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COMMUNITY'S ADAPTIVE CAPACITY DUE TO COASTAL FLOODING IN SEMARANG COASTAL CITY, INDONESIA

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Abstract: Community's response and adaptive capacity is a one of the key roles on the disaster management and risk reduction program. This study is aimed to investigate the coastal community's response and adaptive capacity due to tidal flood hazard in the Terboyo Wetan Village and Trimulyo Villages along the coastline of Semarang City. These two villages are suffered from tidal flood hazards, and further consequences are land subsidence hazards as the impact of man-made activity and worsened by industrial activity. The research is inductively attaining data and concluding the result as in a descriptive manner via questionnaire. The result reveals that the local communities are aware of the tidal flood hazard, but this understanding did not manage to support their decision to leave the area. The community has adapted the tidal flood by simple physical adaptation strategy, such as increase the floor level following the water level and making small dam to blocking water enter the house. This response is not sufficient and aesthetically not proper from the environmental point of view. From the community's perception obtained during the research, it can be said that instead of taking the tidal flood as the risk, the community in the research area tends to neglect the hazard and considered that the tidal flood is no longer as threat towards their wellbeing.

Key word: community's response and adaptive capacity; coastal area; tidal flood hazard; Terboyo Wetan and Trimulyo Villages; Semarang City.

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INTRODUCTION

Local community response and community resilience toward hazard and natural disaster become an important subject on disaster management studies. The community resilience defined as the evaluation towards the community competence to adapt and or to improve their current state towards particular threads (Thomalla et al., 2007; Twigg, 2007).

The competence of the community generally addressed as the adaptive capacity. The community response and adaptive capacity can be in any form of economic development, social capital, information or communication and or community competence. Different disaster occurrence and type provokes different level of frequency and magnitude which in a way correspond with the availability of resource to cope with it. Thus, the nature of community

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response and adaptive capacity is unique and dynamic (Adger et al., 2004). It means that in particular area, the evaluation towards the adaptive capacity is essential to be carried out in order to identify the existing local community resources to cope with any other disaster occurrence.

Community response and adaptive capacity is illustrated in a form of culture setting, as argued by Gunawan (2001).

The cultural setting correlates the human adaptation to their environmental setting. The adaptation method is not easily shifting without any cultural transition (Miller and Weitz 1979; Moran, 1982; Gunawan, 2001).

Inversely, the adaptive capacity in the community is define inclusively, depends on the characteristics of wellbeing, existence of threads and local resource (Luers et al., 2003). In order to delineate the homogenous community, scholars generally address to the village level, as the smallest unit (example: Dewi, 2007; Marfai et al., 2008).

In the developing countries such as Indonesia, the village level (desa/kelurahan) generally comprise of the people who share the same tradition, occupation, and sometimes borne from the same kinship. It is reasonable since the community in the village generally lacking of know how technology and less informed to any innovation. Therefore, it is argued that in this level, the adaptive capacity assumed to be homogenous since it was built from the collective understanding.

Series of research to identify the coastal hazard management, tidal flood management and the land subsidence impact in the coastline along the Semarang city has been conducted (Marfai and King, 2007; Marfai and King, 2008a; Marfai et al., 2008).

There are abundance of literature on the coastal hazard management in Semarang City, such as Soedarsono (1996), Kobayashi (2003), Marfai (2003, 2004a, and 2004b), Dewi (2007), Directorate of Geology and Environment of Bandung and BGR (2008), and Marfai and King (2008b).

Since the 2001, it was revealed that the most common local adaptation conducted by the local community is in a form of structural or physical adaptation in their houses and any kind of building type (Arbriyakto and Kardyanto 2001). Most of the studies focus on the identification of the impact of either tidal flood or land subsidence in Semarang City. Less of the literature provide an insight of how the local community adaptation characteristics changing from time dimension and promotes the positivism approach of the coastal hazard management.

This article aimed to elaborate any significant changes towards local response in the Terboyo Wetan Village and Trimulyo Village along the coastline of Semarang coastal area. Previously, at early millennium the local adaptation is in a form of structural and physical adaptation, while there are so many up dates know- how technologies, *„how is the form of adaptation changing in the community level?"* The research tries to answer this question using descriptive analysis.

RESEARCH SETTING

The research is conducted in the prone area of land subsidence and tidal flood along the coastline in the Semarang City, Central Java Province, Indonesia. There are more than twenty villages along the Semarang City coastline suffered from the coastal inundation which produce tidal flood and enhance the land subsidence phenomena (figure 3).

Among these twenty villages, the research shall focus on the identification of the local adaptive capacity in the two villages, Terboyo Wetan and Trimulyo. The identification of the two villages is aimed to complete the information along the coastline in Semarang City in order to have complete series of data related to the community adaptation strategy.

Some villages, neighboring this two villages along the coastline of Semarang, have been investigated by previous researches Kobayashi (2003), Dewi (2007), Directorate of Geology and Environment of Bandung and BGR (2008), and Marfai and King (2008b), thus this research will complete the information related the community's response to flood hazard along the Semarang coastal area.

The location of these two villages is relatively strategic for the industrial area and other commercial type of land use. The land use of the two villages are varied, ranging from the settlement, terminal, freight terminal, middle industrial estate, hospital, and university.

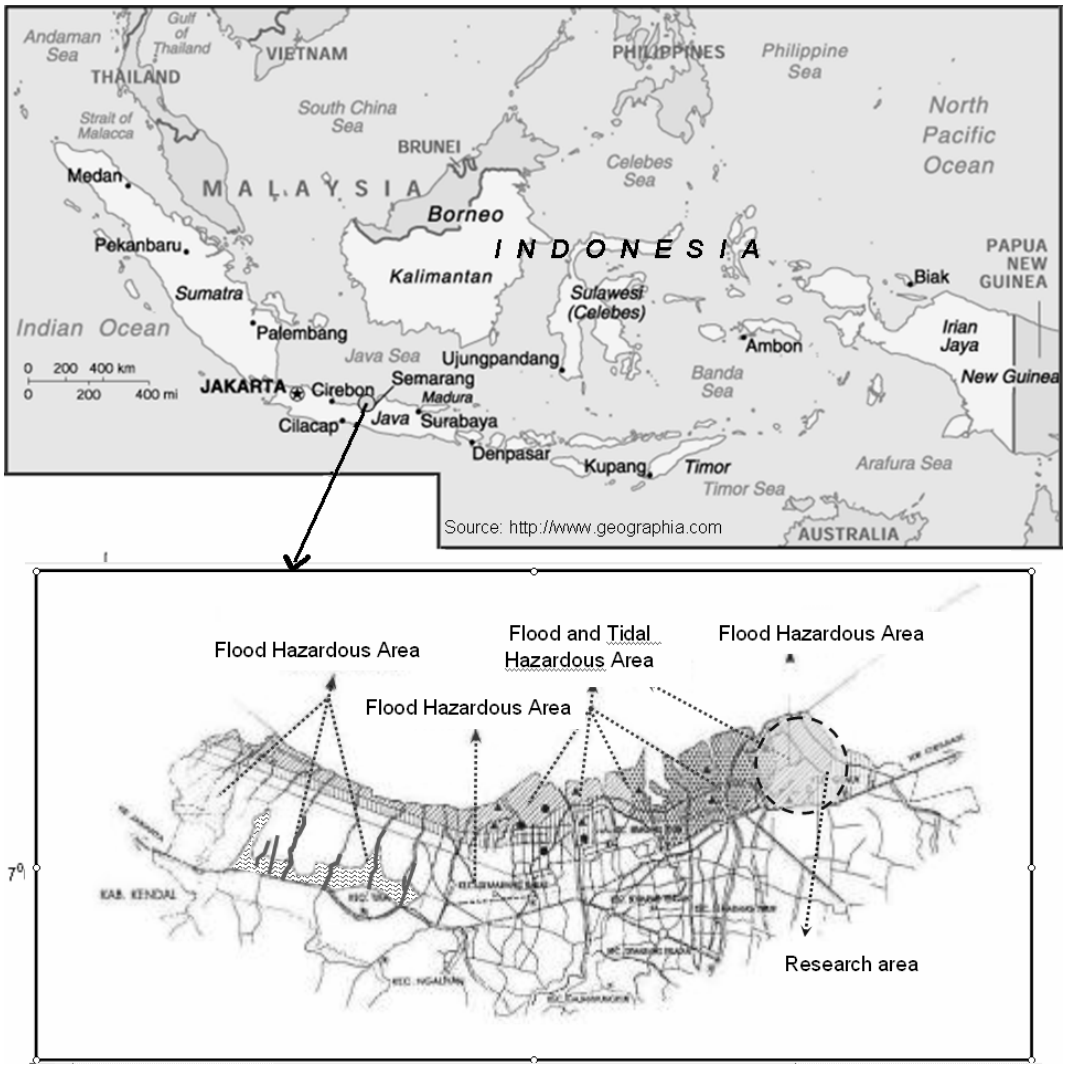

Figure 1. The Distribution of Hazardous Area along the coastline in Semarang City
(Source: Regional Development Board, Semarang Municipality, 2002)

The strategic commercial land use is signified with the densely populated area per hectare (table 1).

Table 1. Demographic Condition of Research area
Source: Regional Development Board, Semarang Municipality, 2002

Village	Total Inhabitant	Width (Ha)	Density per (Ha)
Terboyo Wetan	1690	127.5	13.3
Trimulyo	4135	295.9	14.0

The community occupation relatively relied upon the environmental setting such as fisherman, harbor, industrial activities, less agricultural activity and recreational activities.

Administratively, these two villages are categorized as the rural area, however, from the physical identification the area may be categorized as urbanized area. As argued, that there are at least four types of flooding in the urban areas: 1) localized flooding occurs in slum area because of the insufficient draining system; 2) small streams in urban areas rise very rapidly due to heavy rainfall; 3) major rivers over the critical height above the land; 4) wet season flooding.

None of these category occurred in the Terboyo Wetan and Trimulyo (figure 2).

Figure 2. Inundated Area along the Semarang Coastline
(Source: Marfai and King 2008c)

Both villages are experiencing tidal flood due to the rise of tidal sea and sea surge, affect the sea level rise over the critical height above the coastal land (Marfai et al., 2008).

The tidal flood highly perceived as the frequent type of natural hazard that should be cope with. The community aware of the tidal flood, however, the severe impact of land subsidence is perceived moderately as longer terms of impact.

The Terboyo Wetan village and Trimulyo village is located in the western part of the coastline (figure 3a).

The elevation of the villages is relatively lower than the coast area, with the darker black color. Additionally, from the figure 3b, the darker red color to the beige yellow color indicates the unstable land (subside up to 8 cm per annual, Directorate of Geology and Environment of Bandung and BGR (2008)), whilst the green color express relatively stable ground (subside 0 cm per annual). Both of the research area is delineated in the red color; it means that the area is suffered from worse land subsidence.

The land subsidence in Semarang City is assumed as the result of the mix natural condition and induced by the human activity. It is predicted that the land subsidence in Semarang City was induced by the usage of groundwater, which exceeds the quantity of natural replenishment. Consequently, water level in the alluvium clay layers and sand sedimentation – composition of the coast area – is declining causing the land subsidence.

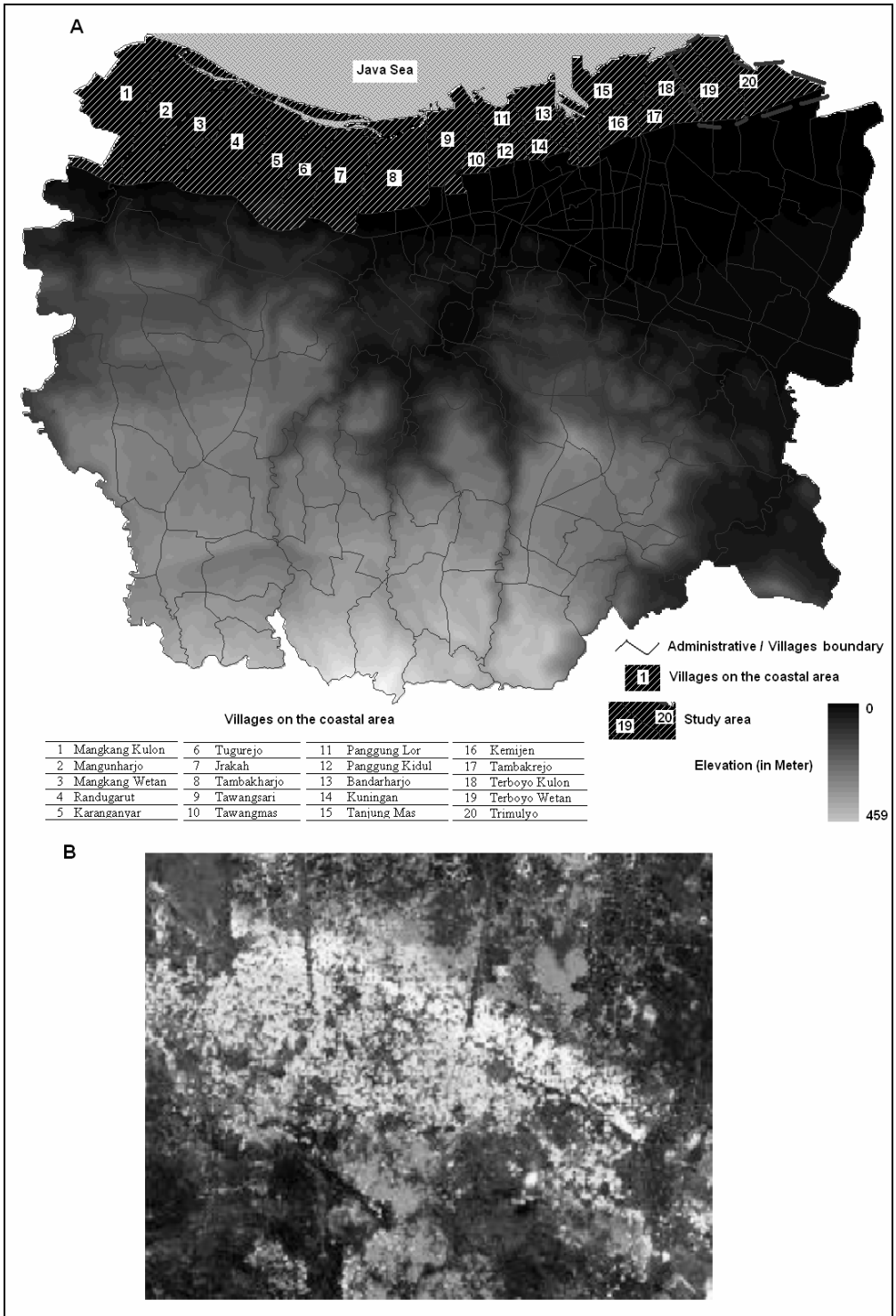

Figure 3. a) Administrative boundaries and DEM data of Semarang,
b) Subsidence in the Semarang coastal area

As noted by Marfai and King (2007), that the prediction of the land subsidence in Semarang City is increasing in longer terms. Subsequently after the sea level rise phenomena and exceeding groundwater usage, it is projected that the area may loss 328.5 hectare per year in 2010 and its getting worse by the year 2020 with total loss of 1464 hectare per year. It means that the area shall suffer from further economic loss and other unquantifiable loss. It was predicted that the public utilities shall suffer the most due to the land subsidence are transportation network, industrial area and warehouses (Kobayashi, 2003).

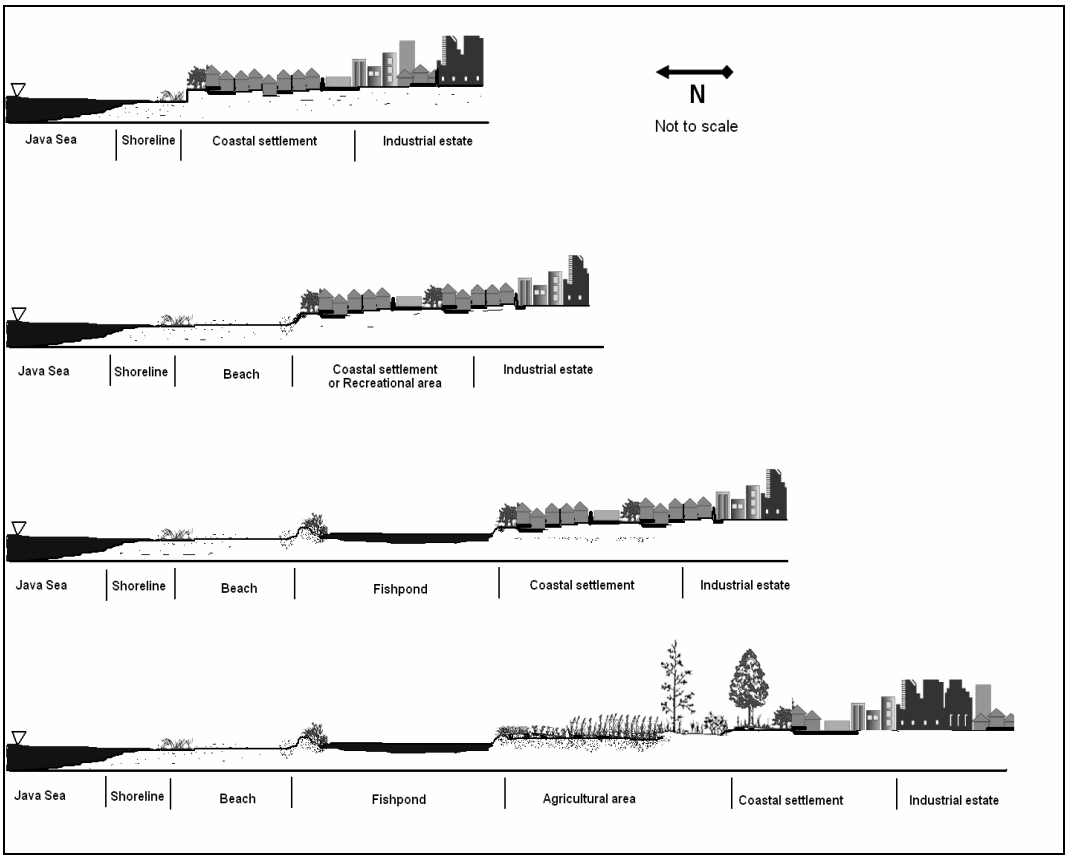

Figure 4. Type of land use system in the coastal area of Semarang City
(Source: Marfai and King 2008b)

It is projected that more people will settled in the research area due to its strategic location. The typified land use system along the coastline can be seen from the figure 4.

Spatially the research area is important to be protection area however the land occupation is not easy to be stopped. The juxtaposition of having the coastline productive at the same time being preserved is merely on the blueprint. The community facing serious difficulties to avoid the natural impact either sea surge, tidal inundation, or the land subsidence.

METHODOLOGY

Summarized from the previous research setting, the research area suffered from unfortunate natural condition – lied in the low land of coastline – hit by immense tidal surge which leads to tidal flooding. At the same time, to fulfill human basic necessity the groundwater keep depleting and induce further natural catastrophe in the longer terms, such as the land subsidence. It means

that the current capacities in the research area should be identified in order to provide better insight in the coastal hazard management in the future.

The research is inductively attaining data and concluding the result as in a descriptive manner. The analytical technique applied to evaluate the data is statistic inferential, because this research simplified the population into the sampling unit. Statistic inferential or inductive statistic is a technique of statistic which applied to observe data from the sampling unit, and conclude the result for the whole population (Sugiyono, 2007).

The unit of analysis is multi level; the household are taken to represent the condition in an area respectively. The questionnaire is applied for the identification of local adaptive capacity in the research area. The content of the questionnaire was adopted from previous research by Dewi (2007) and Marfai et al., (2008).

The questionnaire was applied by Marfai et al., (2008) in the Bandarharjo and Tanjung Mas Villages, Semarang Coastal area. Our research is conducted in Terboyo Wetan and Trimulyo Villages. By using the similar questionnaire, we expect to have a comprehensive data along the coastline of Semarang City in the future. Detailed research method can bee seen in the figure 5.

The field observation is conducted to identify the real condition in the community level (village or des a / kelurahan). The primary data are obtained via in depth interview and semi-closed questions on the risk perceptions and the methods of response and adaptive capacity. Total respondent are 40 people with the assumption of validity of statistical analysis (n > 30).

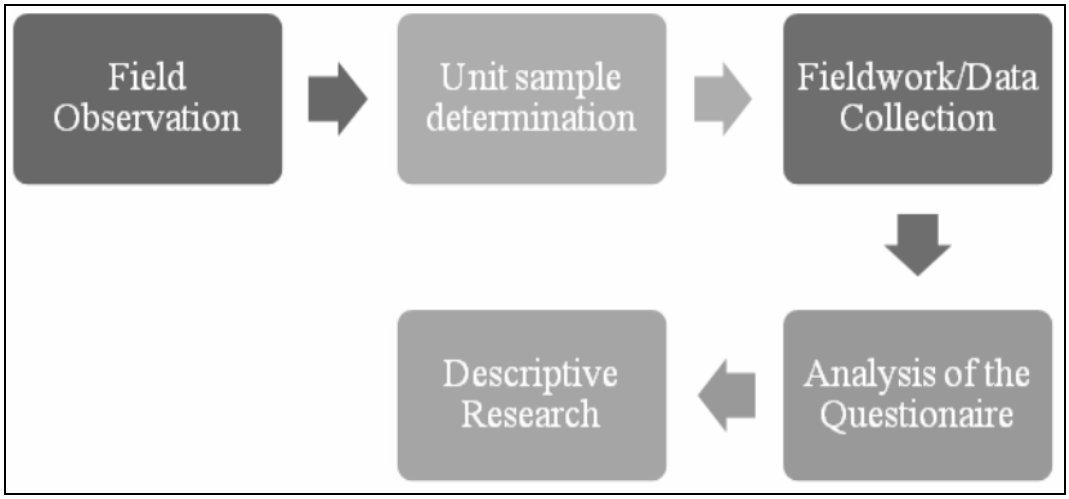

Figure 5. Research Method

The questionnaire comprise of several important element subjected to the research goals, such as: 1) General information about the respondent, 2) Respondent perception on tidal flood hazard in their area, 3) Impact of the tidal flood hazard, 4) Affected building / supra-structure / infrastructure due to the tidal flood hazard, 5) Physical adaptation, and 6). Task force to deal with the tidal flood hazard.

RESULT AND DISCUSSION

CHARACTERISTIC OF THE RESPONDENT

Local adaptive capacity in Terboyo Wetan and Trimulyo village are evaluated using the questionnaire. The characteristics of the respondent are shown in the table 2.

There are 40 respondents which comprise of 20 respondents from Terboyo Wetan and 20 respondents from Trimulyo. Based on the demographic condition, there are 67.5% of male respondent,

and most of the respondent are in productive ages 18 – 65 years. Predominantly, the respondents are graduated from the secondary school (52.5%), higher education (35%) and non-education (12.5%).

Responding to the characteristics of the environment, most of respondent work in the industry as a labor and farmer. Small share of the respondent is working as the government employer and other type of jobs.

As noted earlier, the type of culture and existing wellbeing should be describe to grasp the potential resource as the origin of capacity in particular area. The type of housing also described in the characteristics of respondent in order to support the wellbeing of the respondent despite the type of occupation.

Table 2. Characteristics of Respondent

Characteristic	Number of respondents	Percent
Sex:		
Male	27	67.5
Female	13	32.5
Age:		
18-25	22	55
25-45	9	22.5
45-65	9	22.5
> 65	0	0
Educational level:		
Non education-primary school	5	12.5
Secondary school	21	52.5
High school and University	14	35
Occupation:		
Industry labor	19	47.5
Farmer/Fisherman	10	25
Government employer	8	20
Other jobs	3	7.5
Type of housing:		
Permanent	34	85
Semi-permanent	6	15

COMMUNITY'S PERCEPTION OF TIDAL FLOOD HAZARD

Local communities are aware of the natural hazard especially tidal flood. But this knowledge did not manage to support their decision to leave the area. The reason is merely on the lack of alternatives, and other classical accessibility reasoning.

Table 3. Distribution of people's perception of tidal flood

People's perception of tidal flood	Number of respondents	Percent
Knowledge of tidal flood hazard:		
Aware that the area is subject to tidal flooding	32	80
Not aware that the area is subject to tidal flooding	8	20
Motivation for their continued stay:		0
Have no other alternatives due to lack of capital	22	55
Accessibility to city centre, industrial estate, public facilities and close to their working place	15	37.5
Believe related culture and they were born in the area	3	7.5
The most often of tidal flood depth:		0
<25 cm	4	10
25-50 cm	12	30
50-75 cm	18	45

75-100 cm	6	15
>100 cm	0	0
The most often of the duration of tidal flood:		0
< 3 hour	5	12.5
3-6 hour	18	45
6-9 hour	12	30
>9 hour	5	12.5
Cause of inundation:		0
Land subsidence	18	45
Poor drainage system	12	30
Sea level rise	6	15
Have no idea	4	10

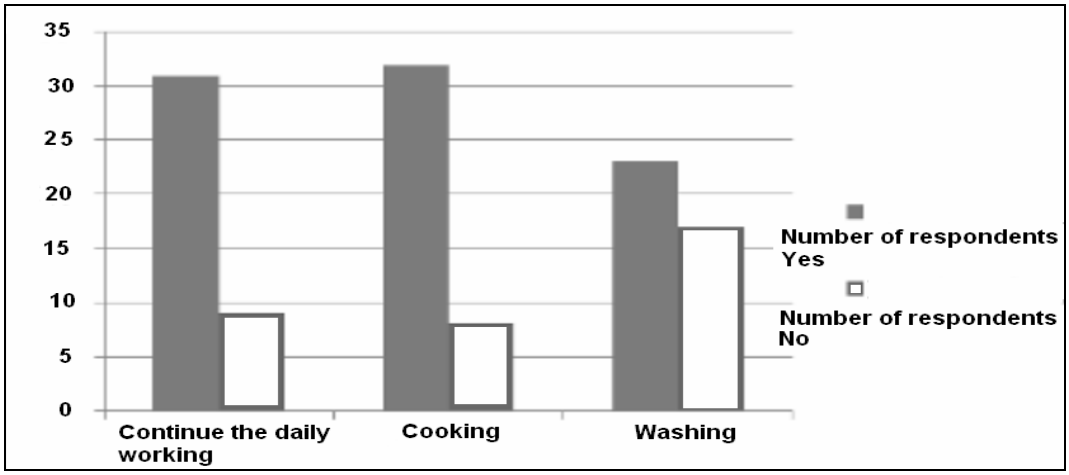

Figure 6. Impact of tidal flood to daily activities

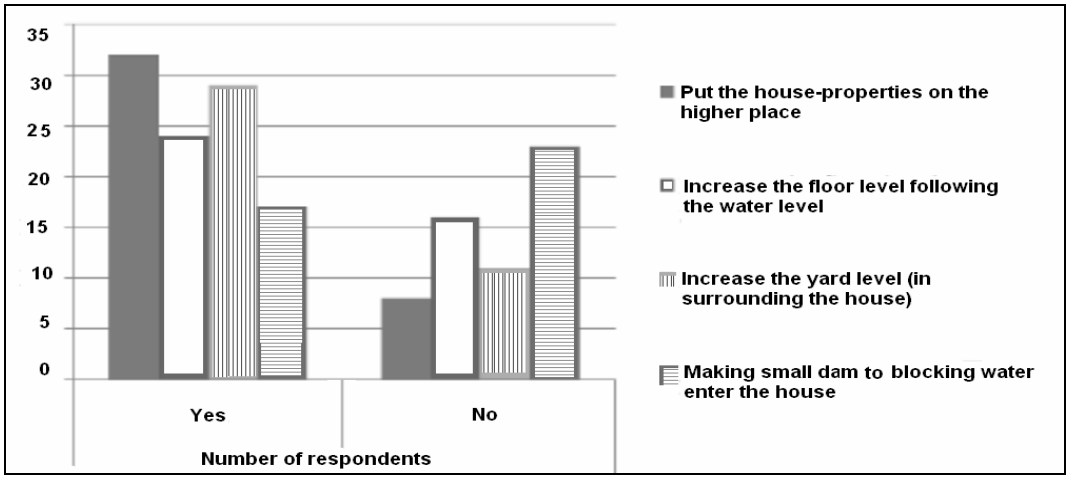

Figure 7. Physical adaptation by respondents

The community express that the current research area is close to city centre, industrial estate, public facilities, and to their working place. Small share of the respondent believes that they should stay in the area due to the bounding with the previous generations and other kinship matter.

Tidal flood in the research are often occurred for more than 3 hours, and lasted for more than 6 to 9 hours. The depth of the tidal flood is relatively from 25 cm to 75 cm.

The community able to identify the cause of the tidal flood, 45% reveals that land subsidence is the main cause of inundation, 30% express that the poor drainage system as the cause, while other 15% deem that sea level rise is the main cause of the inundation.

Most of the community express that the natural system as the leading factor causing the inundation. The elaboration towards the distribution of people's perception towards tidal flood can be seen in table 3.

In addition, the tidal flood occurrence did not force the community to leave their activities, on the other hand, they continue working and doing daily activities. It means that the tidal flood generally occurred and the community did not distract over the tidal flood occurrence. Figure 6 - 7 reveals the impact of tidal flood to daily activities.

COMMUNITY'S RESPONSE AND ADAPTIVE CAPACITY

Since the occurrence of tidal flood did not distract the daily activities, it means that the community relied upon some adaptation methods, which they believe able to rescue their belongings. The physical adaptation methods relied upon some technique, such as: put the house property on the higher place – the most economical methods – increase the yard level in surrounding house, increase the floor level and making small dam to block the water from entering the house; for the details see figure 8.

Figure 8. a) heightened housing foundation; b) inundated house; c) small dyke in front of the house; d) heightened housing type (rumah panggung)
(Source: photo courtesy: Marfai 2009)

The economical factors are essential in the preference of adaptation method. More than 50% respondent claimed to put their belongings on the higher place so that the tidal flood will not ruin it. Subsequently, the respondent is familiar with the type of increasing the yard level, since it is more efficient and relatively cheaper than increasing the floor level. At the latest order, the technique of making small dam to block the water is also available.

As the Figure 8-a, describe that to heightened the housing foundation the type of house is relatively different with those house in figure 8c. The social economic condition plays an important role on how the community applied the local adaptation. The traditional and cultural setting in the community is relatively stagnant, each generation pass through some methods which are relatively applied by the next generations. These methods had been lasted for almost a decade it means that the methods of physical adaptation are not dynamic and quite stable as long as the cultural and socio-economic condition did not change drastically.

The physical adaptation may be very traditional, efficient and economically feasible for the community, however the adaptation technique may be classified to improper technique when it comes to aesthetic point of view and health point of view. The unhealthy environment created by the tidal flood and the improper technique is sufficient only temporal condition, however for any longer circumstance it was not fit at all. It is important that the government identify the existing institutional setting to provoke better condition for the research area.

Moreover, Structural measure and non-structural measure to address the problem has been initiated by the government. The structural measure includes the improvement of drainage system, the pumping stations, the reshaping of land surface and land reclamation along the beach. The non structural measure includes the improvement of the neighborhood by coastal planning and management (Marfai et al., 2008).

Detailed task force related to tidal flood hazard can be seen in the table 4.

Table 4. Task force related tidal flood hazard

Subject	Plan and measures	Agencies
Coastal land use	Detail coastal master plan Monitoring land use change on the coastal area Law enforcement and implementation of the regulation system	Regional development board Public work department
Garbage disposal	Improvement garbage disposal system Involving local community on the public awareness system	Public work department Municipality health office Community
Tidal flood prevention	Improving of the polder system Improving number of pump stations	Regional development board Public work department
Land subsidence	Monitoring land subsidence Monitoring groundwater extraction	Public work department Mining and geology department
River and drainage system	Detail drainage master plan Improving drainage capacity and reduce sedimentation on the drainage system	Regional development board Public work department Water resources department

The community's response and physical adaptation strategy is fourfold respectively due to economic feasibility, level of understanding and simplicity of the technique.

The physical adaptation is quite stable for longer terms since it involved the other resource such as financial resource per household. Rather to have better improved environment, the community from time to time live in the deteriorating environment, which cannot support any better wellbeing. Thus, the physical adaptation is seemingly neglected and lack of any update technology.

However, since the community aware of any up-date information regarding the correlation between sea level rise, tidal inundation and land subsidence, they appeared open

toward any empowerment program. By doing so, the government could at least approach the community to keep up to date about their deteriorating environment, thus any adaptation should not just relied on the economic feasibility but also to the health consideration and any aesthetic environment consideration.

CONCLUSIONS

The community is independent in finding their solution towards the hazards in the area. The hazard is no longer considered as threat towards their wellbeing. Instead of taking it as the threat or risk, the community in the research area tends to neglect the hazard.

The community's response and adaptive capacity in the research area is unique, depends on the type of the economic background and know-how technology. The coastal community has responded the flooding by physical adaptive capacity, which is quite stable from time to time. Therefore, such an institutional adaptive capacity, such as governmental action plan is needed in order to have a better strategy and response toward tidal flood. More training, forum group discussion, and other community empowerment will be an advantage to improve the community understanding and enhance their know-how technology.

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REFERENCES

Adger W. N., Brooks N., Bentham G., Agnew M., Eriksen S. (2004), *New Indicators of vulnerability and adaptive capacity*. Tyndall Centre for Climate Change Research;

Arbriyakto D., Kardyanto D. (2001), *Identifikasi Pengukuran Kerugian Fisik Bangunan Rumah dan Kerugian Sosial Penduduk Kawasan Pantai Kota Semarang. Kerugian pada Bangunan dan Kawasan Akibat Kenaikan Muka Air Laut pada Kota-Kota Pantai di Indonesia*;

Dewi A. (2007), *Community-based analysis of coping with urban flooding: a case study in Semarang, Indonesia.* M.Sc. thesis, ITC, Enschede, The Netherlands;

Gunawan B. (2001), Kenaikan Muka Air Laut dan Adaptasi Masyarakat. Seminar Dampak Timbal Balik Antar Pembangunan Kota dan Perumahan dan Lingkungan Global, Dampak Kenaikan Muka Air Laut pada Kota-Kota Pantai di Indonesia. Bandung.

Kobayashi H. (2003), *Vulnerability assessment and adaptation strategy to sea-level rise in Indonesian coastal urban areas. Tsukuba-city, Japan*, National Institute for Land and Infrastructure Management; Ministry of Land, Infrastructure and Transport;

Luers A., Lobell D., Sklar L., Addams C. L., Matson P. (2003), *A method for quantifying vulnerability, applied to the agricultural system of the Yaqui Valley, Mexico*, Global Environmental Change 13 , 255 - 267;

Marfai M. A., (2003), *GIS modelling of river and tidal flood hazard on a coastal urban Area, a case study: Semarang city, Central Java, Indonesia*, M.Sc Thesis ITC, Enschede, The Netherlands;

Marfai M. A., (2004a), *Tidal Flood Hazard Assessment: Modelling in Raster GIS, Case in Western Part of Semarang Coastal Area*, Indonesian Journal of Geography, Vol 36, Number 1, June 2004. ISSN 0024-9521 Page 25-38;

Marfai MA., (2004b), *Spatial Modelling of Tidal Flood Hazard on East Semarang Coastal Area*, Journal of Forum Geografi, Indonesia. Vol 18, No 1, July 2004. ISSN 0852-2682. Page 60-69;

Marfai M. A., King L. (2007), *Monitoring Land Subsidence in Semarang, Indonesia*, Environmental Geology, 651 - 659;

Marfai M. A.. King L. (2008a), *Coastal flood management in Semarang, Indonesia*, Environmental Geology 55: 1507-1518;

Marfai M. A., King L. (2008b), *Potential vulnerability implications of coastal inundation due to sea level rise for the coastal zone of Semarang city, Indonesia*, Environemntal Geology 54: 1235-1245;

Marfai A., King L. (2008c), *Tidal inundation mapping under enhanced land subsidence in Semarang, Central Java Indonesia*, Natural Hazards, 93 - 109;

Marfai M. A., King L, Sartohadi J., Sudrajat S., Budiani S. R., Yulianto F. (2008), *The impact of tidal flooding on a coastal community in Semarang, Indonesia*, Environmentalist, 28: 237-248;

Miller E. S., Weitz C. A. (1979), *An Introduction to Anthropology*, New York: Prentice Hall Inc;

Moran E. F. (1982), *Human adaptability: An introduction to Ecological Anthropology*,Westview Press Inc: Colorado;

Soedarsono S. (1996), *Impact of flood inundation due to sea level rise on the settlement area in Semarang City*, (in Indonesian). Master Thesis, Geography Faculty, Gadjah Mada University, Indonesia;

Sugiyono S. (2007), *Metode Penelitian Kuantitatif Kualitatif Dan R&D*, Bandung: PT Alfabeta Bandung;

Thomalla F., Downing T., Spranger-Siegfried E., Han G., Rockstrom J. (2007), *Reducing human vulnerability to climate-related hazards: Towards a common approach between the climate change adaptation and the disaster risk reduction communities*, Swedia: SEI Risk, Livelihoods and Vulnerability Programme;

Twigg J. (2007), *Characteristics of a Disaster-Resilient Community: A Guidance Note*, DFID Disaster Risk Reduction Interagency Coordination Group;

*** (2002), *Development Planning Board (DPB), Semarang city planning 2000–2010 (in Indonesian)*, Development Planning Board of Semarang, Government of Semarang, Indonesia;

*** (2008), *Directorate-of-Geology-and-Environment-of-Bandung (BGR)*, Detection of land subsidence in Semarang/Indonesia using persistent scatterer interferometry (PSI). Retrieved October 28, 2008, from http://www.bgr.bund.de/nn_337150/EN/Themen/GG__Fernerkundung/Projektbeitraege/indonesia__mitigation__georisks__psi.html

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