EVALUATION OF NEW YOGYAKARTA INTERNATIONAL AIRPORT (NYIA) IN TEMON DISTRICT BASED ON TSUNAMI DISASTER RISK USING GEOGRAPHIC INFORMATION SYSTEM (GIS)

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ABSTRACT

Yogyakarta is a province that has an appeal to be visited by the domestic and foreign visitors. Two important factors that cause people to go to Yogyakarta are many tourism places and good educational institutions. Because of the increase in the number of passengers and the bustle of activity in Adisucipto airport (previous Airport), in 2012 the central and local government of Special Propince of Yogyakarta unveiled a new airport, which it is now still in progress and targeted to be completed in 2019. The election of new airport site is very close to the subduction zone of Eurasia and Indo-Australia plates where it frequently occures earthquakes and high probability of tsunami. In this study, to predict the risk level of the tsunami, we use the Crunc model, which the multiplication of the hazard to the vulnerability and subsequently modeled by Geographic Information System (GIS). Based on the simulation of tsunami wave height of 15 meters. There are 690.73 Ha (18.78%) of Temon Distrcit area which are medium risk while 210.239 Ha (5.71) of Temon District area with high risk. In addition, low risk in NYIA area is about 14.38 Ha (2.54%) and medium risk in NYIA area is near 440.84 Ha (77.88%). The area which has high risk in the NYIA area is about 110.81 Ha (19.57%).

Keywords: Evaluation, Tsunami Disaster Risk, GIS

INTRODUCTION

International airport plays important thing in Yogyakarta Special Propince because of economy, population growth, many tourism places and good education factors. Yogyakarta is densely populated propince with 3.679.179 population number and 1.9% population growth per year (BPS, 2015). In addition, historically, Yogyakarta is a propince which has many educational institutions offering good education and learning for societies. Mentioned as Student City by Indonesian people, Yogyakarta serves certain levels of education and mostly popular universities located in Yogyakarta (10 state universities, 106 private universities) with more than 180 thousands students and one of universities, Gadjah Mada University is the oldest and the best university in Indonesia (BPS, 2015). Located in several kinds of landform, there are unique and beautiful natural penomen^{2}a which make 4.056.916 visitors interested to visit

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those places (BPS, 2015). Yogyakarta becomes the second place in Indonesia which is the most visited by foreign people around the world to spend their holiday after Bali Island.

There are eight tourist destinations ranging from the beaches, cave tours, cultural tours, sightseeing crafts, museum tours, religious tourism, MICE (Meeting, Incentifes, Conferencing and Exhibitions) and tourism village (Mardiatno, et al, 2016). Moreover, there are two important heritges, Borobudur and Prambanan Temple which many travellers are interested to visit as well. Since a programme of ASEAN, ASEAN Open Sky was opened in 2015, it results a growth of the number of visitors and arrival flight in Indonesia especially in Adisucipto International Airport of Yogyakarta Special Propince (Saputra and Sardjito, 2016).

Unfortunately,Adisucipto International Airport which serves departures and arrivals the passangers of domestic and foreign flights experiences alot of flaws and problems. Some weakneses are the limited runway (2.200 m), there is no paralel taxiway, apron cannot accomodate airbus, and an increase of passangers every year (Petrak and Karl Peter, 2009). Whereas, it contributes to serve *Joglosemar Area* (radius Jogja, Solo, and Semarang City), which means Yogyakarta towards to three areas is served by Adisucipto International Airport. It is also included as a military airport that surely makes crowded. 5.198.082 passengers, 23.171 arrival flights and 40 timess of flight per day (BPS, 2015) really indicate that this is the third busiest airport in java after Soekarno hatta (Jakarta) and Juanda (Surabaya) airport. The impacts of this problem are the passengers should make a line for long time and sometimes get trouble in schedule of flights so that this condition is not comfortable and ineffective.

Master Plan of New Yogyakarta International Airport had been unveiled on 7 of August 2012 specified as publlic international airport caused by limitation of Adisucipto International Airport facilities. There are some criterion to determine this airport such as land geometry for runway orientation, sufficient land for long runway, suitable topography, ability to avoid critical obstacles, located outside volcanic zone, minimal relocation of residents, compliance with propincial law, catchment area and no current mining lease constracts. Based on those factors, in 2013, Indonesia Government (Menteri Perhubungan) decided KP 1164 2013 that the location of New Yogyakarta International Airport is located in Temon District, Kulonprogo Regency, Yogyakarta (Mardiatno, et al, 2016). In specific, this place is suitable because it is placed in Temon District with 0-25 cm ASL (low land), dencity 920 persons/km^2, available main road, train way, bareland and also near by Yogyakarta City.

Negative side, geologically, New Yogyakarta International Airport in Temon Distrct is a disaster prone area. It is located near the Indian-Australian Plate which moves northward and Eurasia Continental Plate which moves to the south (Taufiq, 2016). Moreover, it lies in coastline and approximately 200 m of the length from the airport to the Indian Ocean which it potentially contributes to tsunami disaster. Tsunami is huge sea waves caused by earthquakes in the seabed (Santius, 2015). Indonesia, started from 1996-2015 has five tsunami

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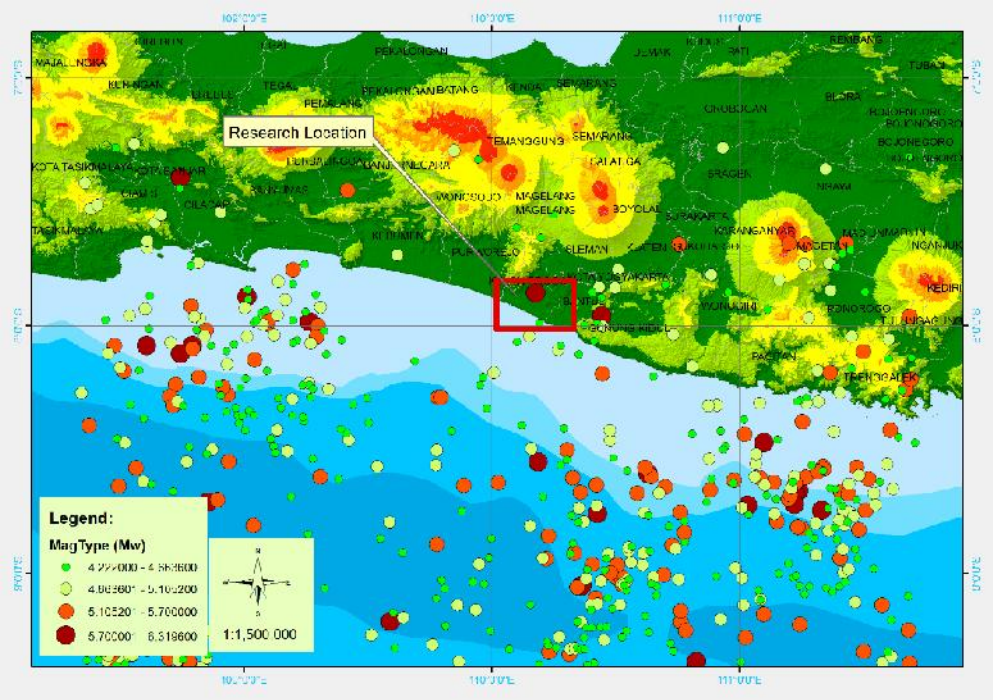
occurances with total deaths 167.044 and it is the most vulnerable country among countries around the world (UNISDR, 2016). According to USGS (2017) earthquake data, there are approximately 582 occurances of earthquake which have ensued surrounding research area in the period 1973-2017. In additions, the highest magnitude of these events is about 6.3 Mw with average 4.9 Mw, which means that magnitude is able to demage buildings of good design and contruction, monuments, walls, heavy furniture overtuned, buildings shifted off fondations, and break chimneys or factory stacts. A map below clearly shows the distribution of earthquake occurances. Related to the number and distance from research area, it is significant potency of tsunami disaster.



Source: USGS

Figure 1 history of earthquake occurances

Recent studies, development of airports in Indonesia mostly in the hazardous areas, which one of the airports is New Yogyakarta International Airport (NYIA). It is caused by safe locations are already built for settlements, buildigs and public infrastructures so that consequently, goverment places airport site is in the prone area. Yohandarwati, (2015), Bhagaskoro, (2016) mentions that there is 60 airports built in the hazardous locatioions (2012). Mardianto et al (2016) conducted a research about multihazard analysis in Temon District which this research results each landform has certain character and correlation with one or more than one hazard. Tsunami, storm surges, and hurricane are main hazard in fluvio-marine landform while earthquakes can occure in fluvio marine and fluvial landform. Widyawati (2013) reported that with scenario 5 meters of tsunami innundation, some villages of Temon District effected by tsunami innundation on the three classes of vulnerability which

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Glagah is very vulnerable, Temon Kulon is vulnerable, and Temon Wetan is less vulnerable. Based on the disaster hazard and vulnerability information, earthquake and tsunami are two disasters which effect to the element at risk in Temon District in particular all buildings in New Yogyakarta International Airport but researches related to the risk of tsunami disaster has not discussed yet by expertise.

Our research aims to know the level of tsunami disaster risk By using Geographical Information System (GIS). We identify the level of tsunami hazard, vulnerability of various exposed elemen of Temon District areas, assess the level of tsunnami risk on New Yogyakarta International Airport, recommend the disaster mitigation strategies such as evacuation routes based on spatial planning. This evaluation based on tsunami disaster risk will benefit to the decision

METHODOLOGY/MATERIALS

Geographical Setting

Temon District is a region in Kulon Progo Regency, Yogyakarta Special Propince (DIY) located at the coordinates 7º 51’ 16,8’’- 7º 55’ 16,2’’South latitude, and between 109 59’49,8’’ - 110 7’ 9,6’’(Fig. 2). It is 6.19% (3.629 Ha) of distribution of total area in Kulonprogo Regency which has 15 villages. Generally, the topographic condition in this regency is between 0 m to > 1000 m above sea level where shouthern region is lowland area with the elevation up to 100 meters above sea level. It is also located in the southern coastal area of Kulonprgo Regency which is potentially vulnerable to tsunami disater. It is triggered by geographical position which directly opposite to the Indian Ocean and the meetiing place of two tectonic plates, Eurasian plate and the Indo-Australia plate.

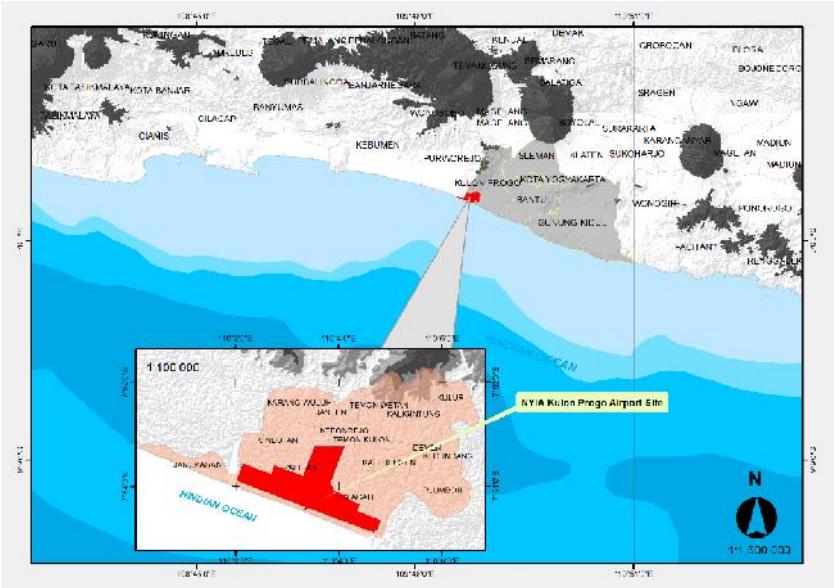

Fig. 2 Research Site

New Yogyakarta International Airport (NYIA) Profiles

New Yogyakarta International Airport (NYIA) as shown on the fig. 2, is lied on Temon District which is an area on the western of Yogyakarta Special Propince region. Site selection of NYIA location was based on some evaluation categories such as regional development, land availability, operational suitability, socio-economic and culture, natural environment, airport access, technical aspect and comparative financial assessment. Firstly, there were seven alternative areas which are suitable for international airport development but the location in Temon District is the best site. Related to Masterplan of NYIA, it is located about 30 km from Yogyakarta City having 4.400m runway (international standard with 3.600m main runway and 900 additional runway). The total area of this airport is 350 Ha which will be equipped by 7 taxiways with 4 interconnect taxiway and there some facilities to support services such as terminal building, commercial building, technical building with Air Traffic Control (ATC) technology. To build this airport, DIY government will spend approximately US$ 500 million. In 2012 PT Angkasa Pura as an investor and Local Government of DIY had Memorandum of Understanding (MoU) to build NYIA which serves 30 millions passangers per year (Kaunand S and Hidayat A. S, 2011).

The Framework of Tsunami Disaster Risk Assessment and Data Requirements

In this research, the assessment of tsunami disaster risk is using Crunch Model. This model states that a disaster happens oly when a hazard affects vulnerable people or a disaster happens when there elements come together (OXFAM, 2012). It means that the multiplication of the hazard to the vulnerability in the research area will result disaster risk for example tsunami disaster risk. The fungtion of this assessment is to know and evaluate that the location of NYIA is located in the level high, middle, or medium risk and then, finally we give some suggestions how to conduct disaster risk management programmes such as mitigation and preparedness actions. Disaster Risk Management (DRM) is defined as the systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters (Westen) Santius (2015), to analyse tsunami disaster risk, there are three steps must be done respectly namely tsunami hazard analysis, vulnerability analysis, and tsunami risk analysis.

Tsunami Hazard Analysis

Tsunami hazard assessment aims at assessing the geographical extent of the tsunami affected area, the intencity of tsunami impact and the probability of the occurance (Strunz et al., 2011, Taufiq, 2016). In this step, we modeled Tsunami hazard analysis. At this stage the modelling of tsunami high decreases as it reaches the mainland using scenarios of high tsunami variation on the shoreline which then it can be determined the area of inundation. The modelling of tsunami hazard that impacted the study area was taken from a result of BNPB

hazard analysis and then it was followed by giving innundation scenario 5m, 10m, and 15m. In this scenario, tsunami inundation height (run up) 5m is a high hazard which refers to BMG survey (Widyawati, 2013). The reason is that The BMG survey reported 4-6 meters are the range of run-up height of Yogyakarta coast area.

We determined 2km as length from the coasline to the coastal area in order to identify NYIA airport site related to tsunami hazard. The level of hazard zones is classified into three types: 1) high, 2) medium, and 3) low. Three hazard zones are shown in the table 1.

Table 1. Level of Hazard Zone

No	Zone	Information
1	High	High level of hazard
2	Medium	Moderate level of hazard
3	Low	Low level of hazard

Vulnerability Analysis

The assessment of the level of vulnerability combined phisical characteristics and socioeconomic conitions in order to develop a composite index of vulnerability (Putra, 2015). Nathan J. Wood & James W. Good (2004) also defined that vulnerability assessment is the evaluation of the exposure of the human-built environment, business enterprises, community social structure and services, and natural resources to various natural hazards, factoring in the preparedness of a community and its ability to respond to and recover from a disaster event. In this research we focused on two vulnerability tyipes; physical and social aspects which their variable and sources used are explained in the table 2.

Table 2. Details of Physical and Social Criterion Value

Nature	Variable	Source
Physical aspect	Topographic elevation	DEM Terrasar with 9m (2009)
	Landuse	SPOT (2015)
	Distance from the coastline	DEM Terrasar with 9m (2009)
Social aspect	Total population	BPS (2016)
	Density	Google Earth imagery (2017)
	Workers and passengers in the airport	Kementerian Perhubungan Republik Indonesia (2017)

Based on vulnerability assessment standard, it is needed to give scores in every variable which is valuable to place how they contribute to vulnerability (Hizbaron, Rahmat, Setyaningrum, & Melawani, 2015). This study was focused on two vulnerability types; physical and social aspects. To evaluate these, we

determined social vulnerability (total population and density which is the highest value (0,25 and 0,75) because logically the most important element ar risk of disasters is human. Meanwhile, Physical vulnerability variable such as topography, landcover, coasline distance and road is supporting elements at risk that are demaged by tsunami, 0.45, 0.36, 0.16, and 0.4 respectively. Then, total vulnerability is a sum of physical and social vulnerability. In Specific, index for all types of vulneraility variable is shown on the table below.

Table. 3 Vulnerability Index

Vulnerability	Types Variable	Index
Physical	Topography	0,44
	Landcover	0,14
	Coasline Distance	0,38
	Road	0,04
Social	Total Population	0,25
	Density	0,75

Tsunami Risk Analysis

The scale of tsunami disaster is combined result of the intensity of the high-energy wave triggered by the quake, local coastal topography and the density of human settlements in harm's way (UNISDR, 2016). A risk to a natural event is defined as the mathematical product between vulnerability and hazard; it refers to the expected loss from a given hazard to a given element at risk (Santius, 2015). According to Putra (2015), to obtain a tsunami disaster risk map, we should multiply between potential tsunami hazard and vulneraility, which this is a definition of Crunch Model. In this research, we created tsunami disaster risk map by overlying both of them. Calculating the tsunami risk level follows this formula:

R = H.V
R = Risk (Tsunami risk index)
H = Hazard (Tsunami innundation class)
V = Vulnerability (Tsunami vulnerability class)

Table 4. Tsunami Risk Matrix

	Low	Medium	High
High	Medium	High	High
Medium	Low	Medium	High
Low	Low	Low	Medium

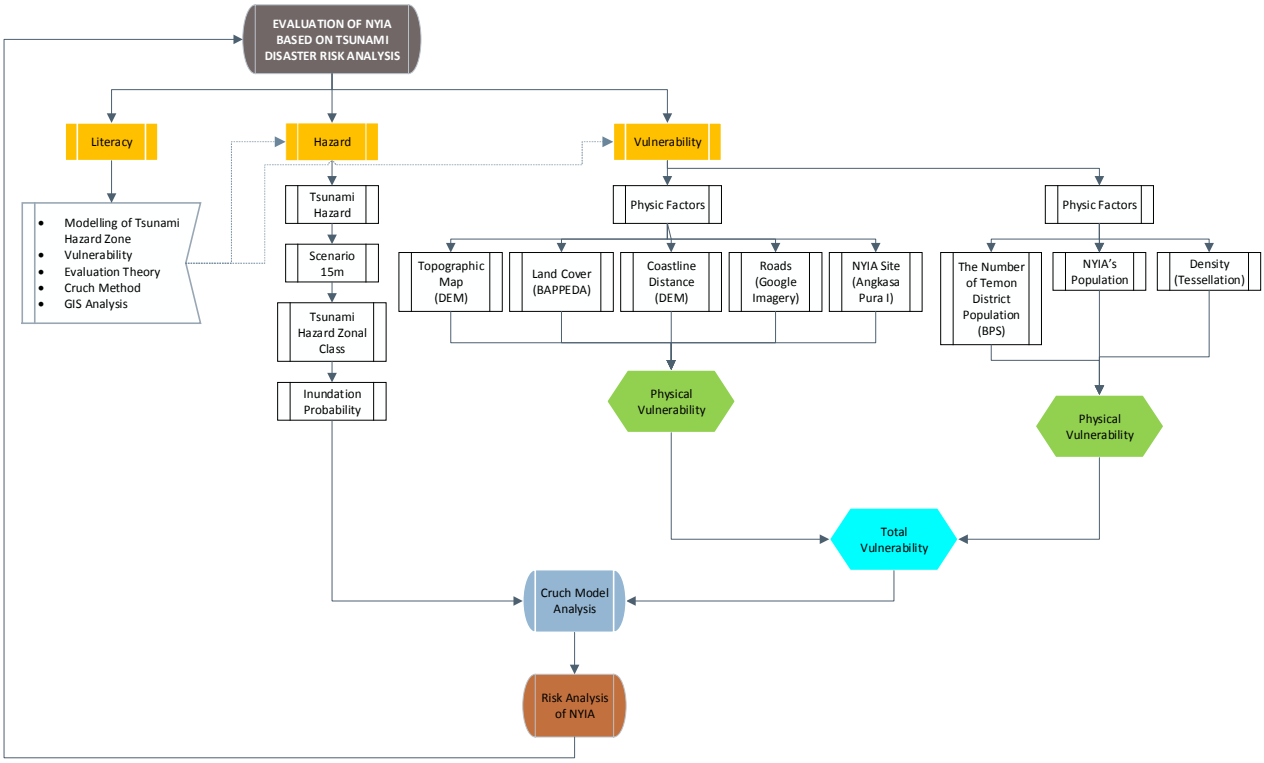

Fig. 3 Work Flow of The Research

RESULT AND D FINDINGS

Hazard Analysis

Inundation Zone Modelling with Scenario 5m, 10m, and 15m

In this scenario, tsunami modelling with height 5m which is a high hazard inundates 98.5 Ha (3.02%) of the total area of Temon District or in particular 2.84 Ha (0.48%) of the New Yogyakarta International Airport area. As shown on the fig. 3 the distribution of high hazard is in the western southeast part of NYIA site. Besides, tsunami hazard scenario with height 10m as a medium hazard inundates 349.35 Ha (10.69%) of Temon District area while about 111.58 Ha (19%) of NYIA inundated by tsunami. Then, with 15m tsunami inundation scenario, it results approximately 621,35 Ha (19.01%) of total area of Temon District and about 281.35 Ha (47.91) of NYIA area area exposured by tsunami inundation.

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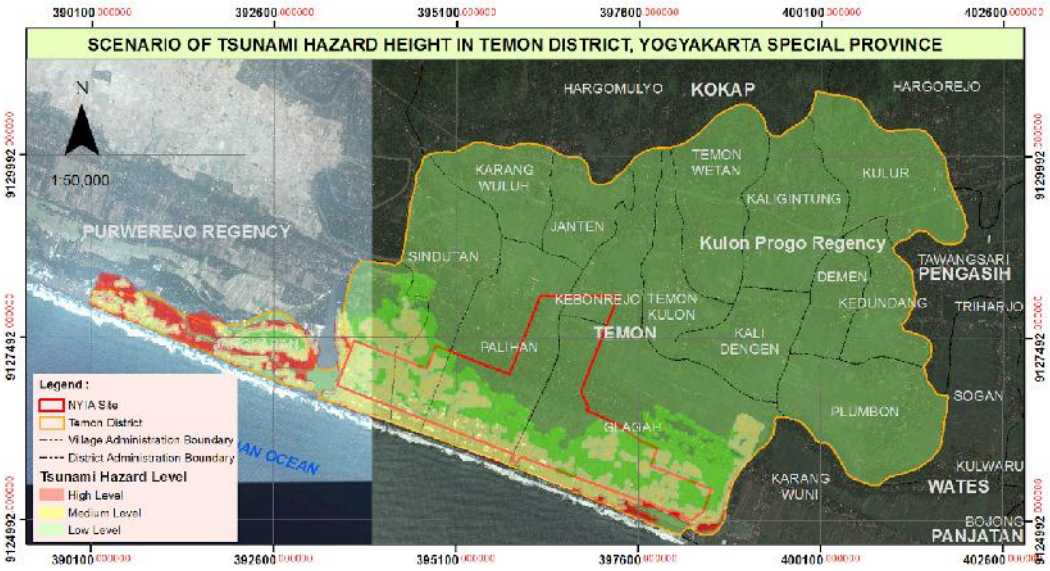

Fig. 3 Scenarion of Tsunami Hazard High in Temon District

Vulnerability Analysis

The parameters used in determining the level of vulnerability of Temon District and NYIA site against the tsunami is the topography, landcover, coastline distance, roads (physical vulnerability) and density of buildings, totall population, the number of workers and passengers in the NYIA (social vulnerability). From these parameters, it was obtained 3 classification levels of tsunami vulnerability in the Temon District and NYIA, which is low, medium, high vulnerability.

Physical and social vulnerability

In general, the medium vulnerabiity dominates the total area of Temon followed by high and low vulnerability. The area with high vulnerability in Temon District is 1.290.63 Ha or ± 35.09% of the total vulnerable areas in Palu City. Areas with medium vulnerabilitiy is 1.398.33 Ha or 38.02% of total area in Temon District while it is about 26.87% or 988.39 areas which are low vulnerable to the tsunami. Meanwhile,

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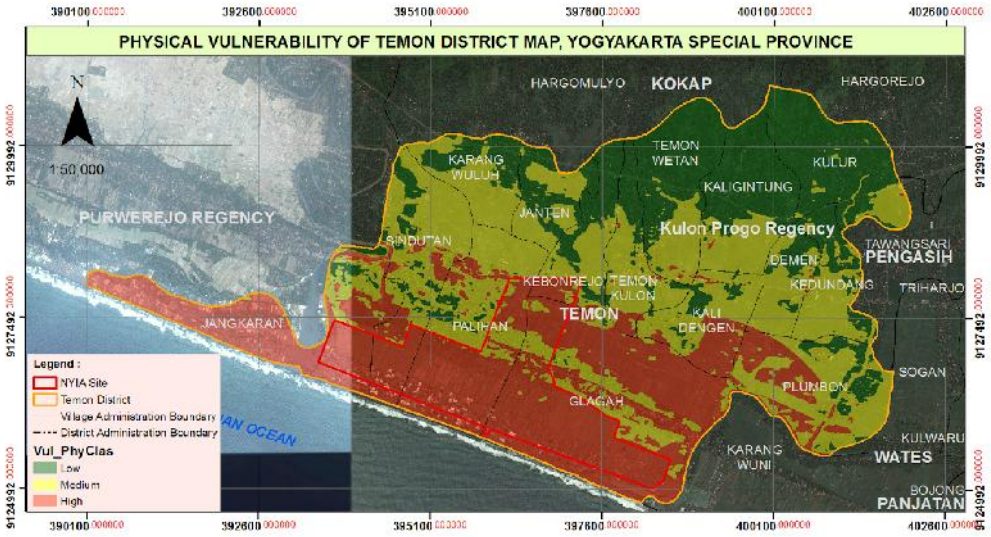

Fig. 4 The Distribution of Physical Vulnerability in Temon District

Social Vulnerability

The distribution of social vulnerability is spreaded on almost all locations in Temon District but interestingly the highest level is mostly located in the NYIA airport. In specific, there are 1.110.56 Ha or 30.05% of the total of Temon District which is high vulnerability. The area with medium vulnerability is more less 811.90 Ha or 21% of the total area in Temon District and 1.773.08 Ha or 47.97% of the total area in Temon District are locations with low vulnerability.

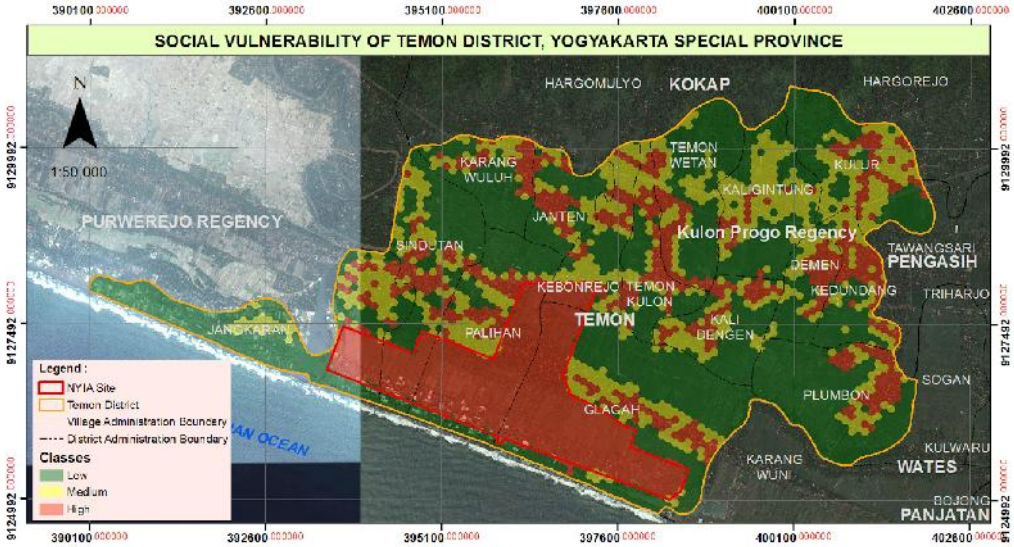

Fig. 5 The Distribution of Social Vulnerability in Temon District

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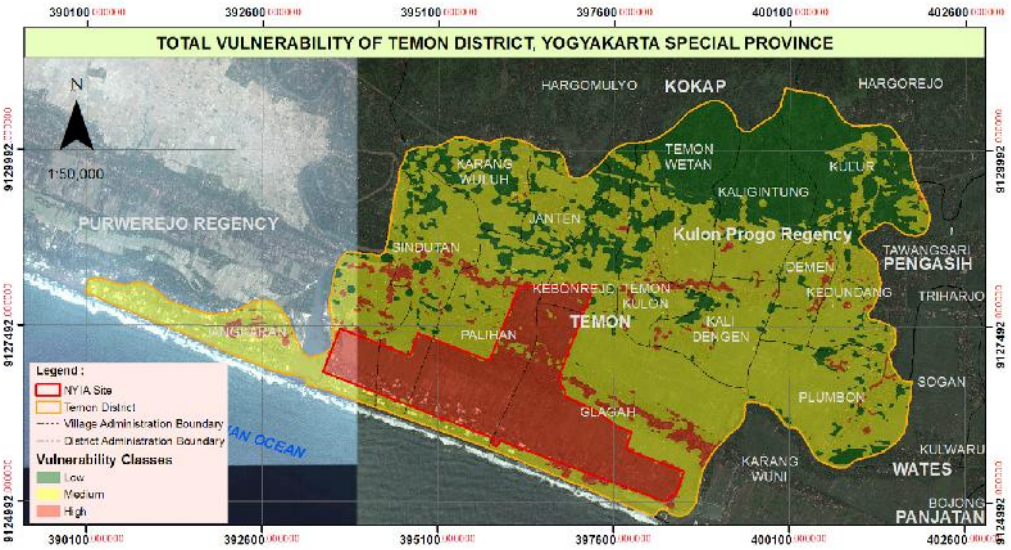
Total Vulnerability



Total vulnerability unites both physicall vulnerability and social vulnerability. Focusing on NYIA's area, there area two levels of tsunami risk which potentially occurs. Mostly all areas in the NYIA are high risk wich is about 550.90 Ha or 85% while medium risk is approximately 15% or 97,32 Ha.

Risk Analysis

Tsunami disaster risk is the result of interaction between hazard potential with vulnerability level. The area of tsunami with low risk in the Temon District is 2.776.39 Ha (75.49%) of the area. There are 690.73 Ha (18.78%) of Temon Distrcit area which are medium risk while 210.239 Ha (5.71) of Temon District area with high risk. In addition, low risk in NYIA area is about 14.38 Ha (2.54%) and medium risk in NYIA area is near 440.84 Ha (77.88%). The area which has high risk in the NYIA area is about 110.81 Ha (19.57%).

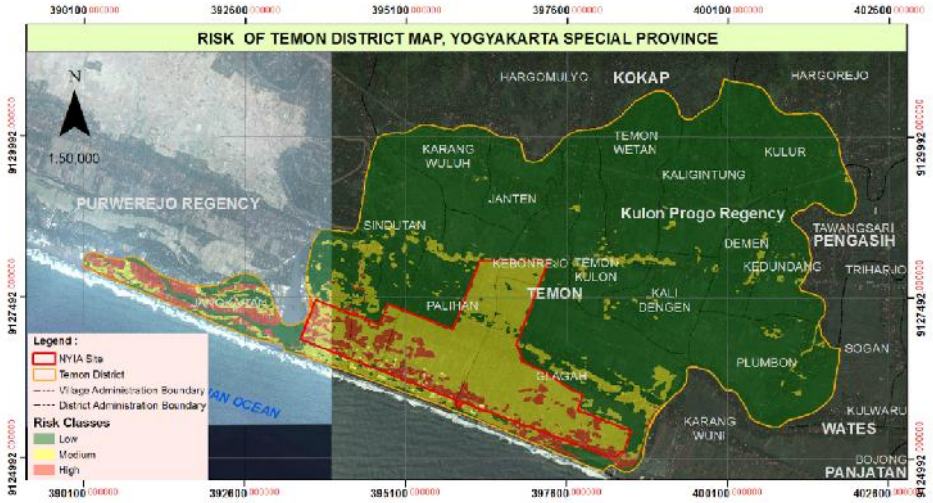


Fig. 6 The Distribution of Physical Vulnerability in Temon District

CONCLUSION

1. The low risk of tsunami disaster in New Yogyakarta International Airport is about 14,38 Ha or 2 % of its area while there are 440,84 Ha or 77,8% included medium risk and 110,81 Ha (20%) are risk area.
2. Because NYIA area is hazardous and a risk area, to reduce tsunami risk Indonesia government and developer (Angkasa Pura II) must develop mitigation system such as evacuation routes, shelters and protection area in the coastal area.

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