ISSN 0024-9521
IJG Vol. 45, No.1, June 2013 (24 - 37)

INDONESIAN JOURNAL OF GEOGRAPHY

HAZARD ASSESSMENT TO TIDAL FLOOD INUNDATION (Case Study: Tegal Municipality)

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ABSTRACT

Tegal Municipality is one of coastal cities suffering from tidal flood inundation. This paper aims to assess current and future hazards to understand the extent of the inundation. Field observation, questionnaires, in-depth interviews, as well as secondary data collection have been great tools in achieving the research objectives. It is found that households in research location are dominated by low hazard indexes. The results are influenced both by current autonomous and planned adaptation strategies conducted by affected households and governments. It is also found that due to its relatively low-lying area, Muarareja is the first village affected by inundation depth increase. A 10 cm inundation depth scenario results in the inundation of more than 85% of Muarareja's total area. Meanwhile in Tegalsari, Mintaragen, and Panggung, a 10 cm inundation depth scenario results in inundation of less than 21% of total areas.

Keywords: Tegal Municipality, Hazard Assessment, Tidal Flood Inundation

ABSTRAK

Tegal Kota adalah salah satu kota pesisir menderita genangan banjir rob. Makalah ini bertujuan untuk menilai bahaya saat ini dan masa depan untuk memahami sejauh mana genangan. Observasi lapangan, kuesioner, wawancara mendalam, serta pengumpulan data sekunder telah alat besar dalam mencapai tujuan penelitian. Hal ini ditemukan bahwa rumah tangga di lokasi penelitian didominasi oleh indeks bahaya rendah. Hasilnya dipengaruhi baik oleh strategi adaptasi saat ini otonom dan terencana yang dilakukan oleh rumah tangga yang terkena dampak dan pemerintah. Hal ini juga menemukan bahwa karena relatif dataran rendah nya, Muarareja merupakan desa pertama yang terkena dampak kenaikan kedalaman genangan. A 10 cm genangan hasil skenario mendalam dalam genangan lebih dari 85% dari total wilayah Muarareja itu. Sementara di Tegalsari, Mintaragen, dan Panggung, 10 genangan hasil skenario kedalaman cm genangan kurang dari 21% dari total area.

Kata kunci: Tegal Kota, Pengkajian Hazard, Pasang Surut Banjir Genangan

INTRODUCTION

Sea level rise, as one of the impact of climate change, is affecting the tidal flood inundation depth and extent, brings potential threat to community, which can be death, injury, illness, threatened life, refugees, destruction or loss of property, and disruption of community activities. Moreover, sea level rise is now differently affecting the sustainability of coastal cities around the globe, with least developed and developing countries as regions suffering the most from the impacts due to lack of information, abilities, and resources to adapt [*UNFCC*, 2007].

Tegal Municipality is one of low lying coastal cities in northern coastal area of Java Island suffering from tidal flood inundation. Tidal flood inundation has been disturbing the activities and the utilization of infrastructures near coastal area. Moreover, other potential natural and man-made resources are threatened from the loss due to inundation [*Marfai*, 2011].

Local households and government of Tegal Municipality have been undertaking various measures in controlling tidal flood inundation, both structurally and non-structurally [*Panturanews.com,* 2012; Suaramerdeka.com, 2011]. However, these efforts do not help much in reducing the impacts of tidal flood inundation due to a partial approach in managing the tidal flood inundation. Despite various autonomous adaptations of local households [*dprdkotategal.org*, 2011]; [*Panturanews.com,* 2012], tidal flood inundation encroachment is still occurring so that affected households need to pay a large cost in overcoming danger of flooding.

This paper focuses on assessing the current and future tidal flood inundation hazard development by means of inundation mapping. Several scholars have conducted coastal flooding mapping under different tidal flood inundation scenarios in different areas of Central Java [*Marfai and King*, 2008; *Marfai*, 2011; *Ward et al*., 2011; *Mardiatno et al*., 2012], yet there is only limited number of publication elaborating tidal flood inundation phenomena in Tegal Municipality [*Bappeda 2010a*; 2010b). Tidal flood inundation mapping has been useful method to understand the affected areas under certain inundation depth as well as the extent of the impacts. Therefore, the inundation mapping is also considered an important task to support disaster risk reduction efforts in Tegal Municipality. Coastal community of Tegal Municipality, especially those who are affected by tidal flood inundation, is able to gain information related to future development. Results of research also provide insight in identifying, evaluating, and prioritizing adaptation strategies in coastal area, particularly in the local level. Figure 1 shows research activities.

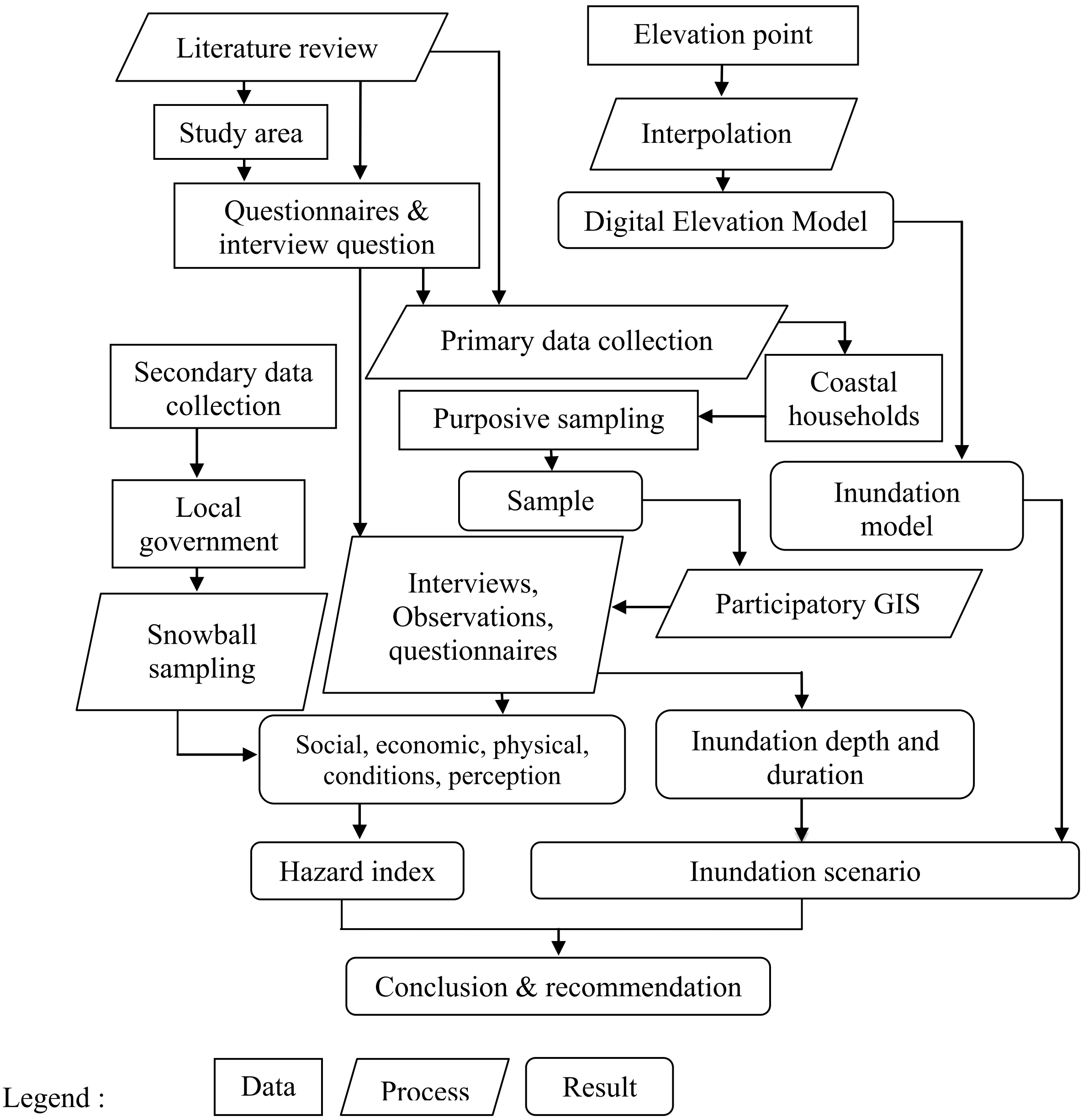

Figure 1. Research Activities

THE METHODS

Fieldwork activities were conducted in Muarareja and Tegalsari villages (Tegal Barat sub-distric) and Mintaragen and Panggung villages (Tegal Timur sub-distric) of Tegal Municipality. Primary data was collected by questionnaires and in-depth interviews. Secondary data were collected by institutional survey to obtain information related to tidal flood and socio-economic condition in research location. Secondary data can be formed as governmental reports (Bappeda, PU, and Kesbangpollinmas), statistical reports (BPS), and previous researches.

Collected data were processed by using *GIS* (Geographical Information System) raster and vector based software. *DEM* data and raster based GIS application proved to be effective and efficient tools in generating inundation map and supporting the extent of inundation impact [*Marfai*, 2011]. *GIS* raster and vector environment tools were used to model future tidal flood inundation encroachment, and to generate supporting maps. Moving average analysis and iteration mathematical operation were utilized in generating tidal flood inundation model. Variables, indicators, and data sources are presented in Table 1.

Table 1. Variables, Indicators, and Data Sources

Variables and Indicators	Data Source
Hazard	
Tidal flood depth and duration	DEM, field observation , questionnaires and interviews, secondary data
Perception	
Households' and governments' perception.	Questionnaires and interviews.

Sampling Method

Non-probability sampling was highly utilized in achieving research objectives. Questionnaires were distributed based on purposive sampling to affected households. Until now, the number of affected households in research location is unknown. There is no special report mentioning the number of affected households to tidal flood inundation. As many as 108 household respondent samples are justified adequate to represent affected households.

Hazard Assessment

Current hazard was measured by participatory mapping and fieldwork observation, in order to understand the depth and duration of tidal flood encroachment. Tidal flood inundation as hazard is measured by three indicators, namely tidal flood depth inside house, on street, and tidal flood inundation duration. Inundation depth and duration are acquired by questionnaires and in-depth interviews. The higher inundation depth or the longer inundation duration are then associated with worse situation.

After obtaining the data, both classes of tidal inundation depth and duration are used to calculate hazard index. It is assumed that flood duration and depth on streets and inside house contribute the same damage, so that both indicators are weighted same, as shown in Table 2.

Table 2. Weight of Hazard Indicators

Indicators	Weight	Low	Medium	High
		1	3	5
dpt_insd	0.33	A	B	C
dpt_outs	0.33	D	E	F
inu_drtn	0.33	G	H	I

Information: dpt_insd: inundation depth inside house, dpt_outs: inundation outside house, inu_drtn: inundation duration

The tidal flood hazard index is created by classification as shown in Table 3.

Table 3. Classification of Hazard Index

Degree of hazard	Numerical range
Low	1 – 1,66
Medium	1. 67 – 2.33
High	2,34 – 3

Example: House 3 = (0.33*1) + (0.33*3) + (0.33*5), which is equal to 1.98 (medium hazard).

RESULT AND DISCUSSION

Informations of hazard perception comprised of tidal flood inundation duration, inundation depth from ground, and inundation depth inside house, were collected through questionnaires. Details of the collected information are presented in Table 4.

Table 4. Households' Hazard Perception

Inundation Duration		Inundation Depth inside House	
< 1 hour	2.78%	< 1cm	19.44%
1 -2 hours	5.56%	2 – 10 cm	35.19%
2 – 3 hours	25.93%	11 – 19 cm	2.78%
3 – 4 hours	28.70%	20 -28 cm	13.89%
4 – 5 hours	19.44%	>28 cm	2.78%
> 5 hours	17.59%	not enter	25.93%
TOTAL	100%	TOTAL	100%

Inundation Depth from Ground	
< 5 cm	12.04%
5 – 10 cm	38.89%
11 -16 cm	14.81%
17 – 22 cm	16.67%
23 -28 cm	6.48%
> 28 cm	11.11%
TOTAL	100%

Source: Fieldwork (2012)

Tidal Flood Inundation Duration

Tidal flood inundation duration refers to the range of time from the onset of inundation, the inundation itself, the sign of no increase in inundation extent, until the onset of the withdrawal of tide. Although it is uncertain, this time range is associated range between households started to feel that water are trespassing into their surrounding environment and the time when the house owners started to mop and dry wet floor of their houses. It is assumed that the longer duration of tidal flood inundation, the severe of its impact to building materials and contents damage.

The perception of households to tidal flood inundation duration varies from place to place, which can be influenced by the relative elevation of a place to its surroundings and the function of discharge channels. Most households mentioned that the duration of tidal flood inundation from its high tide until low tide is 3 hours 1 minute – 4 hours (28.7%). In certain locations, due to their low-lying elevation or insufficient discharge channels, the inundation stays longer, as stated by Tony (35, Mintaragen), *"the inundation starts to accumulate from 3 pm until 6 pm, it fills all the water channels until full and then the water creeps into streets and houses, then the inundation lessened at about 10 pm"*. In some places inundation water usually dries through evaporation.

The often occurrences of inundation caused by tidal flood in northern coastal area of Tegal Municipality indicate the insufficient condition of drainage rivers and channels. Moreover, the mouths of rivers equipped with breakwater provide the estuaries with sand sedimentation which hampers flow of water from river to sea. These facts, somehow, increase duration of tidal flood inundation in surrounding areas.

Average of Tidal Flood Inundation Depth from Ground

Most households perceived that the average depth of tidal flood from the ground range from 5 – 10 cm (38.89%). In addition, there were quite significant numbers of households mentioned that the inundation depth ranges from 11 – 16 cm (14.81%) and 17 – 22 cm (16.67%). The higher the inundation depth from ground is associated the higher risk of building materials, contents, and outside properties. Figure 2 shows different pictures of inundation depth from place to place.

Figure 2. Different Level of Inundation Depth from Place To Place: Inundation Occurs in Low Elevation Streets (Tegalsari - left), Inundation Encroaches to House with Relatively Low Elevation (Muarareja - right) *Source*: Fieldwork (2012)

Average of Tidal Flood Inundation Depth inside House

The perceived tidal flood inundation depth inside houses ranges from 2 - 10 cm (35.19%). Some households mentioned that the inundation inside houses is less than 1 cm (19.44%). The permeation of water from pores of wall or floor is termed by local households as *nuthuk*. Furthermore, some households mentioned that nowadays tidal flood does not inundate inside their houses due to certain efforts in adaptation (25.93%). It is assumed that the higher tidal inundation depth inside house, the higher risks of building materials and contents. Figure 3 shows different tidal flood inundation inside houses.

Hazard Index

Hazard index of households is derived from three indicators, namely tidal flood inundation duration, depth from the ground, and depth inside house. It is assumed that hazard index has positive correlation with risk index. Therefore, the higher hazard index, then the higher the value of the risk index.

Although Muarareja is located in lower-lying elevation compared to other villages, dominantly, observed households in Muarareja have low hazard index (53.85%). Various adaptation measures by local households and government to reduce inundation duration and depth, such as by increasing floor and street elevation, fish pond and river dyke establishment, and water gates assembly at mouth or river connected to sea and in drainage channels connected to fish ponds or rivers, are reasons for this result. It was common to find new houses built with floor elevation adjusted higher than perceived average level of tidal flood inundation in Muarareja.

Most observed households in Tegalsari, Mintaragen, and Panggung have low hazard indexes, which are 41.67%, 46.51%, and 56.25% consecutively. The result is due to certain adaptation measures conducted by households and government, such as floor and street elevation, availability of water gates, and river dykes establishment. More information is presented in Table 5.

Figure 3. Different Level of Inundation Depth inside Houses: A Lady Pinpoints The Level of Water Inundated Her House (Mintaragen - left), Water Inundated One of Houses (Tegalsari – right) *Source*: Fieldwork (2012)

Table 5. Hazard Index

Villages	Class	Hazard	
		Number	Percentage
Muarareja	Low	7	53.85
	Medium	3	23.08
	High	3	23.08
Tegalsari	Low	15	41.67
	Medium	8	22.22
	High	13	36.11
Mintaragen	Low	20	46.51
	Medium	8	18.60
	High	15	34.88
Panggung	Low	9	56.25
	Medium	4	25.00
	High	3	18.75

Source: Fieldwork (2012)

Scenario of Tidal Flood Inundation

The models described the inundated land use in three different scenarios, 10 cm, 40 cm, and 100 cm. The models were proposed with certain assumptions, including (a) there is no further efforts, whether from households or governments, to minimize impact of tidal flood inundation, (b) there is no major events that can change the topography of research location, such as earthquake or volcano eruption.

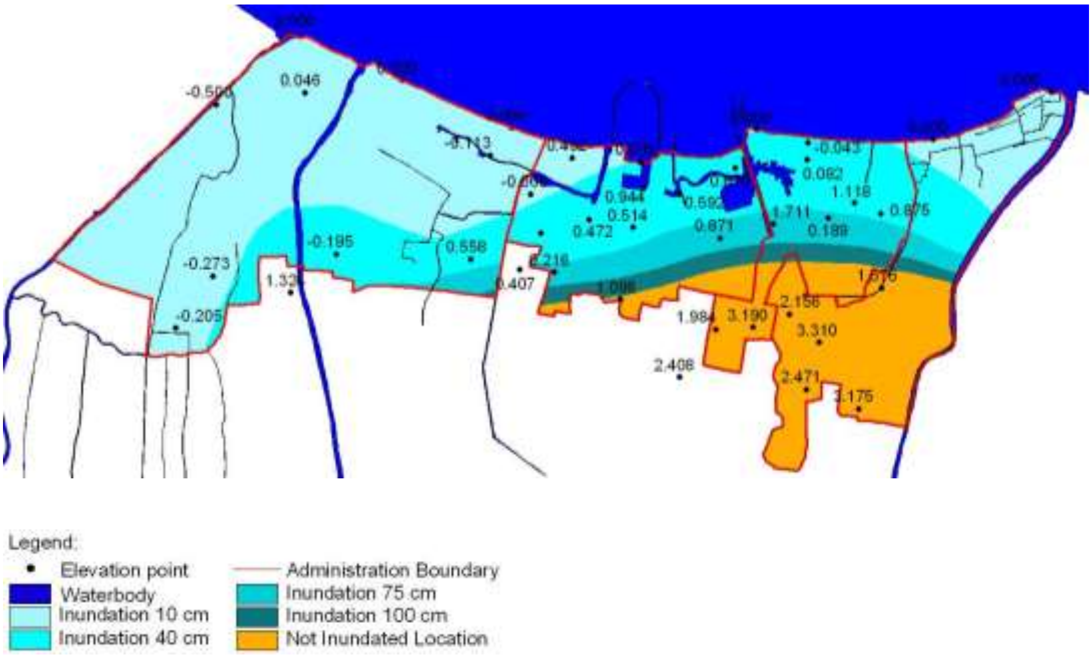

Figure 4. Inundation Scenario – Source: Data Analysis (2012)

Impacts of the tidal flood rise are varies between villages. Muarareja was predicted as the first area to be affected by tidal flood inundation rise. In Muarareja, the 10 cm tidal flood scenario results in inundation of more than 85% of total area of Muarareja (approximately 5,131,155.48 m^2). This result was due to its low-lying location. Fishpond, as dominant land use (81.3%) directly connected to sea, exacerbates the current tidal flood inundation risk in Muarareja. The rise of inundation depth subsequently threatened the livelihood of households, particularly those relying in fishponds as source of income. Furthermore, a 40 cm tidal flood inundation scenario resulted in more than 95% of total area in Muarareja.

In Tegalsari, 10 cm tidal flood rise resulted in quite significant inundation to fishpond (155,037.23 m^2), open space (24,387.08 m^2), and settlement (49,244.34 m^2). While 10 cm inundation depth seemed give little impact to inundation in port (18.57 m^2), the 40 cm inundation depth would definitely cause disruption of port activities, with extents of approximately 42,826.38 m^2 (99.13% of total area of port of Tegalsari). Port was particularly vulnerable to tidal flood inundation increase due to its adjacent location to sea. A 40 cm inundation depth will also affect a great extent of settlement area in Tegalsari (approximately 454,946.02 m^2).

Likewise Tegalsari, in Mintaragen, a 10 cm tidal flood inundation would affect small portion land use, namely 4,477 m^2 inundated open space and 2,570.145 m^2 submerged fishponds. Scenario of 40 cm inundation depth would severely affect public services in Mintaragen, with inundation of 100% of total area of port, education, and religion facility.

Most of land uses in northern area of Panggung were quite similar with Muarareja, utilized as fishponds, yet Panggung has higher elevation than Muarareja related to sea level. Moreover, fishponds in Panggung were well preserved than fishpond in Muarareja, which in turn function as water retention area. Scenario of 10 inundation depth predicted that particularly 446,968.198 m^2 would be affected (89.21% of total fishpond). A great extent of 28,910.327 m^2 of open space and 6.543 m^2 of settlement area would also be affected. Further increase in inundation depth would subsequently inundate larger area, including 34,672.080 m^2 inundated education facility by 40 inundation depth. Complete information of inundation depth in different scenarios is described in Appendixes.

Further, it is predicted that the number of settlements occupied the coastal area of Tegal Municipality will increase due to its strategic location and relatively low cost of either to buy or to rent lands. The scenarios of inundation only provide the extent of affected areas. It also covers only the potential tangible economic loss, the intangible loss is predicted worse due to the multiplier effects of disturbed economic activities.

CONCLUSION

Households in research location are dominated by low hazard indexes. The result is influenced both by current autonomous and planned adaptation strategies conducted by affected households and governments. Muarareja is predicted as the first area to be affected by tidal flood inundation rise. The higher the scenarios of inundation depth, then the areas inundated are increasingly wider.

DEM data and *GIS*-raster environment tools, such as moving average and iteration operations, have become useful tools in term of cost, scale, and time, in modeling impact of tidal flood inundation. Information of the areas affected by current and future inundation becomes invaluable information in planning disaster risk reduction efforts in coastal area of Tegal Municipality.

Although various adaptation measures have been reducing the hazard indexes of affected households, the growing tendency of land use changes, especially into settlements and fishponds, and the emerging maladaptive practices, somehow, expose the coastal households to greater vulnerability from tidal flood inundation.

Households involvement and participation in both structural and non-structural measures in minimizing risk of tidal flood inundation, such as promotion of mangrove forest, creation of forums of coastal environmental watch, improvement and utilization of households capacities, improvement and rehabilitation of drainage system, and coordination between households and government related to creation of coastal issues solution, are highly suggested.

REFERENCES

Bappeda (2010a), *Studi Penanganan Rob Paket 1*, Bappeda of Tegal Municipality.

Bappeda (2010b), *Studi Penanganan Rob Paket 2*, Bappeda of Tegal Municipality.

Dprd-kotategal.go.id (2011), *Peninggian Jalan Diprotes Warga: Dinilai Sebabkan Masalah Baru*, Published July 10, 2011, Accessed March 4, 2012, 19:08 WIB. http://dprd-tegalkota.go.id/index.php?option=com_ content&task= view&id=1249&Itemid=18.

Mardiatno D., Marfai M. A., Septriayadi R., Mutiarni Y. S., Tanjung R., Rahmawati K, (2012), *Penilaian Multirisiko Banjir dan Rob di Kecamatan Pekalongan Utara*, Universitas Gadjah Mada.

Marfai M. A. (2011), Impact of Coastal Inundation on Ecology and Agricultural Land Use: Case Study in Central Java, Indonesia. *Quaestiones Geographicae* 30(3), Bogucki Wydawnictwo Naukowe, Poznań, pp. 19–32, 22 Figs., 4 Tabs. ISBN 978-83-62662-75-3. ISSN 0137-477X.

Marfai M. A., and King L. (2008b), Tidal Inundation Mapping under Enhanced Land Subsidence in Semarang, Central Java Indonesia, *Natural Hazards*, pp. 93 – 109.

Panturanews.com (2012), *Penanggulangan banjir dan Rob difokuskan di Empat wilayah*, Published December 20, 2012, 09:33 WIB, Accessed March 4, 2012, 19:08 WIB, http://www.panturanews.com/index.php/ panturanews/baca/5059/20/12/2011/penanggulangan-banjir-dan-rob-difokuskan-di-empat-wilayah

Suaramerdeka.com (2011), *Pembangunan Tanggul di Sepanjang Pantai Jadi Solusi*, Published November 11, 2011, 22:38 WIB, Accessed March 4, 2012, 19:08 WIB. http://suaramerdeka.com/v1/index.php/read/news/ 2011/11/11/101568

UNFCC (2007), *Climate Change: Impacts, Vulnerability and Adaptation in Developing Countries*, United Nations.

Ward P. J., Marfai M. A., Yulianto F., Hizbaron D. R., Aerts J. C. J. H. (2011), Coastal Inundation and Damage Exposure Estimation: A Case Study for Jakarta, *Natural Hazards*, Vol. 56. pp. 899–916.

APPENDIXES

Appendix 1. Scenario for Muarareja

Landuse	Exsisting	Inundation Depth							
	Area	10 cm	%	40cm	%	75 cm	%	100 cm	%
Religion Facility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education Facility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sport Building	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Health Facility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Port	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Disposal	92936.50	65334.79	70.30	92936.50	100.00	92936.50	100.00	92936.50	100.00
Graveyard	2365.24	2365.24	100.00	2365.24	100.00	2365.24	100.00	2365.24	100.00
Station	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bus Terminal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Service	*95301.74*	*67700.03*	71.04	*95301.74*	100.00	*95301.74*	100.00	*95301.74*	100.00
Trade & Service Center	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Station	21753.65	21753.65	100.00	21753.65	100.00	21753.65	100.00	21753.65	100.00
Market	1692.43	1692.43	100.00	1692.43	100.00	1692.43	100.00	1692.43	100.00
Alam Indah Beach	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Office Building	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Business Center	*23446.07*	*23446.07*	100.00	*23446.07*	100.00	*23446.07*	100.00	*23446.07*	100.00
Field	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Park	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Empty Land	61378.97	55770.46	90.86	61378.97	100.00	61378.97	100.00	61378.97	100.00
Open Space	*61378.97*	*55770.46*	90.86	*61378.97*	100.00	*61378.97*	100.00	*61378.97*	100.00
Settlement	*384900.21*	*384055.87*	99.78	*384900.21*	100.00	*384900.21*	100.00	*384900.21*	100.00
Paddy Field	*312572.87*	*291488.26*	93.25	*312572.41*	100.00	*312572.87*	100.00	*312572.87*	100.00
Aquaculture	*4718937.75*	*4134303.96*	87.61	*4605913.53*	97.60	*4714320.36*	99.90	*4718937.75*	100.00
Garden	*27474.27*	*27474.27*	100.00	*27474.27*	100.00	*27474.27*	100.00	*27474.27*	100.00
TOTAL	5804138.67	5131155.48		5691113.99		5799521.28		5804138.67	
PERCENTAGE	100	88.40		98.05		99.920		100	

Source: Regional Development Board (2009), Public Work Department (2003), Data Analysis (2012)

Appendix 2. Scenario for Tegalsari

Landuse	Exsisting Area	Inundation Depth							
		10 cm	%	40cm	%	75 cm	%	100 cm	%
Religion Facility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education Facility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sport Building	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Health Facility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Port	43201.33	18.57	0.04	42826.38	99.13	43201.33	100.00	43201.33	100.00
Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Graveyard	14340.10	0.00	0.00	0.00	0.00	14340.10	100.00	14340.10	100.00
Station	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bus Terminal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Service	*57541.43*	*18.57*	0.03	*42826.38*	74.43	*57541.43*	100.00	*57541.43*	100.00
Trade and Service Center	90675.35	0.00	0.00	2623.20	2.89	18063.68	19.92	37557.52	41.42
Gas Station	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Market	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alam Indah Beach	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Office Building	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Business Center	*90675.35*	*0.00*	0.00	*2623.20*	2.89	*18063.68*	19.92	*37557.52*	41.42
Field	968.02	0.00	0.00	0.00	0.00	238.39	24.63	419.75	43.36
Park	5932.98	0.00	0.00	0.00	0.00	2336.35	39.38	5932.98	100.00
Empty Land	217701.06	24387.08	11.20	132841.45	61.02	168025.20	77.18	203559.12	93.50
Open Space	*224602.06*	*24387.08*	10.86	*132841.45*	59.15	*170599.93*	75.96	*209911.85*	93.46
Settlement	*1034187.02*	*49244.34*	4.76	*454946.02*	43.99	*736075.49*	71.17	*909900.63*	87.98
Paddy Field	*0.00*	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00
Aquaculture	*477632.05*	*155037.23*	32.46	*450926.16*	94.41	*477503.21*	99.97	*477516.79*	99.98
Garden	*31094.91*	*0.00*	0.00	*3564.62*	11.46	*18665.66*	60.03	*25699.86*	82.65
TOTAL	2288551.64	253092.86		1266018.87		1724654.44		2023138.88	
PERCENTAGE		11.06		55.32		75.36		88.402	

Source: Regional Development Board (2009), Public Work Department (2003), Data Analysis (2012)

Appendix 3. Scenario for Mintaragen

Landuse	Exsisting Area	Inundation Depth							
		10 cm	%	40cm	%	75 cm	%	100 cm	%
Religion Facility	0	0	0	0	0	0	0	0	0
Education Facility	39674.384	0	0	39674.384	100	39674.384	100	39674.384	100
Sport Building	0	0	0	0	0	0	0	0	0
Health Facility	0	0	0	0	0	0	0	0	0
Port	42485.057	0	0	42485.057	100	42485.057	100	42485.057	100
Waste Disposal	0	0	0	0	0	0	0	0	0
Graveyard	0	0	0	0	0	0	0	0	0
Station	0	0	0	0	0	0	0	0	0
Bus Terminal	0	0	0	0	0	0	0	0	0
Public Service	*82159.441*	*0*	0	*82159.441*	100	*82159.441*	100	*82159.441*	100
Trade and Service Center	91745.311	0	0	0	0	0	0	465.05	0.50
Gas Station	0	0	0	0	0	0	0	0	0
Market	0	0	0	0	0	0	0	0	0
Alam Indah Beach	12782.022	0	0	12782.022	100	12782.022	100	12782.022	100
Office Building	8591.699	0	0	8591.699	100	8591.699	100	8591.699	100
Business Center	*113119.032*	*0*	0	*21373.721*	18.89	*21373.721*	18.89	*21838.771*	19.30
Field	1316.612	0	0	0	0	0	0	0	0
Park	2974.131	0	0	2974.131	100	2974.131	100	2974.131	100
Empty Land	158688.052	4477.097	2.82	132476.870	83.48	149326.343	94.10	153879.637	96.96
Open Space	*162978.795*	*4477.097*	2.75	*135451.001*	83.10	*152300.47*	93.44	*156853.768*	96.24
Settlement	*899517.183*	*15.526*	0.001	*226510.843*	25.18	*460305.904*	51.17	*594544.436*	66.09
Paddy Field	*5348.647*	*0*	0	*1077.163*	20.13	*5348.647*	100	*5348.647*	100
Aquaculture	*187509.728*	*2570.145*	1.37	*187509.728*	100	*187509.728*	100	*187509.728*	100
Garden	*103554.083*	*0*	0	*54778.582*	52.89	*78180.535*	75.49	*86238.59*	83.27
TOTAL	1912444.177	11539.865		947844.642		1243012.086		1395345.361	
PERCENTAGE		0.60		49.56		64.99		72.96	

Source: Regional Development Board (2009), Public Work Department (2003), Data Analysis (2012)

Appendix 4. Scenario for Panggung

Landuse	Exsisting Area	Inundation Depth							
		10 cm	%	40cm	%	75 cm	%	100 cm	%
Religion Facility	127.092	127.092	100	127.092	100	127.092	100	127.092	100
Education Facility	51709.379	0	0	34672.08	67.05	37616.646	72.75	37616.646	72.75
Sport Building	0	0	0	0	0	0	0	0	0
Health Facility	0	0	0	0	0	0	0	0	0
Port	0	0	0	0	0	0	0	0	0
Waste Disposal	0	0	0	0	0	0	0	0	0
Graveyard	63437.81	0	0	0	0	4887.367	7.70	18875.423	29.75
Station	19957.206	0	0	0	0	0	0	0	0
Bus Terminal	0	0	0	0	0	0	0	0	0
Public Service	*135231.487*	*127.092*	0.094	*34799.172*	25.73	*42631.105*	31.52	*56619.161*	41.86
Trade and Service Center	42274.926	0	0	0	0	0	0	3067.677	7.25
Gas Station	0	0	0	0	0	0	0	0	0
Market	6.438	0	0	0	0	0	0	0	0
Alam Indah Beach	0	0	0	0	0	0	0	0	0
Office Building		0	0	0	0	0	0	0	0
Business Center	*42281.364*	*0*	0	*0*	0	*0*	0	*3067.677*	7.25
Field	14323.758	1472.817	10.28	5208.954	36.36	8414.365	58.74	8414.365	58.74
Park	2786.423	0	0	0	0	0	0	0	0
Empty Land	245321.858	27437.51	11.18	140920.564	57.44	167368.304	68.22	167658. 44	68.34
Open Space	*262432.039*	*28910.327*	11.02	*146129.518*	55.68	*175782.67*	66.98	*176072.8*	67.09
Settlement	*1171243.598*	*76534.455*	6.53	*129021.223*	11.01	*175641.64*	14.99	*211649.2*	18.07
Paddy Field	*150364.107*	*9765.067*	6.49	*64675.641*	43.01	*64675.641*	43.01	*64675.641*	43.01
Aquaculture	*501015.158*	*446968.2*	89.21	*501015.158*	100	*501015.16*	100	*501015.16*	100
Garden	*180605.172*	*7781.093*	4.308	*9884.278*	5.47	*16620.687*	9.20	*22256.034*	12.32
TOTAL	2883117.815	599123.651		1066453.68		1194780.67		1271115.31	
PERCENTAGE		20.78		36.99		41.44		44.09	

Source: Regional Development Board (2009), Public Work Department (2003), Data Analysis (2012)

Dewi.A.K (2004), *Erosion Hazard Level Study on Agricultural Land in Sub Watershed Ci Kendang Garut Residence*, Geografi FPIPS UPI.

Dietz, T (1998), *Entitlements to Natural Resources Contours of Political Environmental Geography, International Book*, Utrecht, Cooperate Remdec, Insist Press dan Pustaka Pelajar Press, Yogyakarta.

Erftemeijer P, Balen, Bas Van and Djuharsa. E (1988), *The Importance of Sagara Anakan For Nature Conservation* (with special reference to its avifauna), PHPA-AWB/INTERWADER,Bogor Residence.

Indonesia Constitution No. 32, 2009. *Environment Management.*

Ismawan, I (1999). *Ecological Risks, behind Economic Growth,* Media Presindo, Yogyyakarta.

Kartasasmita (1997), *Factors Affecting the Development of Civil Society in Political Participation.* [Online]. available: http://pustakaonline.wordpress.com /2008/03/ 22/ faktor- faktor-yang-mempengaruhi-partisipasi-politik-masyarakat-dalam-pembangunan-desa/18 [18 des 2010].

Meadows H, et.al (1980), *The Limits of Growth*, Report to the Rome Group, Gramedia Press, Jakarta.

Rahmawaty, S (2004), *Forests: Function And Role For Community*, Faculty of Agriculture, Forest Science Program University of North Sumatra, 2004 Digitized by USU digital library.

Sastropoetro (1988), Participation, Communication, Persuasion and Discipline in National Development, Alumni Press Bandung.

Satyana A (2010), *Sedimentation at Segara Anakan*, Cilacap. [Online] Available : http://www.mail-archive.com/iagi-net@iagi.or.id/msg21920. Html, [21 Jun 2011].

Sherry R, Arnstein R (1969), *A Ladder of Citizen Participation* [Online]. Tersedia:http://lithgow-schmidt.dk/sherry-arnstein/ladder-of-citizen-participation.html, JAIP, Vol. 35, No. 4, July 1969, [21 Maret 2011].

Sinatala, A (1989), Soil and Water Conservation, IPB Press, Bogor.

Soemarwoto. O (2001), *Environmental Impact Assessment*. Gadjah Mada University Press, Yogyakarta.

Soeriaatmadja, R.E (1997), *Environmental Science*, ITB Press Bandung.

Stipulation of Forestry Minister No. 677/Kpts-II/1998 about, The Forest management.

Sukardi. Y (2010), *Problems of Sagara Anakan*. [Online]. Avalaible :http://sidhat. blogspot. com/29 Juli 2011.

Suryanto, E.S (2004). Environmental Management Of Village Forest In The Middle Watershed Segment (Case Study: Development Of Forest Village At Babon Watershed in Semarang City), *Thesis*: Environmental Studies Program, Graduate School Universitas Diponegoro

Wazir W.A. *et al*., ed. (1999), S*trengthening management guide* NGOs. Jakarta: INDHRRA supported by AusAID through Indonesia HIV/AIDS and STD Prevention and Care Project.