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JOGJA, SEPTEMBER 6TH - 8TH, 2013

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"Water Related Disaster Solutions"

SHERATON MUSTIKA YOGYAKARTA, INDONESIA
SEPTEMBER 6TH - 8TH, 2013

Indonesian Association of Hydraulic Engineers

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PREFACE

The International Seminar with special focus on "Water Related Disaster Solutions" was implemented successfully from 6th to 8th September 2013 in Yogyakarta attended by experts and professionals from many countries including Indonesian as the host.

The discussions of the Seminar had covered the entire aspects of the water related disaster solutions including its risk management, the innovation in disaster mitigation and adaptation, as well capacity building and community participation aspects, involving highly notified professionals with numerous technical models, state of the arts as well as scientific and empirical deliberations.

The overall presentations, discussions and debates during the Seminar concluded that the outputs will undoubtedly contribute to remarkable concepts, strategies, lessons learned, and sharing of experiences on the water related disaster solutions, particularly on the environmentally sound technologies and sustainable practices on the years to come. Based on this fact, I believe that the proceeding of this Seminar will be valuable document for the implementation of the adaptation and mitigation to the climate change.

I would like to thank the organizing committee, peers and writers, seniors and all members of HATHI for enormous supports to the Seminar. May God bless you all.

Dr. Ir. Moch. Amron, M.Sc., PU-SDA

Chairman of HATHI,
September, 2013

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INTERNATIONAL SEMINAR ON

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Sub Theme 1

Risk Management in Water-Related Disaster

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RISK ASSESSMENT APPROACH FOR CLIMATE CHANGE ADAPTATION IN TANJUNG API-API PORT AREA BANYUASIN VALLEY, SOUTH SUMATERA

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Abstract

Climate change as impact of global warming could exacerbate the decline in environmental quality as a result of drought risk, water reduced availability and flooding. According to the Assesment Report 4 of Working Group II of Inter-Governmental Panel on Climate Change (2007), there are five approaches in Climate Change Impact, Adaptation and Vulnerability assessment, where the risk assesment is the one of approach to be applied in mainstreaming adaptation option into policy-making globally. The government of Indonesia has explored the use of risk assessment approach for climate change adaption planning since 2008. In Province of South Sumatra including the preparation of national document namely Climate Change Risk and Adaption Assessment. South Sumatra Province is one of the areas in Indonesia which tipped to be prone to the impact of climate change. South Sumatra is very vulnerable due to its lowland areas that it may threat coastal, water, agriculture, and health sector. In the district of Banyuasin, at this time the program has been planned deep sea port development at Tanjung Api-api area. The components of coastal flooding hazards caused by the combination of sea level rise, storm surges, and La-Nina phenomenon at maximum tide. The study concluded the oceanographic scientific basis of sea level rise to around 13.5 ± 6.15 cm in 2030 relative to current conditions (greenhouse gas emission scenarios are moderate - SRESa1b). In the vulnerability map it is known that at the sites did not reach a high level of vulnerability. The low vulnerability has an index of vulnerability by 0.18 and the moderate vulnerability by 0.52. The percentage of very low risk is 0.01% and 11.51% low risk, 39.29% moderate risk, high risk of 46.02%, and 3.22% very high risk at projection condition in 2030 with open green retaining area of 30% of the area Banyuasin Valley area.

Keywords: Climate change, risk assessment, lowland

INTRODUCTION

South Sumatra province is an area particularly vulnerable to climate change to sea-level rise, extreme waves, ocean currents, rising temperature, increased frequency of extreme events such as Elnino and La nina. Precipitation, sea level rise and extreme waves cause Flood, inundation, Erosion and deposition, Salt water intrusion,Its impact on water resources, Agriculture and Forestry, health and Infra-structure (KRAPI South Sumatra, Bappenas, GIZ, 2012)

Sea Level Rise is likely to cause saltwater intrusion into surface waters and coastal aquifers, advance of saltwater into estuaries and coastal river systems, more extensive coastal inundation, higher levels of sea flooding, increases in the landward reach of sea waves and storm surges and new or accelerated coastal erosion. These consequences are expected to be overwhelmingly negative and particularly serious in deltas and small islands. Variability of climate change are also expected to impact agriculture, largely through a decline in soil and water quality.

Climate change is defined as long process and contain high complexity that very unpredictable, although using strictly mitigation. From Freeman, P., et.al (2001), climate change is forecasted to bring gradual changes in weather patterns, and changes in the variability of extreme events to broad geographic regions. Climate change may increase the risk of structural damage to buildings, especially damage resulting from strong wind, flood associated with more intense tropical cyclone and storms.

The IPCC has outlined representative examples of projected infrastructure impacts of extreme climate phenomena (IPCC 2001a). Identifying the impact of climate change on infrastructure as distinct from other influences on our need to maintain, repair, and replace infrastructure, benefits from explicit attention to a conceptual model for impact assessment.

As a awareness to climate change, Bappenas (Republic of Indonesia) with GIZ (*Deutsche Gesellschaft fuer Internationale Zusammenarbeit*) have done vulnerability assessment in macro level (national). This assessment developed to meso level (regional) by Suroso, et. al (2012) in South Sumatera Province.

In the district of Banyuasin, at this time the program of deep sea port development in the Tanjung Api-api. Supporting region District Tanjung Api-api covers most of the areas Banyuasin District II, District Tanjung Lago, and Muara Telang District. The area is bordered by the supporters of protected forest and river water telang

Banyuasin to the north and west, Telang River to the east, and Canal Sebalik (PU) in the south. Overall the area is about 12,282 hectares. The development of Tanjung Api-api International seaport is also prone to the impact of flood and sea level rise.

Risk assesment approach has been well developed within the disaster communities and has been increasingly adopted within the climate change comunities. Risk Assesment Framework, based on Wisner (2004), can be schematized as R=HxV. Under this approach, hazards is the natural events that may affect different places singly or in combination which can be though as the manifestation of the agent that produces the loss. This paper derived hazards from the climate change parameters such as change of Precipitation (P), Sea Level Rise (SLR), and extreme events (EE). For flood hazards assesment the parameters P, SLR, and EE are converted into flood hazards maps. Vulnerability refers to the potential for casualty, destruction, damage, disruption or other form of loss in a particular element. Therefore, under this framework, hazards assesment caused by climate change is firstly done, then it will be continued with vulnerability assesment. After that risk assesment is conducted.

MATERIALS AND METHOD

The research was conducted from April 2011 to June 2012, take a sample of raw water at five locations and laboratory test to know turbidity,salinity and conductivity of raw water, distributing questioner to find out data condition of people at Banyusin Valley. As many as 253 respondents were randomly selected from comunity of 3 village i.e Tanjung Lago, Muara Telang and Banyuasin II. Direct observation was also done to find out data for tidal measurement for hazard by sea level rise.

Flood hazards model is using administrative map of Banyuasin Valley, Digital Elevation Model (DEM), rainfall data, and land use map. Hazards in this study is a result of the components of the hazard scenarios from the sea. The rise in sea level made up the highest seawater tidal components (HHWL) and the average tide (MHWL), high sea waves, the projected sea level rise due to climate change (SRES A1B), La-Nina phenomenon, as well as threats storm waves from the South China Sea.

Vulnerability in the study was obtained from the preparation of component parameters / indicators of vulnerability consisting of housing conditions, number of occupants, water consumption, and income per month which will be overlays with land use maps at the sites. To get the data parameter susceptibility field survey and questionnaire filling.

RESULTS AND DISCUSSION

Laboratory test results showed that the conductivity of water in a village location is in the range of 65.8 to 108.9 Rather µS / cm. No. Permenkes. 907/2002 sets maximum conductivity 300 µS / cm so it can be concluded that the conductivity of water in a village location of Canal Sebalik meet water quality requirements. The results of measurements of salinity or the amount of dissolved salt content at Canal Sebalik for all six samples have the largest variation in the value of 191.7 mg / l and the smallest is 6.31 mg / l which is well below the threshold value was set at 500 mg / l.

From the description of the analysis of some of the parameters in the test, it can be concluded that in contrast to the canal site used as a source of raw water to be processed into clean water.

Hazard Assesment of Climate Change

The components of coastal flooding hazards caused by the combination of sea level rise, storm surges, and La-Nina phenomenon at maximum tide. The study concluded the oceanographic scientific basis of sea level rise to around 13.5 ± 6.15 cm in 2030 relative to current conditions (greenhouse gas emission scenarios are moderate - SRESa1b). Sea level rise is complete sea level variability, both of which occur periodically every day once the tide (with riding around 3.3 m) and that occur incidental result of the increase in La-Nina phenomenon (the influence of the Pacific Ocean) which can lead to an increase at 15 cm to sea level under normal conditions may occur once in 1-3 years. In the future La-Nina phenomenon predicted the long and often occur that can result in increasingly high waves. The storm surge of the South China Sea with a height of about 20 cm can occur 3 times a year. (The Risk Assessment on Climate Change Adaptation in South Sumatra, 2012). From the measurement results obtained in the calculation of the location of high tide water level maximum (HHWL) 190 cm and the mean high water tide - average (MHWL) is 140 cm. (Figure 1)

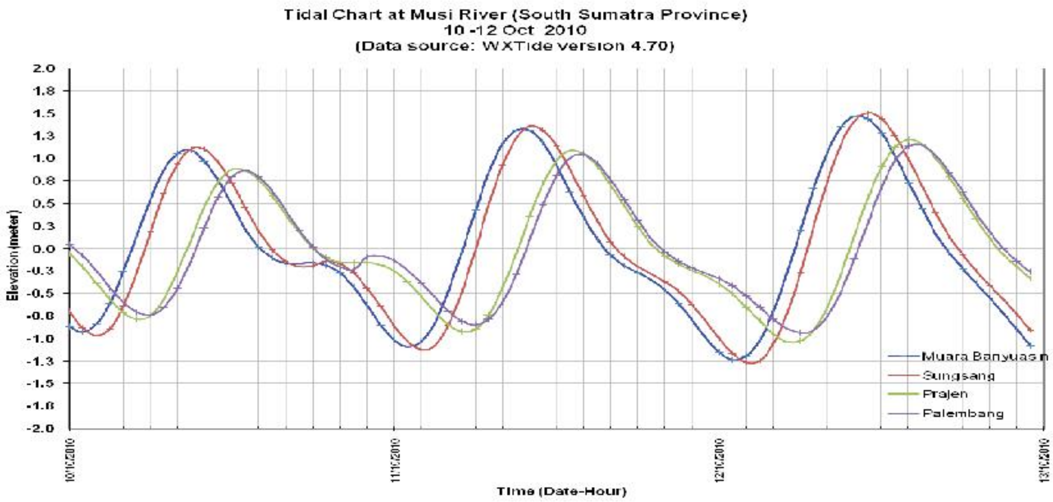

Figure 1. Measurement of sea tidal of Musi River (10-20 Oct 2010)

Basis of the results of scientific studies and oceanographic measurements on the tides hazard scenarios formulated by the hazard element that can be seen in Table 1.

Table 1. Element of hazard at research location

Element of Hazard	Hazard code	SRES A1B Projection	
		2010 (cm)	2030 (cm)
Tide (MHWL)	1a	140	140
Tide (HHWL)	1b	190	190
Maximum Wave	2a	31.1	31.1
Significant Wave	2b	38.4	38.4
Sea Level Rise	3	0	13.5 + 6.1
La Nina	4	15	15
Surges	5	20	20
Flooding	6	100	100

Table 2. Scenario of hazard

Scenario	Cummulative	SRES A1B PROJECTION	
		2010 (cm)	2030 (cm)
Scenario 1a (Eksisting)	1a + 2a + 3	171.1	184.6
Scenario 1b (Ekstrim)	1b + 2b +3	228.4	241.9
Scenario 2a (Ekstrim + La-Nina)	1b + 2b + 4 + 3	243.4	256.9
Scenario 2b (Ekstrim + Surge)	1b + 2b + 5 + 3	248.4	261.9
Scenario 3 (Ekstrim + La-Nina + Surge)	1b + 2b + 4 + 5 + 3	263.4	276.9
Scenario 4 (Ekstrim + La-Nina + Flood)	1b + 2b + 4 + 6 + 3	343.4	356.9

Calculation of hazard assessment done by following a script that has been compiled as Table 2. for baseline conditions (in 2010) and the condition of projection (year 2030). Further elevation of sea level is the 0 m mean sea level so in this study the map inundation scenarios simulated using DEM with inundation at an elevation of 0 m above sea level at the height of immersion scenarios 1a 171.1 cm for 2010 and scenario inundation at an elevation of 0 m above sea level with altitude 356.9 cm for projection condition at 2030.

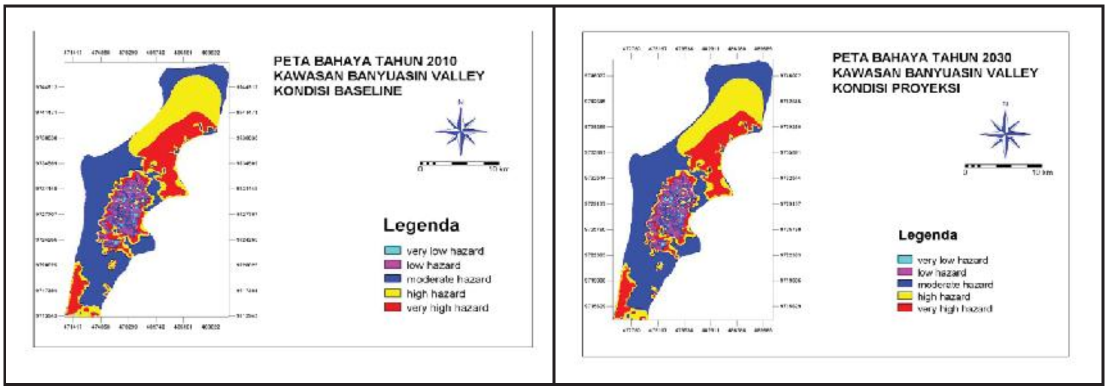

Figure 2. Hazard map for scenario 3 at 2010 and 2030

Based on calculations it is known that in scenario 1a Hazard of sea level rise in 2010 at the height of tide (baseline condition). As for the flooded area is 1.06% or 130.19 ha area and the area that is not inundated (no hazard) of 98.94% or 12,151.81 hectares. In scenario 1b to scenario 3 using tidal height in 2010 and 2030, the area of the danger posed by rising sea level is 566.20 ha (4.61%) and the area that is not inundated (no hazard) is 11715.80 ha (95.39%), while in scenario 4 using tidal height in 2030 (projection condition) the area of danger from sea level rise is equal to 1845.98 ha (15.03%) and the area that is not flooded 10436.02 ha (84.97%) of the total area Banyuasin Valley region.

Projection hazard (hazard) is more focused on the rise of sea level (sea level rise), which has been projected in accordance with the Global Circulation Model (IPCC AR-4). The projection used to use IPCC SRES (Special Report on Emission Scenarios) A1B. In this study, the danger in assuming projected rainfall remains. Visually can not see a significant difference between the scenario projection hazard of climate change, this is due to changes in sea level (sea level rise) that occurred 0.6 - 0.8 cm / year.

Vulnerability Assesment

The vulnerability assessment at Banyuasin Valley, the vulnerability is determined by the index of vulnerability resulting from the parameters / indicators that are owned by the elements - elements that have the potential risk to the impacts of climate change. In this study, the type of vulnerability focused on the conditions and circumstances that existed throughout the Tanjunglago village to Sungsang village. Parameter / vulnerability indicators used in the assessment of vulnerability is the condition of the home, number of occupants, water consumption, and a monthly income of existing residents and the region will be in overlay to land use at the sites. The index of vulnerability is classified into three classes, namely low vulnerability, moderate vulnerability and high vulnerability and map for total vulnerability can be see at figure 3

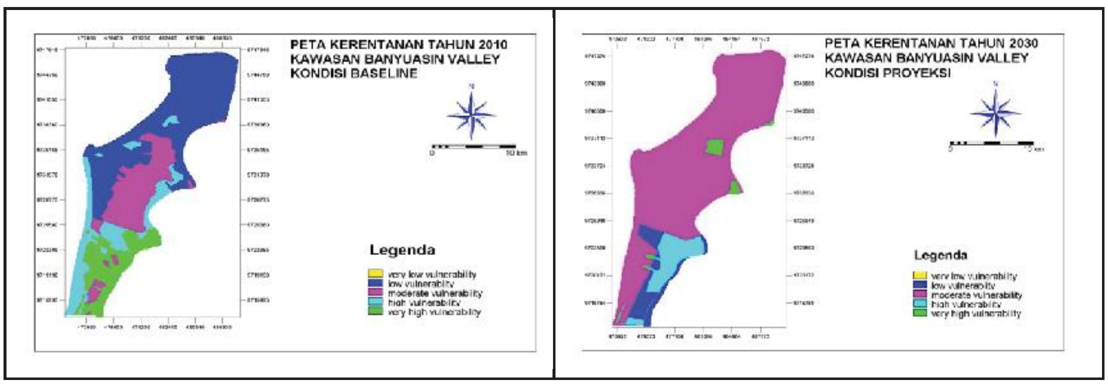

Figure 3. Vulnerability map at Banyuasin Valley in 2010 and 2030

The vulnerability results from map calculation total and slicing using ILWIS GIS applications. Based on the results of the calculations using ILWIS GIS applications that generate vulnerability maps in total with the level of vulnerability information. On the vulnerability map (Figure 3) It is known that at the sites did not reach a high level of vulnerability. The low vulnerability has index of vulnerability by 0.18 and the moderate vulnerability by 0.52.

Risk Assesment

The level of risk is classified into five classes, namely very low risk, low risk, moderate risk, high risk, and very high risk. The level of risk resulting from the overlay level hazard and vulnerability levels in 2 dimensional table.

Table 3. Two dimensional table of ILWIS

2-Dimensional Table "Risk2010" - ILWIS

File Edit View Help

	very low vulner	low vulnerablit	moderate vulner	high vulnerabil	very high vulne
Very Low Hazard	Very low risk	Very low risk	low risk	low risk	moderate risk
Moderate Hazard	low risk	low risk	moderate risk	high risk	high risk
Low Hazard	Very low risk	low risk	low risk	moderate risk	high risk
High Hazard	low risk	moderate risk	high risk	high risk	very high risk
Very High Hazar	moderate risk	high risk	high risk	very high risk	very high risk

Based on the study of climate change hazards (hazard assessment), the risk assessment are show in figure 4

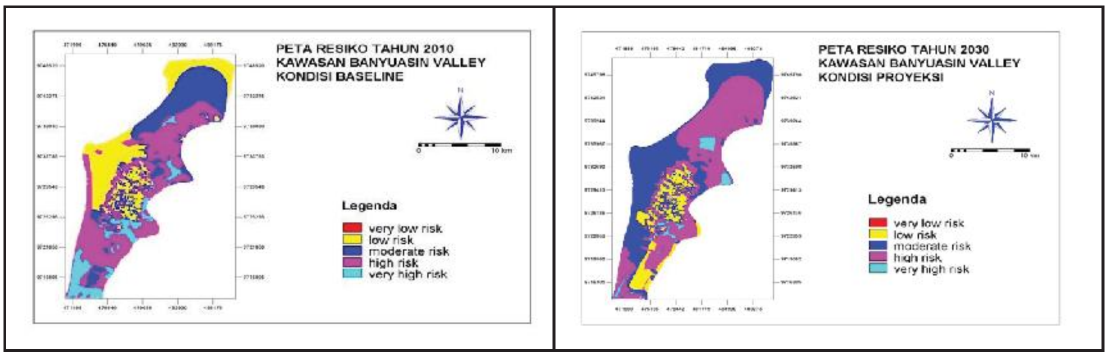

Figure 4. Map of potential risks of water availability in region banyuasin valley against the hazards of climate change in 2010 and 2030

Table 4. Recapitulation of risk analysis results banyuasin valley region

Level of Risk	Percentage in 2010	Percentage in 2030
Very Low Risk	0	0,01
Low Risk	25,37	11,51
Moderate Risk	26,74	39,25
High Risk	38,87	46,02
Very High Risk	9,02	3,22

From the summary above shows that by maintaining green open space in accordance with the law No. 32 on the Strategic Environmental Assessment (KLHS) can reduce the risk in 2030 to the dangers of climate change.

CONCLUSION AND REMARK

From the test result of water quality at research study the location is still possible to take raw water for clean water at Canal Sebalik and must be kept from impact of climate change. From preliminary study at Banyuasin Valley, hazard and vulnerability at baseline condition is still in safe condition and and the need to restructure the space for future development to keep from impact of climate change. In projection condition with scenario 3 by maintaining green open space area 30 % can reduce the risk in 2030 to the dangers of climate change.

REFERENCES

Abdurahman, Oman and Setiawan, Budhi. 2010. *Indonesia Climate Change Sectoral Roadmap: Water Resources Sector*, Editors: Djoko Suroso, Irving Mintzer, Syamsidar Thamrin, Heiner von Luepke, Philippe Guizol, Dieter Brulez. Badan Perencanaan Pembangunan Nasional. ISBN: 978-979-3764-49-8

Alistair Hunt · Paul Watkiss, *Climate change impacts and adaptation in cities: a review of the literature* Climatic Change (2011) 104:13–49 DOI 10.1007/s10584-010-9975-6 Springer Science+Business Media B.V. 2010

Bappeda Kabupaten Banyuasin, 2008. RDTR Kawasan Pendukung Pelabuhan Tanjung Api-api

Bappeda Provinsi Sumatera Selatan, 2010. RTRW Prrovinsi Sumatera Selatan 2011-2030

Beyond El Nino : Decadal and Interdecadal Climate Variability, Springer – Verlag,Berlin,pp 73-102

Blaikie, P., Canon, T., Davis, I., dan Wisner, B., 1994, *At Risk Natural Hazards, People's Vulnerability and Disaster*; Published by Routledge, London.

Boer,R & Faqih,A 2004, *Global climate forcing factors and rainfall variability in west java: case study in Bandung district*, Indonesian Journal of AgricultureMeteorology, vol 18,no2,pp.1 -12

Brooks, N., 2003, Vulnerability, risk and adaptation : A conceptual framework, Tyndall Center, Working Paper No 38.

Danaryanto, H. et al. (2005), *Airtanah di Indonesia dan Pengelolaannya*, Pusat Lingkungan Geologi, Badan Geologi, Departemen Energi dan Sumber Daya Mineral, Jakarta

Departement of Environment and Heritage Australian Greenhouse Office, 2005 .Climate Change, Risk and Vulnerability.

Downing, TE., dan Patwardhan.A,2003, Vulnerability Assessment for Climate Adaptation, Adaptation Policy Framework: A Guide for Policies to Facilitate Adaptation to Climate Change*,* UNDP.

Hadi, Tri Wahyu and Sofian, Ibnu. 2010. *Indonesia Climate Change Sectoral Roadmap: Scientific Basis*, Editors: Djoko Suroso, Irving Mintzer, Syamsidar Thamrin, Heiner von Luepke, Philippe Guizol, Dieter Brulez. Badan Perencanaan Pembangunan Nasional. ISBN: 978-979-3764-49-8

IPCC, 2007, *Climate Change 2007: The Project Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

ISDR, 2004, *Living With Risk*, United Nation, Washington.

IPCC, 2001, *Climate change 2001: Impacts, Adaptation and Vulnerability, Summary for Policymakers*, WMO.

Joseph F.St. Cyr, 2005. *At Risk: Natural Hazard, People's Vulnerability, and Disasters,*Journal of Homeland Security and Emergency management.

Kementerian Negara Lingkungan Hidup, 2009, Buku Panduan Kajian Kerentanan dan Dampak Perubahan Iklim : Untuk Pemerintah Daerah, Author : Djoko Suroso Ph.D, Dr. Tri Wahyu Hadi, Dr. Asep Sofyan, Dr. Ibnu Sofian, Dr. Hamzah Latief, Dr. Budhi Setiawan, Dr. Anggara Kasih, Novi Nuryani, ST.

Kementerian Negara Lingkungan Hidup, 2012, Kajian Resiko dan Adaptasi Perubahan Iklim Sumatera Selatan: Laporan Final, Author : Ir. Emma Rahmawaty,MS.c, Drs. Haneda Sri Mulyanto, MAS, Djoko Suroso Ph.D, Dr. Tri Wahyu Hadi, Dr. Asep Sofyan, Dr. Ibnu Sofian, Dr. Hamzah Latief, Dr. Budhi Setiawan, Tilman Hertz,Prof. Ridad Agus, Prof. Handoko, Dr. Ruminta.

Keputusan Menteri Kesehatan RI. 907/ 2002. *Syarat-syarat dan Pengawasan Kualitas Air Minum*.Kementrian Kesehatan.

Kodoatie .Robert J. , M Basoeki, 2002, *Kajian Undang-Undang Sumber Daya Air*, Andi Offset , Jogyakarta.

Messner F., dan Meyer V., (2005), *Flood damage, vulnerability and risk perception –challenges for flood damage research*, UFZ Discussion Paper 13/2005.

Mock FJ. 1973. *Land Capabilty Appraisal Indonesia, Water Availability Appraisal*. Bogor. UNDP-FAO

Nicola Ranger,Stéphane Hallegatte ,Sumana Bhattacharya, Murthy Bachu ,Satya Priya, K. Dhore , Farhat Rafique , P. Mathur , Nicolas Naville , Fanny Henriet , Celine Herweijer , Sanjib Pohit , Jan Corfee-Morlot., *An assessment of the potential impact of climate change on flood risk in Mumbai* Climatic Change (2011) 104:139–167 DOI 10.1007/s10584-010-9979-2 Springer Science+Business Media B.V. 2010

OECD, 2009, Integrating *Climate Change Adaptation Into Development Co-operation : Policy Guidance*, Chapter 10 : Introduction to Local Level. ISBN-978-92-64-05476-9.

Rygel, L., O'sullivan D., dan Yarnal, B., 2006, *A Method for Constructing a Social Vulnerability Index : An Application to Hurricane Storm Surges in a Developed Country, Mitigation and Adaptation Strategies for Global Change* (2006) 11: 741–764, Springer Ltd.

Saratri wilinuyudho, 2007. *Perencanaan Kota Berbasis Bencana*, Jurnal teknik sipil dan perencanaan, no 2 vol 9-juli,hal 163-170

Setiawan, Budhi, Puspita, Norma dan Setiojati, Ambiyar, 2010, *Vulnerability Assessment of Urban Infrastructure : A Framework and Conceptual Model*, Proceeding Seminar Nasional Teknik Sipil VI – 2010. Vol II : p-C61-C70. ISBN 978-979-99327-5-4.

Stéphane Hallegatte · Jan Corfee-Morlot, *Understanding climate change impacts, vulnerability and adaptation at city scale: an introduction* Climatic Change (2011) 104:1–12 DOI 10.1007/s10584-010-9981-8 Springer Science+Business Media B.V. 2010

Suroso, D., Wahyudi, T., Sofian, I., Latief, H., Abdurahman, O., dan Setiawan. B., 2009, *Vulnerability of Small Islands to Climate Change in Indonesia : a case study of Lombok Island, Province of Nusa Tenggara Barat*. Proceeding World Oceanic Conference: Water and Coastal Sector. Manado.

Suroso, Hery A Susanto, *Pengaruh Perubahan tata guna Lahan Terhadap Debit Banjir Daerah Aliran Sungai Banjaran.* Jurnal Teknik Sipil, Vol.3. N0.2, Juli 2006, hal 75-80

Tini Mananoma, Widandi Soetopo,: Pemodelan Sebagai Sarana Dalam Mencapai Solusi Optimal. 2000

Wigati, Mayasih,: Improving Flood Hazard and Vulnerability Assessment Based on Social Assessment in Bogowonto River, International Institute For Geo-Information And Earth Observation, Enschede, The Netherland, 2008

Wurjanto, A., Sudirman, D., :Modul Perhitungan Debit Andalan Sungai, Penerbit ITB, Bandung. 2008

Yusuf, Arief A., dan Francisco, H..: Climate Change Vulnerability Mapping for Southeast Asia. Economy and Environment Program for Southeast Asia. 2009

Yunan Hamdani, B Setiawan, D Setyawan, Azhar K Affandi, *Kajian Lingkungan Hidup Strategis (KLHS) dalam penataan ruang untuk mitigasi penurunan ketersediaan air*, Proceeding MPBA Yogyakarta ISBN 978 – 602 – 98679 – 1 – 1 , September 2011