814***	Pemecutan	96.25	18308
	(41.12%)	***(31.74%)***	**Total**	***1118.18***	***202478***
				(22.95%)	***(33.51%)***
Low Risk:					
Serangan	17.63	3783	**High Risk:**		
Sanur Kaja	67.88	8053	Kesiman	100.65	8218
Dauh Puri Kangin	16.69	4425	Ubung	52.71	9092
Pemecutan Kelod	193.84	27481	Renon	105.59	8450
Padangsambian Kaja	145.36	12125	DanginPuriKauh	23.38	7652
Sumerta Kelod	8.19	625	Padangsambian	170.68	17651
Sumerta Kaja	58.06	7496	Panjer	180.27	17781
Kesiman Petilan	13.15	1030	TegalHarum	147.42	10704
Tonja	18.23	1868	**Total**	***780.7***	***79548***
Kesiman Kertalangu	177.86	12549		***(16.02%)***	***(13.16%)***
Total	***716.89***	***79435***	**Very High Risk:**		
	(14.71%)	***(13.14%)***	Dangin Puri Kangin	59.72	10007
Medium Risk:			Dangin Puri Kaja	68.46	12899
Kesiman	21.81		Dauh Puri	35.26	10743
Renon	27.69	1781	Dauh Puri Kauh	89.37	17332
		2216	**Total**	***252.81***	***50981***
				(5.19%)	***(8.43%)***

[1]population data was taken from Center Statistical Bureau of Denpasar City [10]

5. Conclusions

Flood hazard in Denpasar is divided into three classes of hazard, medium hazard over an area of 251.7 ha (2.11%), high hazard of 4686.7 ha (38.9%) and very high hazard of 7107.1 ha (59%).Low to moderate hazard spatially distributed in North Denpasar Sub-district, high hazard distributed in most

areas of East Denpasar Sub-district and very high hazard distributed in most areas of West Denpasar and South Denpasar Sub-district.

The vulnerability of population in Denpasar city can be divided into four classes, very low, low, medium and high vulnerability. High vulnerability with total of 19091 population located in Kelurahan Kesiman and Ubung Village. Medium vulnerability in total of 241303 population located in 19 villages, meanwhile total 229043 of population are included in low vulnerability class which located in 11 villages over 3 Sub-districts, South Denpasar, North Denpasar and West Denpasar. Very low vulnerability located in 6 Villages over 3 Sub-districts, South Denpasar, North Denpasar and West Denpasar with total population reached 81851 people.

The availability of budget for development isused as parameter for coping capacity. The availability of budget itself is different for each village, ranging from IDR 304,900,000.00 (USD 22,886) until IDR 9,627,400,000.00 (USD 722,663). Villages with the highest budget are Kesiman, Ubung Kaja, Sumerta Kaja, Padang Sambian Kelod, KesimanKertalangu, Sesetan, Pedungan, Dauh Puri Kaja, Penatih, Peguyangan Kangin, Pemogan and Sidakarya.

Flood risk in Denpasar city was divided into five classes, very low risk, low risk, medium risk, high risk and very high risk.Total population with very high risk reached 202478 people or 13.16% of total population. The total area is 780.7 ha or 16.02% from total settlement in Denpasar city.Total population with high risk reached 202478 people or 13.16% of total population. The total area is 780.7 ha or 16.02% from total settlement in Denpasar city.The number of population with medium risk reached 202478 people or 33.51% of total population which occupied 22.95% of total settlements or 1118.18 ha. The total number of population with low risk reached 79435 people or 13.14% of total population with area of low flood risk is 716.89 ha or 14.71% of total settlements in Denpasar City. Very low flood risk with total population at risk reached 19184 people or 31.74% of total population and occupied 2003.54 areas or 41.12% of total areas of settlements.

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