Integrated analysis of adaptation and mitigation on coastal flood

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Abstract: The northern coast of Central Java Province – Indonesia is considered as the critical area of flood path. The area always suffers from flood due to heavy rainfall and/or sea level rise. As the consequence, people are suffering, properties are damaged and lost. A number of efforts have been carried out to manage the flood problem, although the achievement is incomplete. It is realized that infrastructures capacity for flood control, community awareness, and other multi-factors significantly contribute in solving the flood problem. This research aimed to outline the strategies of flood adaptation and mitigation. Quantitative and qualitative method ware employed to analyze the data. The results of this study indicated that the level of vulnerability the Central Java to flood was in the medium category. The exposure and adaptive capacity variables were significantly contributed in determining the vulnerability level. Flood adaptation can be carried through anticipation and reactive adaptation, in which each type could be practiced by public and private. Flood mitigation can be carried out through structural, non-structural and community roles.

Keywords: Coastal, Flood, Adaptation, Mitigation, Vulnerability

1. Introduction

Evidence suggests that there has been a long-term upward trend in the number of floods since 1815 to 2015, which was 5,233 occurrences or approximately 38.99% of the total nature disaster in Indonesia. Central Java Province – Indonesia was recorded to have high frequency of floods, particularly at the northern coast of Central Java Province – Indonesia. During 2011-2015, 368 cases of floods in Central Java Province – Indonesia were reported and the number was continuously rising (BNPB, 2016). In addition, they had very big impacts including 58 victims, 191,422 evacuated people, 31.012 Ha destroyed area, 139 km broken road, and 1,104 heavily damaged houses (BNPB, 2016). The figure could be significantly higher if the property damaged by surface water flooding was also taken into account.

Flood risks, however, have a propensity to extend massively in the future, especially due to the impacts of climate change (Pitt, 2008). As flooding is a hazard that, could possibly occur due to weather condition (heavy rainfall) coupled with other causes (e.g. inadequate drainage, overflowing river banks, etc.), higher intensity and frequency of such weather extremes are likely to increase the risk of flooding. Fowler and Wilby (2010) reported that the trend of increasing rainfall intensity was actually had been estimated as there

was an increase of heavy rainfall, both in frequency and intensity. In fact, the recent prevalence of floods in Central Java Province – Indonesia is mostly caused by heavy rainfall, that is likely to enhance in the future, according to the above-mentioned evidence.

Evans et al. (2004) explained urbanization, environmental regulations, land management, increased national wealth, and social impacts were the main drivers for future flood risks in addition to climate change. Continuous pressure to build in the areas vulnerable to floods became a factor that potentially increased flood risk. As the consequence, the society would be more vulnerable to flood risk, regardless to the prevailing debate on whether the climate change would increase the intensity and frequency of flood in the future. Thus, the community participation in the adaptation and mitigation against flood risk and extreme weather becomes an important aspect in building resilient communities. The need for building resilient communities, which can bounce back from the impacts of such hazards, has become a focal point of discussion during the recent years (Manyena, 2006; Paton, 2006; Cutter et al., 2008).

Flooding can have a critical impact on communities either it affected them directly or indirectly. Building damages, infrastructure damage or loss, ineffective workdays and business, and community inconvenience were several short-term impacts of flooding in the coastal zones. Moreover, long-term impacts included disrupted cash flow and income loss. Although direct impacts were often highlighted, indirect impacts of flooding could also bring major effects on communities. Woodman (2008) identified 53% off-day staffs, 38% of premises flooded (offices, shops, etc.), and 27% of disrupted supplier became the main impacts of flooding experienced by 255 businesses as the respondents in 2007, furthermore, the findings suggested that the impacts of flooding extended highly beyond the direct impacts.

Previous facts suggested the importance of flood adaptation and mitigation among the communities as they were highly vulnerable to disruptions. Whilst many of the studies regarding with adaptation and mitigation have focused on long-term climate change, the importance of adapting to short-term climate stimuli such as flooding is also recognized. For instance, one of the principals of the adaptation policy framework developed by Spanger-Siegfried et al. (2004) is that "adaptation to short-term climate variability and extreme events serves as a starting point for reducing vulnerability to longer-term climate change". In this respect, adaptation to flooding is important not only as a response to current risk of flooding, but also as a starting point to long-term adaptation to changing climatic conditions. Further, given that climate change mitigation is likely to come before adaptation to many (Morton et al., 2011), flood risk adaptation can be used to highlight the need for adaptation rather than mitigation alone.

Flooding is one of the main weather extremes that have affected Central Java Province – Indonesia in the last few years. The occurrences in 2010, 2013, and 2015 were among the disastrous floods. The National Disaster Management Authority (BNPB) has identified coastal flooding as high probability risk with extensive impacts. In fact, recent flood in the Central Java Province – Indonesia had caused significant effect on communities, especially the communities in the

northern coast of Central Java province that were frequently affected disproportionately and adversely by such hazard and were less prepared to manage the consequences (Isa, 2015). Adaptation to the risk of flooding, thus, has become a significant and importance issue, particularly on how to prevent any potential disasters and disruptions in the case there was a risk of flooding (Crichton, 2008).

Many efforts related to flood adaptation and mitigation had been done by the government and society of Central Java Province – Indonesia. Swart and Frank (2007) and Thomas et al (2003) explained adaptation and mitigation as two concepts, which are aimed to reduce the flood risk. Flood mitigation is defined as the effort to reduce the flood impacts, such as to diminish the number of dead victims, destroyed things, and loss. Flood adaptation is defined as the effort of natural and human being system, Adaptation is considered as the response towards the risk stimulus, mainly: the vulnerability that consists of: exposure, sensitivity, and adaptive capacity aspects. Swart and Frank, (2007) suggested flood impact as the concept of flood risk as function from danger; and vulnerability, while the vulnerable factor as the function of exposure, sensitivity, and adaptive capacity (Balica et al. 2012, Isa, 2015, Isa, 2016).

The vulnerability is reflective of (or a function of) the exposure and susceptibility of that system to hazardous conditions and the resilience of the system to adapt and/or recover from the effects of those conditions (Smit and Wandel 2006). Exposure can be understood as the values that are present at the location where floods can occur. These values can be goods, infrastructure, cultural heritage, and people. Exposure is generally described as patterns and processes that estimate its intensity and duration (Balica et al. 2012). Sensitivity relates to system characteristics, including the social context of flood damage, especially the awareness and preparedness of people regarding the risk they live with (before the flood), the institutions that are involved in mitigating and reducing the effects of the hazards and the existence of possible measures, like flood hazard maps to be used during the floods. The ability of individuals and social systems to handle the impact of floods is often correlated with general socio-economic indicators. Adaptive capacity is the capacity of any kind of system, community, society or environment, potentially exposed to hazards to adapt to any change, by resisting or modifying itself, in order to maintain or to achieve an acceptable level of functioning and structure (Pelling 2003).

Flood adaptation and mitigation can be done through: (1) Structural and non-structural strategies (Changzhi Li, et al., 2012; Wedawatta and Ingirige, 2012; Lawson et al. 2011), (2) Identification and efforts to reduce the vulnerability level of physical, environmental, social and economic aspects (Moser, et al., 2010; Florina, 2007; Chaliha, 2012, Balica, et al, 2012), (3) Identification of the vulnerability of exposure sensitivity, and adaptive capacity aspects; (Smit and Wandel, 2006; Turner et al., 2003; and Brenkert and Malone, 2005), (4) Improvement and development program on education, income, insurance and poverty alleviation (Chan, 1997; and Eziyi, 2011), (5) community participation (Olofsson, 2007; Fordham, 1998; Quarantelli, 2005), and (6) community awareness and capacity development (Zein, 2010).

Despite intensive flood adaptation and mitigation at Central Java Province – Indonesia had been carried out lately, but the flood risk was still high. It was allegedly due to inappropriate flood strategies of adaptation and mitigation. In addition, the community's belief in flood as the "Act of God" and the external aspect beyond human being ability was lingered. As an act of God, flood was perceived to be a punishment, warning, or examination from GOD, meanwhile, flood as an external aspect beyond people ability required technology innovation to reduce the risks. Therefore, local wisdom related to flood mitigation and adaptation was often ignored. This research aimed to outline the strategies of flood adaptation and mitigation.

2. Materials and Methods

2.1. Studi Area

Central Java is one of 34 provinces across Indonesia. It has 3.254.412 hectares of area or 1.70% of the total Indonesia's area. Central Java is bordered by the Indian Ocean and Yogyakarta to the south, West Java to the west, East Java to the east, and Java Sea to the north. Central Java is located between 5o 40' and 8o 30' South Latitude and between 108o 30' and 111o 30' East Longitude. More than 53% of Central Java region is lowland. The lowlands lie on The North Coast and The West Coast. The North Coast is more vulnerable to flooding. The flooding is caused by (1) high rainfall, (2) overflow of the rivers, and (3) damage of dams/water gates. Flooding is more common in Pati Regency, Pekalongan Regency, and Semarang City. Several major rives crossed these areas. Therefore the rivers make the areas vulnerable to flooding. The over land function to residential area, agricultural expansion and industrial development on the lowland contribute to the degradation of coastal areas in Pati, Pekalongan, and Semarang City. This study is conducted in three sites that deputize both east, central, and west area of the Northern Coast of Central Java. These areas are Pati, Pekalongan, and Semarang City. Figure 1 shows the location and geographic coordinates of the study area.

Source: BPS (2017)
Figure 1. Location of the study sites.

2.2. Data Processing and Analyses

Vulnerability is considered here based on the use of indicators. An indicator, or set of indicators, can be defined as an inherent characteristic that quantitatively estimates the condition of a system; they usually focus on minor, feasible, palpable and telling piece of a system that can offer people a sense of the bigger representation. Therefore, it is very important to know the impacts on the people, cities, natural resources, via the use of these indicators.

Table 1. Variables and Indicators that make up the sub-indices of exposure, sensitivity and adaptive capacity

Sub-Index	Indicator	Variable
Exposure	Flood Frequency	Number of years experiencing extremely high rainfall and severe floods taken as a proxy (number)
	Flood water deep	Total depth of the floodwater. In simple measurable terms, it would mean whether the flood water reached the knee length or till the abdomen (meters)
	Flood Duration	Total amount of time the flood persist in the village (days)
	Elderly	Percentage of household > 65 years old (%)
	Child	Percentage of household < 5 years old (%)

	Proximity to river	Total distance of the house from the river (metres)
Sensitivity	Health	Number of household have health problem caused due to the flood (number)
	Water availability during floods	Number of high raised tube wells in a village taken (%)
	Income	Total income of the respondent (IDR)
	Migration	The number of families migrated to town during the last three years (number)
Adaptive capacity	River, embankments, and sluices condition	River, embankments, and sluices condition (%)
	The presence of flood-prone maps	The presence of flood-prone maps (number)
	Education	Percentage of literate member in the household (%)
	Distance the the nearest health care center	Distance travelled to reach the nearest public health Centre (m)
	Evacuation sites	Distance travelled to reach the nearest evacuation site (m)
	Number of NGO Providing relief	Total number of NGI providing relief to the floods victims in the region (number)
	Information access	Number access of flood information (Number)
	The number of flood camps	The number of flood camps (number)
	Flood awareness	Percentage of household having assurance (%)
	Emergency services	Number of emergency services (number)
	Early warning of the flood	Early warning of the flood (number)
	Dissemination of flood prevention	The amount of dissemination on flood risk (number)
	Training of flood prevention	The amount of training on flood risk (number)

The communities affected by floods in those three sites were the population of the study. Subsequently, multistage sampling method was applied by using the Slovin's formula. The result was the number of samples of 390 respondents. The respondents were interviewed directly by using questionnaires. The questionnaires were used as a guide for the researcher in which they contained a list of questions to obtain the respondents' answers as the data.

Having chosen the suitable indicators, now these need to be normalized so as to bring the values of the indicators within the comparable range (Nelson, et al., 2010b; Gbetibouo & Ringler, 2009; Vincent, 2004). Normalization is done by subtracting the mean from the observed value and dividing by the standard deviation for each indicator. Next, weights should be assigned to these indicators.

The normalized variables are then multiplied with the assigned weights to construct the indices (for exposure, sensitivity, and adaptive capacity separately) using the following formula (Luni et al. 2012 dan Chaliha, 2012).

$$I_j = \sum_{i=1}^{k} b_i \left[\frac{a_{ji} - x_i}{s_i}\right]$$

where, 'I' is the respective index value, 'b' is the loadings from first component from PCA taken as weights for respective indicators, 'a' is the indicator value, 'x' is the mean indicator value, and 's' is the standard deviation of the indicators.

Vulnerability index formation region on flood assessment survey respondents carried through to all aspects of vulnerability, ie exposure, sensivity, and adaptive capacity, and then the assessment results are compiled. Greater its value indicates the level of vulnerability getting smaller. The results of data compilation study every aspect of Vulnerability and then normalized to obtain a score of 0-1 (Luni et al, 2012). To show the level of Vulnerability region, in the preparation is done processing Vulnerability index score, which is 1 minus the result of the normalization of data. The results showed that the higher the number (closer to 1) the higher the degree of vulnerability.

The next step is to do the weighting aspect Vulnerability in consideration of the influence of each variable on the area above the flood vulnerability. The greater the influence of these variables, given the higher weight. Weighting obtained through indepth interviews with relevant stakeholders in the research sites. Results depth interviews showed that the weight of the exposure by 40%, the weight of adaptive capacity by 35% and sensitivity of 25% weight.

$$Vulnerability\ index = \sum_{i=1}^{3} (W_1 \times X_1) + (W_2 \times X_2) + (W_3 \times X_3)$$

Vulnerability Index = Vulnerability Index
W_1 = Exposure Weight
X_1 = Exposure Score
W_2 = Sensitivity Weight
X_2 = Sensitivity Score
W_3 = Adaptive Capacity Weight
X_3 = Adaptive Capacity Score

Vulnerability Index is determined by multiplying the total score of all indicators and weights exposure variables, sensivity, and adaptive capacity. Vulnerability index results can be interpreted by three criteria; high Vulnerability (index value ≥ 0.67), Vulnerability is being (an index value of between 0.34 and 0.66), and lower Vulnerability (index value $\leq$ 0.33). Vulnerability Index is calculated by the formula below (Luni et al, 2012).

3. Results and Discussion

Flooding in the northern coast of Central Java Province – Indonesia was generally triggered by river narrowing and siltation as well as damaged embankment and floodgate (Nughroho, (2002), Rachmat dan Pamungkas (2014)). In the study area, river had been narrowed, river sedimentation was high, and the embankment and the floodgates were non-optimal. River narrowing in the study area was caused by the building construction along the riverbanks. Siltation was the impact of waste from human activity, sediment carried out by runoffs, and declined catchment area in the upstream. Numbers of embankments and floodgates were non-optimal mainly due to maintenance shortage. Those conditions affected the river capacity since it could not accommodate the excess water during heavy rain and prolonged rainfall. Greater runoffs led the river out of roadway and flood occurred.

1. Flood Zone Vulnerability

Vulnerability index of the northern Coast of Central Java – Indonesia was 0.63. The index indicated the medium level of vulnerability, although the results were diverse in

accordance to the city or district. Pekalongan District had the highest vulnerability level with an index of 0.67 which could be classified as high vulnerability. Pati District and Semarang City were at medium level with indexes of 0.62 and 0.60, respectively.

Table 1.
Index of Flood Area Vulnerability in the northern coast of Central Java

	Exposure		Sensitivity		Adaptive Capacity		Vulnerability Index
	Score	Weight	Score	Weight	Score	Weight	
1. Pekalongan	0.70	0.40	0.57	0.25	0.72	0.35	0.67
2. Semarang	0.59	0.40	0.54	0.25	0.66	0.35	0.60
3. Pati	0.73	0.40	0.32	0.25	0.71	0.35	0.62
Vulnerability Index	0.81		0.36		0.73		**0.63**

Source: Primary Data (2016).

Based on the result, Pekalongan District was the most vulnerable areas in compared with other sites and it was classified as high level of vulnerability. The result was similar to the Flood Risk Index released in 2014 by the National Disaster Management Authority (BNPB). The high vulnerability level in Pekalongan District was triggered by the high frequency of flooding, flood water level, duration of the flood, and ineffective management of Local Government. It was also influenced by the human factors as indicated by 79.4% of the local people worked as farmer/fisherman. In addition, 81.5% of respondents had primary educational background (elementary and junior high school) and 76.3% of them earned ≤ 1 million per month.

Table 1 indicates the exposure variables and adaptive capacity were at high vulnerability level. The two variables significantly contributed in determining the vulnerability level of the northern coast of Central Java, with index values of 0.81 and 0.73, respectively. The sensitivity variable was classified in the medium vulnerability with an index of 0.36. The levels indicated the government and society should pay more attention to the exposure variables which consisted of flood frequency, flood duration, the number of elderly and infants, and the distance of settlements from the flood area.

The causes of flood zone vulnerability were divided into three aspects of: **flood aspects**, **local government service aspects,** and **individual aspects**. Flood and local government service were the external aspects of society. Therefore, local government and community can mitigate flood as a solution, for example, to create rain infiltration, to improve drainage, to normalize the river, to arrange buildings in accordance with the applicable Spatial Plans, and to conduct institutional development. Institutional development could be in the forms of the strengthening of the Local Disaster Management Agency, the flood SOP development, and the strengthening of flood prevention management.

Flood and local government service were the external aspects of the flood zone vulnerability in the northern coast of Central Java. The aspects consisted of flood frequency, water

level, and flood duration. In addition, the vulnerability level was also affected by the distance of the settlement from the river. It was also affected by the lack of local government services, such as: (1) early warning of the flood, (2) dissemination of flood prevention, (3) training for flood prevention, (4) non-governmental organizations involved in flood, (5) evacuation route, (6) the number of flood emergency services, (7) the distance of evacuation site from settlements, (8) the number of aid camp for the victims, (9) access to the health services, and (10) the condition of the river, embankments, floodgate.

Based on the internal aspects of the community, the high vulnerability level to flood was caused by the low level of public awareness such as to obtain flood information as well as individual insurance. The low educational background and the numbers of infant and elderly were also influential. Alternative solution in the form of the dissemination of in technology and knowledge was required to address the internal issue.

Based on the indexing aspect, the exposure value variable that contains flood duration, the number of elderly are in the high level of vulnerability, while the flood frequence, puddle hight, and the distance between house and flood source (river) are in medium level of vulnerability.

Adaptive capacity indicators includes (1) the presence of flood-prone maps, (2) education levels, (3) insurance holdings, (4) emergency services, (5) number of early warning, (6) number of socialization, (7) the amount of training on flood risk, are on the high level of area vulnerability. While such indicators as (1) river, embankments, and sluices condition, (2) evacuation sites, (3) number of non-governmental organization, (4) access to information, and (5) the number of flood camps are on the medium level of area vulnerability. The evacuation route aspect is on the low level of area vulnerability.

The sensitivity index values for income of the people indicator is on the high level area vulnerability to flooding, as well as the index values of frequency of treatment and access to clean water that are on the medium level of area vulnerability to flooding. While migration is on low level of area vulnerability to flooding.

2. Adaptation and Mitigation Strategies

The communities in the area prone to flood had implemented a range of adaptation options. Figure 2 shows the main adaptation options implemented by communities. Accordingly it can be seen that communities had prepared themselves for similar hazard, and it had covered every consequence related to the previous flood. It can be seen that communities had implemented property-level measures such as the establishment of flood gates and flood-resilient embankment, as well as under floor grill and drain to dispose water quickly.

The entire efforts related to flood are flood adaptation and mitigation. Flood adaptation is short-term and related straightforwardly to the aspects that have potential risk. The activity is carried out immediately during and after the hazard. Subsequently, flood mitigation is long-term activity that focuses on anticipation aspect or flood prevention, and post-flood activity such as rehabilitation and reconstruction.

Scheme of flood adaptation and mitigation in the northern coast of Central Java Province is presented In figure 1.

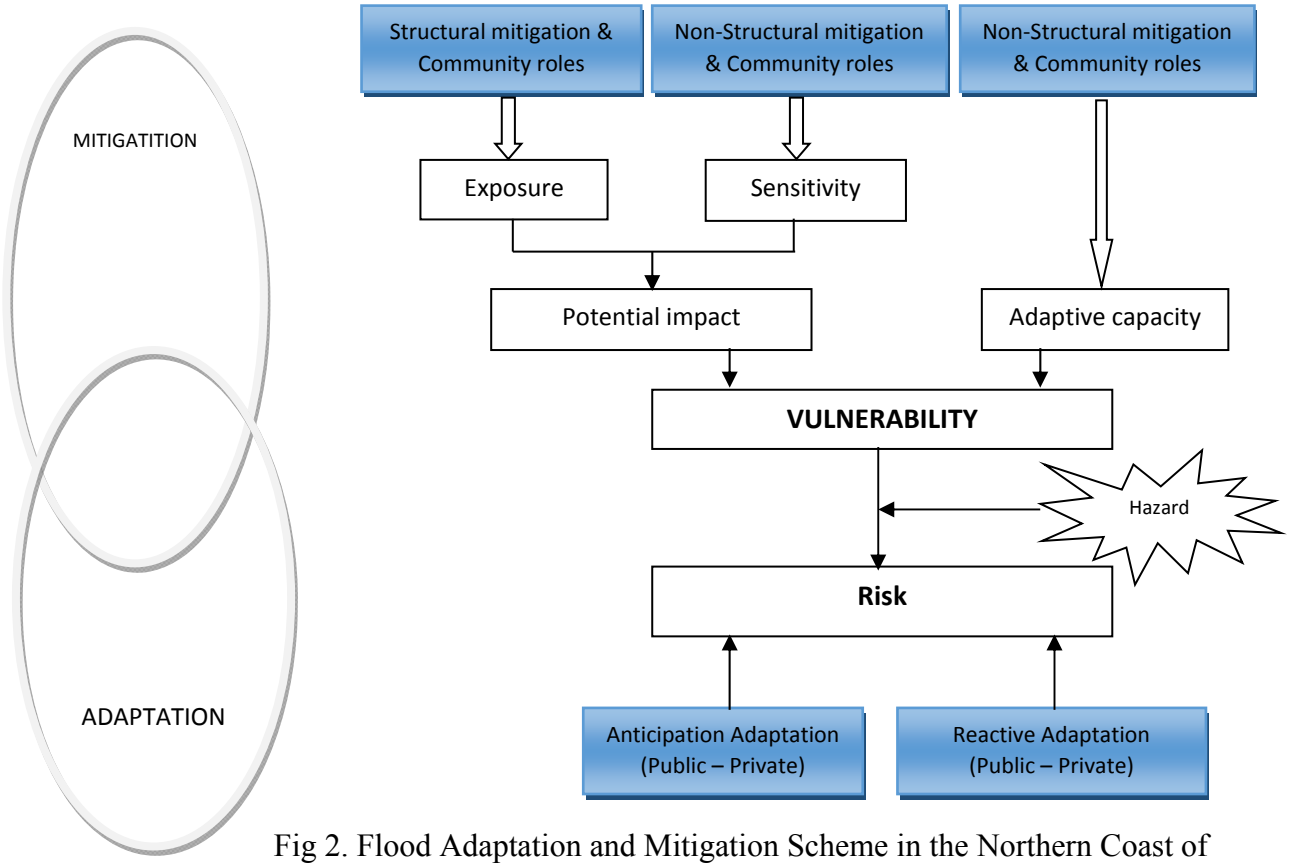

Fig 2. Flood Adaptation and Mitigation Scheme in the Northern Coast of Central Java.

Based on Figure 2, there were 2 types of adaptation carried out by community and government in facing flood in the northern coast of Central Java. Based on timing, those types were anticipation and reactive adaptation, in which each type could be practiced based on agents public and private. Anticipation adaptation was aimed to anticipate subsequent hazard, also referred to as proactive adaptation, while reactive adaptation was carried out as to address the consequences. Private adaptation was the initiation carried out by individual, household, or businessman based on the rationality of their respective interest, meanwhile public adaptation was the initiation performed by the government, both the local and central government. They were the reflection of collective need. Specifically, flood adaptation is elaborated in table 2.

Table 2. Activities of Flood Adaptation

	ANTICIPATION	REACTIVE
PRIVATE	▪ Insurance (natural disaster) ▪ 12-year compulsory education ▪ Participation in flood prevention training and socialization ▪ Information access from newspapers, TV, and radio ▪ Planning the number of family member through Family Planning Program ▪ Establishment of infiltration well	▪ Community cooperation in sewer and drainage clean-up ▪ Elevation of building foundation or levee on terrace to block the water flow into the house ▪ Secure important document ▪ Establishment of temporary embankment made on bamboo and sandbags
PUBLIC	▪ Provision and socialization on early warning system and equipment ▪ River maintenance ▪ Embankment and floodgate maintenance ▪ Preparation and socialization of flood hazard map ▪ Preparation and implementation of spatial plan ▪ Establishment of polder/dam/reservoir ▪ Ban on logging in the upstream (conservation) area ▪ Establishment of green area ▪ Provision of flood emergency plan	▪ Evacuation system ▪ Provision of evacuation shelters ▪ Establishment of public kitchen and food supply maintenance ▪ Evacuation route ▪ Active role of LSM-NGO ▪ Operation of suction machine water (water pump) for water discharge ▪ Rehabilitation on the upstream area ▪ Elevation of village street ▪ Relocation of housing in the area prone to flood

Community-level flood protection schemes can be considered as the first line defence against flooding, and major preventive response. The examples of community-level flood protection scheme include storage basins, raised river embankments, coastal defences (Bichard and Kazmierczak, 2012), maintained river channels, floodwalls, and barriers. Such community-level flood protection scheme attempts to reduce the risk of flooding in the local communities level including on infrastructure, households, and businesses.

Moreover, as flooding is a multifaceted risk, there is still a risk of properties damage although the implementation of community-level flood protection scheme in the coastal area has been carried out. For instance, despite the presence of barrier and other flood management initiatives, some areas in Central Java were still endured the risk of flooding, and had been affected by the hazard in the past years.

Given the fact it was practically difficult to protect every property from the risk of flooding through community-level strategic flood protection scheme, adaptation effort i.e. The implementation of property-level flood protection measures was considered effective to manage the risk to existing buildings. Therefore, property-level flood prevention was also recognized as a prominent feature that should be included in the communities's response to flood risk.

The process, however, was frequently accompanied by external hindrances. For instance, Bosher et al. (2009) argued that Indonesia construction sector is currently ill-prepared to build-in resilience to flooding", implying that communities were likely to encounter difficulties in implementing such adaptation options. One of the recommendations of the panel appointed by the Indonesian government to review the occurrence of the summer floods of 2007 was to encourage the take-up of property flood protection by communities. It was recommended to assign the responsibility to local authorities, as part of discharging their responsibilities under the Civil Contingencies Act 2004 to promote communities sustainability. Furthermore, it was recommended to revise building regulations to ensure all new and refurbished buildings in high flood-risk areas were flood resistant or resilient. Given that the Indonesian government had expressed that it "supports changes in response to all of the recommendations in the review" (Defra, 2011 and 2014); such possible regulation changes would have an immediate impact on the construction of new buildings or refurbishments of existing buildings by communities. Therefore, it was recommended for communities in high flood-risk areas to improve flood protection measures, both resistant and resilient, as they were important.

Flood mitigation can be carried out through structural, non-structural and community roles (Changzhi Li, et al., 2012; Wedawatta and Ingirige, 2012; Lawson et al. 2011). Structural activities included the establishment of physical faculties to reduce the flood risk, while non-structural activities included the development of non-physical activities such as the preparation to the training of flood risk reduction. The role of communities was crucial that could be conducted to their participations to prevent flood and to reduce the risk. Specifically, the activities are described in table 2 below.

Table 3. Floods Mitigation in the Northern Coastal Area of Central Java.

	Activity
Structural	1. The establishment of embankment on the riverbank. 2. The regulation of water flow rate and discharge in the upstream area. 3. River dredging and channeling.
Non-Structural	1. Recommendation in the establishment and improvement of flood management facilities. 2. Data monitoring of precipitation, flood, inundation area and other information required to estimate the hazard, area affected by the hazard, and area prone to the hazard. 3. Preparation of flood susceptible map that informs the evacuation route, evacuation location, and flood observation post. 4. Provision and maintenance of early warning system. 5. Implementation of logistic and financial plan as well as equipments and materials required for flood emergency activity/effort. 6. Plan and preparation of SOP for emergency plan 7. Provision of flood information system and direct dissemination among the communities. 8. Training on flood emergency activity for the staff of BPBD and volunteers. 9. Cross-agency and cross-sector networking and LSM/NGO involvement. 10. Public education on flood prevention.
The Community Role	1. Flood causes aspect a. Not throwing garbage into rivers and sewer, b. Not building bridges and/or building that block or narrow the river basin, c. Not living in the riverbanks, d. Not building house or other building outside the spatial plan on flood retention area, e. Stop illegal logging and deforestation in the catchment area, f. Participate in controlling urbanization rate and population growth. 2. Participative aspect a. Actively participate in flood mitigation trainings such as flood prevention and evacuation preparation, hazard early warning system training, and others, b. Actively participate in the programs of resilient housing construction such as for storey house and selection of waterproof and scouring-resistant materials, c. Participate in public education and consultation related to the development of flood prevention facilities and mitigation efforts; d. Community cooperation in drainage maintenance.

Dawson et al. (2011) asserted the ability of reducing the risk of flooding by implementing a portfolio of structural and non-structural flood risk management measures; and claimed that "society is capable of adapting and significantly reducing flood risk using currently available measures", that suggested the importance and feasibility of flood adaptation and mitigation. Whilst it is the responsibility of the relevant authorities to introduce some of the measures such as land use planning policies, the implementation of measures related to resilient property construction become the individual property owners'responsibility. However, individual-level adaptation

measures were likely to be infrequently implemented in Indonesia, partly due to the communities' reliance on the state to provide full protection against the natural hazard (Isa, 2015).

Most of communities living in high flood-risk areas were infrequently concerned on the impact of flooding. The lack of awareness was actually not only found in the Indonesian community context, as the finding was also detected in, other countries, such as Germany (Kreibich et al., 2011, 2012), France (Pivot and Martin, 2002), Australia (Gissing et al., 2005), and USA (Tierney, 1995), where communities were found to be less concerned about flood risk adaptation. Thurston et al. (2008) noted that some communities believed that the implementation of collective measures in the local level had reduced the risk of flooding significantly, thereby individual-level adaptation was no longer required. Hence, community-level flood protection scheme can be identified as a defence that was relied on by the communities, in addition to their individual-level adaptation strategies.

4. CONCLUSIONS

Vulnerability index was 0.63, it indicated the medium level of vulnerability. The exposure and adaptive capacity variables were at high vulnerability level and significantly contributed in determining the vulnerability level of the northern coast of Central Java – Indonesia.

Flood adaptation can be carried through anticipation and reactive adaptation, in which each type could be practiced by public and private. Flood mitigation can be carried out through structural, non-structural and community roles.

Community-level flood protection measures are the available first line defence against the flood risk. In the northern coast of Central Java Province-Indonesia, a significant amount of funds has been invested in commissioning and maintenance of schemes, annually. However, it is important that individual properties should be equipped with the second line defence, to provide subsequent protection level for property against flood risk through community-level scheme. From the policy-making perspective, there is a propensity that the communities prefer to implement the property-level adaptation based on their flood experience.

Information related to the importance of property-level protection, the available options, and costs/benefits of the options are likely to be received optimally by the communities after a flood experience. Hence, it is important to ensure the availability and accessibility of information among the communities. Since the implementation of property-level adaptation requires cost and long-term commitments, it is important that the measures should involve the capacity to ensure the business sustainability. The post- flood situation should offer an opportunity to improve the existing building stock in terms of flood protection. The fact that the risk of flooding potentially increases in future due to climate change and other factors, the existing building stock should be kept up-to-date in terms of flood protection.

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