REMOTE SENSING TECHNOLOGY APPLICATION ON DISASTER RISK REDUCTION

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ABSTRACT: Disaster risk reduction (DRR) has long been known in the literature for mitigating the impacts of natural hazards on environmental, social and economic. Remote sensing technology is one method for achieving the DRR by spatial and temporal analysis. This research applying the remote sensing technology to observe the hazard area as a quick response DRR to achieve the environmental sustainability. The study area is in Semarang City, which has some environmental issues such as flood, land subsidence and sea level rise. A new method of remote sensing, namely, *Differential synthetic aperture radar interferometry (D-InSAR)* was applied to generate the subsidence area, a flood data from BNPB was used for mapping the flood distribution, and the field survey was conducted to observe the government and community adaptation response. By analyzing those data, the distribution of flood and land subsidence were generated. It can be used for forecasting on the early warning system as the goal of DRR.

KEYWORDS: Disaster risk reduction (DRR), land subsidence; Differential synthetic aperture radar interferometry (D-InSAR); flood; adaptation responses.

1. INTRODUCTION

Environmental development is a concept to achieve the sustainability. Environmental development has three components which are economic sustainability, social sustainability, and environmental sustainability. Sustainable development could be obtained when the present generation needs could be fulfilled without compromising the future generation needs (WCED, 1987). According to the Environmental Sustainability concept, when environmental problems are increasing, the environmental managers figure out how to reduce the damage or wastage (Sutton, 2004). Environmental sustainable is the ability to maintain the qualities that are valued in the physical environment (Sutton, 2004). One part of the environmental sustainable is Human settlements and habitats that covering cities, urbanization and transport (Moldan, et al., 2012).

One of a challenge on environmental development is how the environmental sustainability can be achieved in the hazard area for example in Semarang City in Indonesia where some environment problems are occurring (Marfai & King, 2008). Semarang city is one of the largest cities in Indonesia, located in Central Java Province with an area of approximately 373.7km^2 and a population of about 3.17 million in 2014 (Bureau, n.d.). For more than 100 years, Semarang City has experienced land subsidence which has had an impact on various aspects of the city life (Abidin, et al., 2012). For example, it has resulted in the flooding of large portions of coastal areas, damaged buildings and infrastructure, caused seawater intrusion, and also influenced human life conditions, such as health and other sanitary issues (Abidin, et al., 2012). Semarang City is also attached to flood and sea level rise problem along the coastal area.

Hyogo Framework defined that hazards are possibly ravaging physical condition, phenomenon or human activity that may affect the loss of life or injury, property loss, social and economic disturbance or environmental degradation (UNISDR, 2009). Hazards can contain covert impact that might follow future risks, and it can be caused due to nature phenomenon (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards). According to this definition, Semarang City can be called as a disaster area.

Starting from environmental problems in Semarang City as a disaster area and the goal to achieve the sustainability environment, the problem in Semarang City can be solved by Disaster Risk Reduction (DRR) concept. For achieving the DRR, we propose the remote sensing technology application. This study can be used as forecasting of the disaster area and can be applied to a quick response to Disaster Risk Reduction (DRR) for achieving the environment sustainability on disaster area. One of the frameworks of disaster risk reduction is early warning systems, including forecasting, dissemination of warnings, preparedness measures and reaction capacities (ISDR-International Strategy for Disaster Reduction, 2002). Disaster risk reduction is the theory and method to reduce disaster risks through organized efforts to examine and reduce the causal factors of disasters. Reducing exposure to hazards, lessening the exposure of society and property, well managing of land use and the environment, and also improving preparedness and early warning for adverse events are all examples of disaster risk reduction (United Nations, 2015).

Remote sensing as tool for DRR is a new technology that can supply information and acceptable parameters as a significant contribution to identifying and mapping environmental problems because it can record all day and night without limitation on the weather condition, low cost comparing ground survey, time efficient, and the large area can be observed (Campbell & Wynne, 2011).

Some researchers have studied the land subsidence in Semarang City by using ground surveys and satellite remote sensing. Semarang Agency installed benchmarks for monitoring areas, and Abidin et al. studied the subsidence by using GPS data (Abidin, et al., 2010). Moreover, the latest technology to monitor the land movement which called the Interferometry Synthetic Aperture Radar (InSAR) technique, it uses the different in phases of the signal to obtain backscattered signals from two images of the same scene, which can calculate differences in the movement to within millimeter accuracies (Zebker & Goldstein, 1986). Abidin et al. conducted the research that applied InSAR to the ascending and descending ALOS PALSAR for measuring the horizontal and vertical movements towards land surfaces (Lubis, et al., 2011), the movement more than 8cm/year. Marfai et al. studied the monitoring of land subsidence caused by groundwater extraction in Semarang and predicted land subsidence by using Digital Elevation Model (DEM) data and Geography Information System (GIS) technique (Marfai & King, 2007). Marfai et al. studied the monitoring of land subsidence caused by groundwater extraction in Semarang and predicted land subsidence by using DEM data and GIS technique (Marfai & King, 2007). The flood adaptation was measured by social aspects such as education and economic, Semarang community adaptation depends on their education and their economic condition; they adapt to flood such as elevating the floor 1 times in 2 years (Harwitasari, 2009).

In this research, the InSAR method was applied to generate the ground displacement or land deformation in Semarang City. The InSAR is the latest method accomplished for detecting land subsidence by the slant-range direction (the antenna line-of-sight) of synthetic aperture radar (SAR) data from two different acquisition times (Stramondo, et al., 2006). The InSAR method is verified by Global Positioning System (GPS) measurements and the *Shuttle Radar Topography Mission* (SRTM) data. This technique can cover wide areas (even in regions of difficult access) and has relatively low cost comparing with ground measuring (Raucoules, et al., 2007). ALOS PALSAR Fine Mode Single Polarization Level 1.0 was utilized to generate the land subsidence by comparing images from January 2007, December 2007 and December 2008. The images were processed by GMTSAR software (Sandwell, et al., 2011).

The National Disaster Mitigation Agency (BNPB) provided the disaster data from sub-district to national level data, besides the land subsidence, Semarang City has to deal with flooding. In this paper, by combining the results of land subsidence from the InSAR technique and the flood history maps in 2009 from BNPB, the distribution of land subsidence and flood were generated. Further, the adaptation of community and government were investigated and together with the land subsidence and flood map we can use this study as one parameter on an early warning system to achieve the DRR.

Because the Semarang city is vulnerable to land subsidence and flood, Semarang City becomes a Hazard area. The Semarang community and government should adapt to this condition. According to IPCC report, adaptation can reduce vulnerability, both in the short and the long-term (IPCC, 2007). Adaptation is a modification in natural or human systems in response to actual or expected phenomenon, which moderates harm or develops beneficial opportunities (IPCC, 2007). The Semarang Community will be resilience or vulnerable to disaster depending their adaptations. They could survive or attack when a disaster occurs depending on their vulnerability.

For observing the adaptation of Semarang city community and government, the field survey was conducted from the end of November until early December 2015 to document and describe community adaptation efforts in Semarang City. By determining the InSAR result and flood inundated areas, the hazard prone area could be detected, because it shows the distribution of land subsidence and flood. The result of this InSAR could explain the rate of subsidence in Semarang city. By combining the land subsidence, flood inundation area, government action for adaptation, and community adaptation in Semarang City the forecast of the land subsidence and the flood generated, it can be use as the early warning system. This study combined the land subsidence data, flood data and also adaptation to flood and land subsidence to propose a new information to the decision maker and community in Semarang City. This study can propose as a quick response to Disaster Risk Reduction.

2. STUDY AREA

The study area is in Semarang City. Geographically, Semarang is located at 6˚58ˈS and 110˚25ˈE, in the east part of Central Java directly adjacent to the northern coast of Java. Semarang is the fourth biggest city in Indonesia and consists of 16 districts and 177 sub-districts.

The landscape in Semarang consists of two major areas. One of them is a low-lying coastal area to the north, with relatively flat topography and slope approximately 0˚- 2˚. The other is hilly areas with a slope of up to 45˚ and altitude approximately 350 m above sea level, as displayed in Figure 1. The land use in the north of Semarang City consists of the residential and industry areas, and higher population density in comparison to the southern parts. Geologically, Semarang City consists of volcanic rock, sedimentary rock and alluvial deposits (Abidin, et al., 2012).

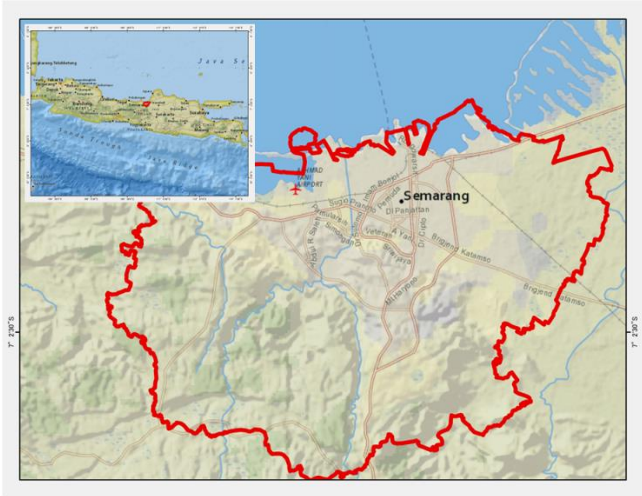

Figure 1 Research location

2.1 Environmental Issues in Semarang City

2.1.1. Flood

Evaluating flood risk is complicated. Risk-related phenomena, for example, flood-inducing precipitation, runoff generation and concentration, downstream flood wave propagation, and flood damage all vary spatially and over time, and is influenced by natural conditions, human activities, and community disaster culture (Sato, 2006). Flood is the type of natural disaster that occurs most frequently throughout the world (Sivakumar, 2005). In Indonesia flooding is the disaster that influences communities the most, with 39% of all disasters that cause damage being flooded (Give2Asia). Based on the local news report Semarang is always attracted by the flood, the latest flood occurred on February 22, 2016, that flood depth was 50 cm, the flood occurring every year in Semarang City (Metro, 2016).

2.1.2. Land subsidence

Land subsidence occurs due to natural phenomena or human activities. Natural phenomena include issues such as limestone formation collapses, whereas human activities can include the construction of the tunnel, land use changes, and other human activities related to groundwater extraction (Marfai & King, 2008). Figure 2 shows the groundwater withdrawal of Semarang City. The groundwater withdrawal activity has increased significantly after 1962 (Marfai & King, 2007). Land subsidence is a kind of ground failure that leads to the lowering of the ground surface, exacerbating the impact of floods, high tides, storm surges or overbank stream flow. Land Subsidence can be caused by natural phenomena, anthropogenic processes or mixed (Chaussard, et al., 2013), as shown in Table 1. Land subsidence in Semarang City occurs by liquefaction and sediment pressure, or oxidation and shrinkage inorganic deposits (Marfai & King, 2008). It is related to geology process and spreads over a large area, with the speed of a few mm/year (Marfai & King, 2007).

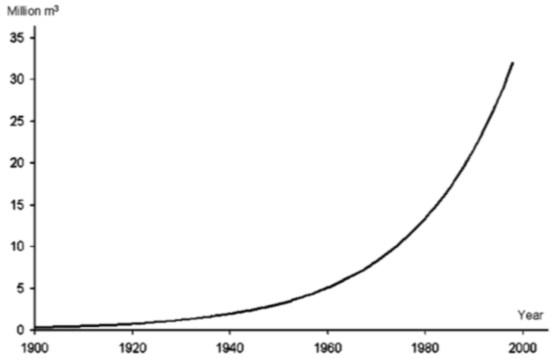

Figure 2 Groundwater withdrawal in million m^3 /year

Anthrophonic impacts can result in rapid subsidence rates, as a result of land extreme modifications, or in environments composed of new sediment deposits. The compaction of land can occur by changing surface water drainage through land reclamation, urbanization, and agriculture activities. In such cases, it can occur over a wide area, and reach speeds of a few cm/year. The withdrawal of liquid or gasses from the ground, such as groundwater, oil or gas extraction, can have a high impact on subsidence, and lead to subsidence rates of up to 10 cm/year (Chaussard, et al., 2013).

Table 1 Characteristics associated with each subsidence process potentially affecting Indonesian cities (Chaussard, et al., 2013)

Subsidence Process		Rates (cm/year)	Spatial pattern	Surface geology	Correlation with surface geology	Land use	Correlation with land use
Anthropogenic	Fluid withdrawal	Up to 10	Large to patchy	Compressible deposit	N	Industry, mixed and agricultural (water, gas, oil extraction.)	Y
Mixed	Sediment loading	<5	Large (sed.loa) Patchy (buildin)	Compressible deposit	-slow subs.: Y -Rapid: N	Industrial and mixed (recent massive building)	Y

2.1.3. Sea level rise

Global sea level rise estimates by satellite altimeter missions have indicated that the sea surface has been rising about 3 mm/year on average since 1993 (Milne, et al., 2009). The trend of sea level rise in Semarang during the 2002-2007 periods was 2.11 mm/year (Radjawane, et al., 2011). Sea level rise has caused to some environmental problems in Semarang such as shoreline erosion and degradation, amplified storm surges**,** permanent inundation, and saltwater intrusion. The rising of sea level rise has also had an influence on tidal flooding. The high rate of land subsidence and sea level rise are the perfect combination that can cause greater tidal floods. However, measuring the impact of sea level rise on tidal flooding is outside the scope of the present paper, and should be the target of future study elsewhere.

3. RESEARCH FRAMEWORK AND METHODOLOGY

There are three essential components in this study which is subsidence data, flood data and adaptation response. Figure 3 displays the frameworks of study; the InSAR method delivered the land subsidence area, and the BNPB data was used as flood inundated area. Overlying two layers by using ArcGIS software the land subsidence area and flood inundated area obtained the distribution of flood and land subsidence. The adaptation method of the community and the government completed the information of settlement condition in Semarang city. By analyzing the distribution of overlaying layer and also the adaptation of community and government, the quick disaster risk reduction for sustainable development could be reached out.

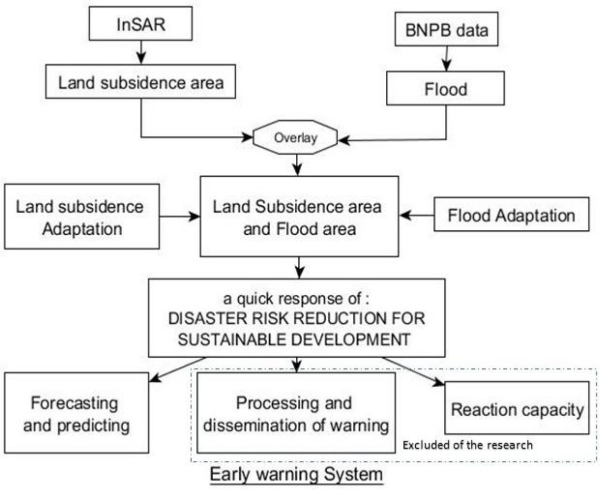

Figure 3 Framework of research

The early warning system is the preparation of timely and efficient information that countenance individuals at risk of a disaster to do an action to prevent or decrease their risk and prepare for an efficient response. Early warning systems component consist of three goals (i) forecasting and prediction of approaching events, (ii) processing and dissemination of warnings to government and community, and (iii) reaction capacity (ISDR-International Strategy for Disaster Reduction, 2002). This research can fulfill one element on early warning system which is the forecasting only. Hence, this paper purpose is a quick response for DRR.

3.1 InSAR

Interferometric Synthetic aperture radar (InSAR) satellites assemble swaths of a side-looking signal at the appropriately high-scale resolution and along-track selection rate to outline high-resolution imagery with depending on the pulse length (*bandwidth*) and the *incidence angle*.

Selecting two complex SAR images from two slightly different viewing angles of the same region is the first step to making a pair of the images. The phase difference ϕ between corresponding complex pixels is proportional to the travel path difference $2\Delta r_o$ (Rocca, et al., 2000).

$$\phi = 4\pi/\lambda \, \Delta ro \qquad (1)$$

where λ is the wavelength.

The SAR image can focus on a point reflector on the ground by consistently summing thousands of sequential signals thus generating a synthetic aperture by manipulating the synthetic aperture method. By summing the complex numbers along a certain range, the proper focus can be achieved. The focus image contains both amplitude (backscatter) and phase (range) information for each pixel (Sandwell, et al., 2011).

Land subsidence was generated from two pairs of image ALOS Palsar. The first pair is ALOS Palsar Images, which recorded on 21 January 2007 (ID: ALPSRP052887040) and 9 December 2007 (ALPSRP099857040); it generated the land subsidence 2007. The second pair is ALOS Palsar images, which recorded on 9 December 2007 (ALPSRP099857040) and 11 December 2008 (ID: ALPSRP153537040); it generated the land subsidence 2008.

The InSAR technique required DEM and GPS Point to build the topography and verify its result. We utilized the SRTM data from NASA website and the GPS point from the previous research. GPS points were generated from the geodetic survey (Abidin, et al., 2010). 35 GPS points were utilized in this research to verify the land subsidence in Semarang City. One point is used as the reference point and 34 points as a measurement point. We assumed that the reference point is constant, there is no subsidence event in this reference point. The measurement point is relative to the reference point.

3.2. Flood

Flood data is a seconder data; BNPB conducted a field survey for recording this information during the flood period. The survey based on the sub-district level that carried out on 8-9 February 2009. It means if there is a flood in one part of sub-district, the flood will be displayed as the flood in the whole area of that sub-district. Hence, the flood inundated areas are overestimated. This flood data does not distinguish the flood type due to rainfall, river flood or tidal flood. The type data of flood is raster. Digitizing process was conducted to provide the polyline data.

3.3. Field Survey

The field survey was conducted at the end of November 2015 and early December 2015. The purpose of the field survey is to know the community adaptation and government adaptation to solve the flood and subsidence problem in Semarang City.

4. ANALYSIS RESULT

4.1. Subsidence and Flood in Semarang

The cause of subsidence in Semarang City is the consolidation of clay within the aquifer systems due to extensive groundwater extraction, especially in the lowland area (Marfai & King, 2007). The lithology of this area is alluvial which composed by deposits of soft clay soil. It is important to note that such subsidence is permanent, as stressing and changing the pressure within the aquifer system influences it, causing the groundwater supply to decrease. Even though the groundwater level can eventually be recharged, the land surface will not return to its original position (Marfai & King, 2008).

In this paper, the subsidence in Semarang City was analyzed and combined with the flood inundation area in Semarang City. The subsidence value in this research is comparative to the reference point. The reference point is located in Banyumanik sub-district, we assume that the reference point is constant. Its movement is null. All the points from P1-P34 are comparative to reference point. The measurement points and reference point are the same locations with Abidin et al. research (Abidin, et al., 2010). Previous research by Lubis et al. calculated a subsidence speed of approximately up to 8 cm per year (Lubis, et al., 2011).

Figure 4 (left) shows the land subsidence in 2007. The largest land subsidence value is -89mm from January 2007 to December 2007, it is located in Genuk Sub-district. The red color area means the high subsidence occurring in this area and the green color mean this location is greater than a reference point, or this location has higher position comparing to the reference point. As shown in Figure 4 (left) the north part of Semarang City has higher subsidence event comparing to the center and east part of Semarang city.

Figure 4 (right) indicated the subsidence distribution in 2008. The pattern is similar to subsidence 2007 which displayed the subsidence distribution in 2007. The highest land subsidence value is -77mm from December 2007 to December 2008, it is located in North Semarang Sub-district. Figure 4 show in same scale color. The color of subsidence level in 2007 for North Semarang, East Semarang, Genuk and Gayamsari from yellow turned to orange in 2008. Tugu, Central Semarang, Ngaliyan, Gajahmungkur, Candisari, Tembalang, and Bayumanik have a green color on subsidence level in 2007 turned to yellow in 2008. That means that the subsidence level from 2007 to 2008 increase.

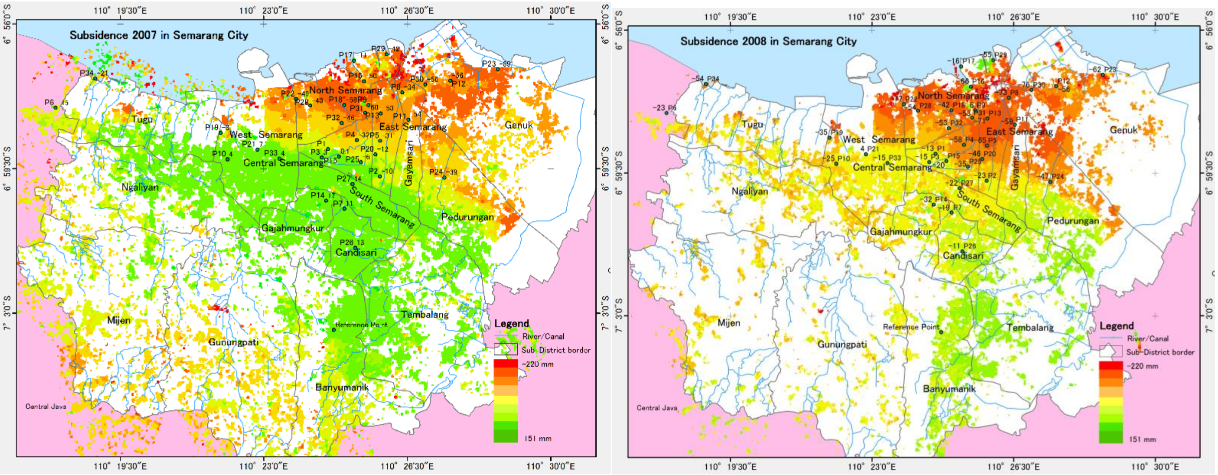

Figure 4 Subsidence 2007 (left) and 2008 (right) in Semarang City

Table 2 shows the subsidence value for all measurement points in 2007 and 2008. Most of the sample points show the land subsidence tendency to increase from 2007 to 2008. There are 34 measurement points and one reference point, the point selected based on the GPS points survey from the previous research (Abidin, et al., 2010). The GPS points delivered from ground survey data. The position is relative to the reference point that means the high of each point depending on the reference point. The reference point is null height, and other measurement points have owned height according to the GPS measurement. The subsidence value from satellite image needs to be corrected by GPS points ground survey. By extracted subsidence value from satellite and demised it using GPS ground survey data, we conducted the subsidence value for each measurement point. Because we assumed that the reference point is null, the positive value means the measurement point is higher than reference point where the negative value means that measurement point is lower than a reference point.

Table 2 Measurement value of subsidence in Semarang City

Point	Subsidence in 2007 (mm)	Subsidence in 2008 (mm)	Point	Subsidence in 2007 (mm)	Subsidence in 2008 (mm)
Reference	0	0			
P1	-11	-13	P18	-58	-42
P2	-10	-23	P19	-8	-35
P3	3	-15	P20	-12	-46
P4	-32	-58	P21	7	4
P5	-31	-65	P22	-49	-77
P6	-15	-23	P23	-89	-62
P7	11	-19	P24	-39	-47
P8	-34	-73	P25	-6	-35
P9	-50	6	P26	14	-10
P10	4	-25	P27	14	-22
P11	-54	-59	P28	-43	-54
P12	-56	-56	P29	-42	-55
P13	-53	-71	P30	-56	-76
P14	17	-38	P31	-60	-53
P15	0.1	-20	P32	-46	-56
P16	-50	-66	P33	4	-15
P17	-11	-16	P34	-21	-54

According to Tabel 2, the maximum subsidence base on the GPS points is at P22 in North Semarang sub-district that reaches up to -77mm from the reference point. The north part of Semarang city has greater subsidence comparing to the center and south of Semarang City.

According to Figure 5, the land subsidence almost occurred in all sub-districts. The high rate of subsidence occurred in North Semarang, Central Semarang, East Semarang, Gayamsari, Pedurungan, and Genuk. The flood in 2009 occurred in Tugu, West Semarang, North Semarang, East Semarang, Gajahmungkur, Candisari, Gunungpati, Pedurungan, Gayamsari, and Genuk. Because the delineation of flood inundated based on the sub-district, the flood inundation is overestimated than actual flood inundation. The area which is relative less land subsidence rate and no flooded, those are Mijen, Ngaliyan, Banyumanik, and Tembalang. Flood2009 occurred due to the high intensity of rainfall and high tidal flood. Those flood caused by mixed from precipitation and tidal oscillation. For example in Tugu,West Semarang, and East Semarang flooded mixed due to high tides and rainfall whereas Gunung Pati sub-district flooded due to the rainfall. Some stream exists in Gunung Pati sub-district, that causing river flood during the rainy season.

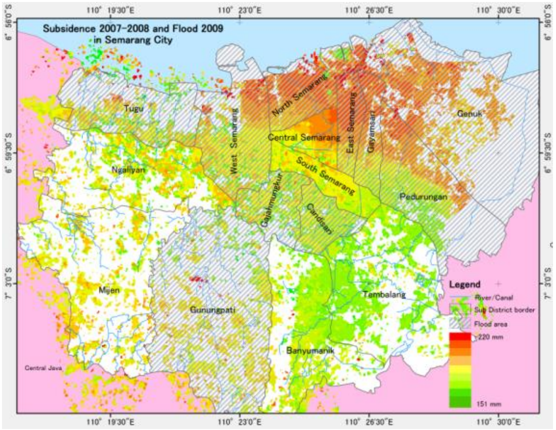

Figure 5 Subsidence 2007-2008 and flood 2009

According to the analysis of land subsidence by InSAR method and combining with the flood inundation data, communities living in Semarang City, are clearly vulnerable to flood and land subsidence. This result can be partly compensated by adopting important and well-informed adaptation strategies. The discussion about Semarang City community and local government response will be discussed in the next section.

4.2. Government and Community Adaptation

The field survey was conducted from the end of November to early December 2015. The data of government and community adaptation was collected. This section talks about their adaptation to flood and land subsidence.
Since flood is a long term event which occurs several times a year, the local community is slowly learning how to adapt to them. Adaptations countermeasures typically depend on the economic level of a community, and both the government and community can work out to reduce the impact of floods ((Marfai, et al., 2008), (Harwitasari, 2009)). For example, the local government in Semarang City has built a seawall to protect the inland areas from the tidal flood during high tides.

Tawang Polder is one of the flood control systems in Semarang City, though it also serves as a recreational area, see Figure 6 (left). The components of Tawang Polder are a dike, floodgate, pump and retention pond. The retention pond acts as a temporary pond to allow water to infiltrate the ground, and become groundwater. Previously the area had a rather bad smell and was thus unattractive to visitors, but after the local government treated the water and embellished the area it became a popular local destination for locals to enjoy sports and spend their free time.

Figure 6 (left) Various infrastructure maintaining Tawang Polder in North Semarang Sub-district and Figure 6 (right) (a) DAM, (b) City drainage, (c) Canal flood control, (d) Dredging the canal from sediment and garage

Semarang government has also built the dam as shown in Figure 6 (right) (a) to control the water discharge of the river and improve the drainage system in the city (b), which is connected to a canal. The canal was built in the west

part of Semarang to control floods (c). Regular maintenance is required, and the local government conducts regular dredging of sediment and waste(d).
The local government has provided pumps at several locations to remove sea water after floods, and approximately 96 were in place in 2014. Other types of adaptation action include the regular elevation of roads. The types of community adaptation actions depend on the economic capacity of residents, as shown in Figure 7. Essentially, high-income communities can afford to build their houses at a level as high or greater than local roads.

Figure 7 Elevating the residence area.

According to McCharty et.al that economic condition has related to the vulnerability to hazard, people from low income are difficult to defend the hazard due to the financial conditions (McCarthy, et al., 2005).

5. DISCUSSION

5.1. Environmental Issues

Flood, land subsidence and sea level rises are three significant environmental problems in Semarang City. The flood becomes worse by land subsidence phenomena occurs all years in Semarang city (Marfai & King, 2008) especially Tugu, West Semarang, North Semarang, East Semarang, Gajahmungkur, Candisari, Gunungpati, Pedurungan, Gayamsari, and Genuk, which flooded in 2009. Semarang City attacks by three types flood, namely, flood due to the rainfall during the rainy season, river flood during the rainy season and tidal flood (Marfai & Lorenz, 2008). The prone area to flooding in the city is approximately 15.000 ha (Dewi, 2007). During the peak rainy season in December and January rainfall inundates the low-lying coastal areas, due to the poor quality of the drainage system. Only approximately 10 % of the rainfall can infiltrate the ground and recharge the water levels, which means approximately 90 % of rainfall becomes runoff (Gatot, et al., 2001). River floods are somehow linked to rainfalls and typically occur during the rainy season due to a flash flood that can overtop the river banks. It occurs when the extreme rainfall, the stream channel and drainage ditch over the capacity. Those floods are mixing during extreme rainfall in the lowland area, especially in North Semarang sub-district. Flood inundated area in Semarang city in 2011 was 1538.8 ha, North Semarang sub-district as the widest flooded area; approximately 508.28 ha was inundated (Ramadhany, et al., 2012).

Tidal flooding occurs during high tides, almost daily phenomenon depends on the tidal oscillation (Marfai & King, 2008). This flood height is 25-50 cm and inundating area approximately 3-9 hours (Marfai, et al., 2008). Several processes as the cause of tidal flood such as high tides due to the moon gravity, strong winds blow the wave, high sea levels mixing with high river flows, and enhanced sea level rise due to global warming has important roles in coastal flooding. It will be severe when occurring in land subsidence places (Marfai & Lorenz, 2008).

5.2. Government and Community Adaptation

The community adaptation in Semarang City is categorized as reactive adaptation; they adapted after have flooding experience and adapted by themselves without pressure from other community or government. The flood experience encourages the community to adapt to worse environmental conditions. During the field survey, the community who attack by the flood were still living in their house even though water inundated as high of the shanks. The adaptation type of local government is protection and accommodation strategies. Protection the land from the sea by constructing the seawall, build the canal, and the tawang polder; and accommodation strategy by still exist in the hazard area by adjusting to the recent condition (Harwitasari, 2009). Government elevate the road regularly and installed pumps for pumping the stuck water.
According to the result of this research, the subsidence rate is up to 88.9 mm in 2007 and 76.8 mm in 2008. The subsidence rates are rather fast, and the local government aware of this condition. Particular efforts have been made to protect the resident from the flood and the land subsidence. The government issued a local regulation in 2013 to attempt to sustainable manage the environment and control ground water extraction and replenishment which the residents in Semarang City can only extract ground water in areas not covered by Municipal Waterworks (Government, 2012).

5.3 Disaster Risk Reduction (DRR)

Disaster Risk Reduction (DRR) is part of sustainable development. DRR objectives to reduce the harm caused by natural hazards corresponding to earthquakes, landslide, tsunami, floods, droughts and cyclones, land subsidence, through an ethic of prevention. In this study, Community and government adaptation were observed in land subsidence and flooding area. Their actions try to protect their living area by doing some actions such as pumping the trapped water, elevating the floor, elevating the road, creating the dikes, build the dam, breakwater, and seawall, and so on. In another side, the flood still occurs every year up to 50 cm depth (Metro, 2016) and land subsidence occurs all year (Abidin, et al., 2012). Semarang City requires a proper city planning by considering the land subsidence and flood distribution.

Remote sensing technology is new technology to generate the spatial data quick, wide, low-cost without direct contact to the location. By developing the InSAR method in remote sensing and combining with the Geography Information System, we could generate a distribution of land subsidence and flood in Semarang. It can be proposed as the is a new method to reduce the disaster risk by using the spatial analysis. The result of this research can be used as a quick response DRR on an early warning system for example during peak rain season; the inundated area could be predicted. It can be applied to forecasting, the rate of land subsidence in 2007 and 2008 were generated, by assuming the causing of land subsidence is constant approximately 7 cm/year, we can predict the decreasing of land in Semarang City in the near future. It can be useful information for community and especially for the government as consideration to make a new policy for the environment.

Indonesia as developing country is highly vulnerable to disaster, not only because of the many hazards affecting it but also because it is unable to manage risks as well as a developed country, due to many financial problems, poor health, and external shocks (Naudé, et al., 2009). The present work has showcased environmental problem in Semarang City and described the community and government action to adapt to the hazard. Future studies should attempt to measure the impact of those environmental issues and attempt to provide solutions that can improve the sustainability and resilience of local communities.

6. CONCLUSIONS

High awareness areas are Tugu, West Semarang, North Semarang, East Semarang, Gajahmungkur, Candisari, Gunungpati, Pedurungan, Gayamsari, and Genuk because as recorded this area flooded in 2009 and subsidence occurring all year. The flood inundation data is overestimated from the actual flood because it was delineated based on the sub-district. The awareness areas to Subsidence are North Semarang, Central Semarang, East Semarang, Gayamsari, Pedurungan, and Genuk. Those areas have a high rate of subsidence comparing to another area. The area which is relative less land subsidence rate and no flooded, those are Mijen, Ngaliyan, Banyumanik, and Tembalang. Those areas are the safest place in Semarang City.

Semarang City is a hazard area which flood is occurring every year and land subsidence rate more than 7cm occurring all years. The tidal flood occurs every high tidal oscillation and during the rainy season, the others flood occurs due to the runoff and river bank overloaded.

The Adaptation system is quite not enough for protection Semarang City from land subsidence and flood attack. This study could use for a quick response to Disaster Risk Reduction (DRR) which the disaster risk reduction. According to the International Strategy for Disaster Reduction concept, this study can achieve the goal of DRR as forecasting on the early warning system.

Further study about the DRR should be conducted by considering the spatial distribution of land use, the sea level rises trend, and deeply measurement about community adaptation.

Reference

Abidin, H. Z, H., Hadi, S., Andreas, H. & Gumilar, I., 2012. *Coastal Flooding of Jakarta (Indonesia): Causes and Impacts.* Vienna.

Abidin, H. et al., 2012. Land subsidence in the coastal city of Semarang (Indonesia): characteristics, impact and causes. *Natural Hazard Risk,* Volume 1, pp. 1-15.

Abidin, H. Z. et al., 2010. *Studying Land Subsidence in Semarang (Indonesia) Using Geodetic Methods.* Sydney Australia.

Bureau, Statistic of Semarang., [Online] Available at: http://semarangkota.bps.go.id/linkTableDinamis/view/id/29 [Accessed 23 3 2016].

Campbell, J. B. & Wynne, R. H., 2011. *Introduction to remote sensing fifth edition.* New York(USA): The Guilford Press.

Chaussard, E., Amelung, F., Abidin, H. & Hong, S.-H., 2013. Sinking cities in Indonesia: ALOS PALSAR detects rapid subsidence due to groundwater and gas extraction. *RS of Environmental,* Volume 128, pp. 150-161.

Dewi, A., 2007. *Community-based analysis of coping with urban flooding: a case study in Semarang, Indonesia,* Enschede: MSc. Thesis ITC.

Gatot, I. S. et al., 2001. *Rainfall-runoff harvesting for controlling erosion and sustaining upland agriculture development.* Purdue University and The USDA-ARS Nation Soil Erosion Research Lab., pp. 431-439.

Give2Asia, *Disaster Preparedness and Resiliency: Indonesia.* [Online] Available at: http://www.give2asia.org/disaster-preparedness-and-resilience-indonesia/ [Accessed 10 12 2015].

Government of Semarang, 2012. *Peraturan Daerah Kota Semarang Nomer 2 Tahun 2013 Tentang Pengolahan Air Tanah,* Semarang: Semarang Government.

Harwitasari, D., 2009. *Adaptation responses to tidal flooding in Semarang, Indonesia,* Rotterdam: ihs.

IPCC, 2007. *Climate Change 2001: Synthesis Report,* Geneva: Intergovernmental Panel on Climate Change.

IPCC, 2007. *Climate Change 2007: Synthesis Report. The Contribution of Working Groups I, II and III to the Fourth Assessment,* Geneva, Switzerland: IPCC.

ISDR-International Strategy for Disaster Reduction, 2002. *Disaster Reduction and Sustainable Development: Understanding the links between vulnerability and risk to disasters related to development and environment,* Johannesburg: United Nations International Strategy for Disaster Reduction.

Lubis, A. M. et al., 2011. Ground subsidence in Semarang-Indonesia investigated by ALOS–PALSAR satellite SAR interferometry. *Journal of Asian Earth Sciences,* Volume 40, pp. 1079-1088.

Marfai, M. A. & King, L., 2007. Monitoring land subsidence in Semarang, Indonesia. *Environmental Geology,* Volume 53, pp. 651-659.

Marfai, M. A. & King, L., 2008. Tidal inundation mapping under enhanced land subsidence in Semarang, Central Java Indonesia. *Nat Hazards,* Volume 44, pp. 93-109.

Marfai, M. A. et al., 2008. The impact of tidal flooding on a coastal community in Semarang, Indonesia. *Environmentalist,* Volume 28, p. 237–248.

Marfai, M. A. & Lorenz, K., 2008. Coastal flood management in Semarang, Indonesia. *Environmental Geology,* Volume 55, p. 1507–1518.

Metro Semarang, 2016. [Online] Available at: http://metrosemarang.com/tag/banjir-semarang [Accessed 14 3 2016].

Milne, G. A., Gehrels, W. R., Hughes, C. W. & Tamisiea, M. E., 2009. Identifying the causes of sea-level change. *Nature Geoscience 2,* pp. 471 - 478.

Moldan, B., Janousková, S. & Hák, T., 2012. How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators,* Volume 17, p. 4–13.

United Nation, 2015. *Sendai Framework for Disaster Risk Reduction 2015-2030.* Sendai: United Nation.

Radjawane, I., Hartadi , D. & Lusano, W., 2011. *Coastal Vulnerability Assessment in Semarang City, Indonesia based on Sea-level Rise and Land Subsidence Scenarios.* Yantai, China, s.n.

Ramadhany, A. S., DS, A. A. & Subardjo, P., 2012. Daerah rawang genangan Rob di wilayah Semarang. *Journal of Marine Research,* 1(2), pp. 174-180.

Raucoules, D., Colesanti, C. & Carnec, C., 2007. Use of SAR interferometry for detecting and assessing ground subsidence. *Comptes Rendus Geoscience,* Volume 339, pp. 333-382.

Rocca, F., Prati, C., Guarnieri, M. & Ferretti, A., 2000. SAR Interferometry and its Application. *Surveys in Geophysics,* Volume 21, pp. 159-176.

Sandwell, D. et al., 2011. *GMTSAR: An InSAR Processing System Based on Generic Mapping Tools,* San Diego: Scripps Institution of Oceanography University of California.

Sato, T., 2006. Fundamental Characteristics of Flood Risk in Japan's Urban Areas. In: *A Better Integrated Management of Disaster Risks Toward Resilient Society to Emerging Disaster Risks in Mega-Cities.* Tokyo: TERRAPUB and NIED, pp. 23-40.

Sivakumar, M., 2005. *Impact of natural disaster in agriculture, rangeland and forestry: an overview,* Geneva: World Meteorological Organization.

Stramondo, S. et al., 2006. Satellite radar and optical remote sensing for earthquake damage. *International Journal of Remote Sensing,* 27(20), pp. 4433-4447.

Sutton, P., 2004. *A Perspective on environmental sustainability? A Paper for the Victorian Commissioner for Environmental,* Australia: Strategy of Green Innovations.

UNISDR, 2009. *Adaptation to Climate Change by Reducing Disaster Risks: Country Practices and Lessons,* Geneva: UNISDR (United Nations International Strategy for Disaster Reduction).

WCED, 1987. *World Commission on Environment and Development ;Our Common Future.* New York(US): Oxford University Press.

Zebker, H. A. & Goldstein, R. M., 1986. Topographic mapping from interferometric synthetic aperture radar observations. *Journal of Geophysical Research: Solid Earth,* 91(B5), p. 4993–4999.