EVALUATING COASTAL FLOOD RISK ADAPTATION IN THE CONTEXT OF CLIMATE CHANGE IN SURABAYA, INDONESIA

Ariyaningsih Urban Environmental Management

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INTRODUCTION • BACKGROUND AND RATIONALE OF STUDY

urbanization

Concentration activities in urban areas

Changing on land use

SURABAYA

urban management became a very complex system

Hazard in urban areas

Surabaya has delta system of coastal morphology and low land

Surabaya has a very high rainfall rate, with yearly average rainfall around 141.1 mm.

INTRODUCTION BACKGROUND AND RATIONALE OF STUDY (cont..)

- Adaptation that government done is not appropriate, this is because adaptation applied in there is only based on sudden-onset hazards, not long term strategies.
- There are conflicts between risk management, climate change adaptation and urban development in coastal area of Surabaya.

No.	The type of disaster	Total	Death	Evacuate	Estimated Loss (million rupiah)
1.	Typhoon	136	5,047	3,328	81,380
2.	Landslide	219	435	8,231	31,286
3.	Flood	299	285	390,356	888,476

Sources:

Bakornas, 2004 in the House of Representatives Commission VIII Committee,2005 a

INTRODUCTION PROBLEM STATEMENT

- Increased population and urbanization, concentration people in urban area, changed land use have made converting natural spaces that have ecological functions.
- high levels of awareness and varying levels of concern about climate change coincide with still very limited knowledge in many countries.
- yet relatively little research focuses on what constitutes successful climate adaptation or how to empirically understand successful adaptations.

INTRODUCTION RESEARCH QUESTIONS

- The questions in this research are:
- 1. What are characteristics of coastal development plan in Surabaya and their functions in terms of climate adaptation?
- 2. What are the criteria to evaluate climate adaptation measures?
- 3. How are the performance of current adaptation strategies in relation to urban development in Surabaya?

RESEARCH OBJECTIVES

The main objective is to evaluate flood risk adaptation in the context of climate change using criteria.

- 1. To assess past and on-going of flood adaptation strategies in term of development context in coastal city of Surabaya
- 2. To determine criteria of evaluating climate change adaptation in relation to coastal urban development
- 3. To evaluate performance of past and on-going adaptation measures
- 4. To recommend how to enhance adaptation measures

INTRODUCTION

this research is focused in stakeholders' perception in past and on going adaptation measure in flood risk. Area of this study is focused in coastal area of Surabaya, has vulnerability of coastal flood.

LIMITATION

the vulnerability area of flood risk is described briefly and only focus on adaptation measure. Then, only local adaptation strategies is analyzed in this study. The selected adaptation measures are only consider on regional level and household level.

LITERATURE REVIEW

Literature Map

Evaluating Climate Change Adaptation



LITERATURE REVIEW (cont..)

Summary and Key Point of Literature Review

- Urban planning is a process involving projection on future usage of space. It requires input from different sectors and stakeholders
- A major gap is the lack of understanding of adaptation at individual and household levels, particularly those that are multi-local
- It has argued that adaptation operates at different spatial and societal scales and that success or its sustainability needs to be evaluated against different criteria at these different levels
- Elements of effectiveness, efficiency, equity efficiency, and sustainability are important in judging success.

LITERATURE REVIEW (cont..)

Measure	Description	Sub-Criteria
Effectiveness: Achieving objectives	An effective adaptation intervention will achieve its stated objectives, be these to reduce vulnerability or risk, increase adaptive capacity, or achieve an enhanced level of protection. Evaluation against this criterion should therefore be relatively straightforward, providing that measurable objectives have been stated and clearly defined at the outset. Whilst effectiveness relates to adaptation outcomes, it also relates to the adaptation process, including capacity building, information exchange and social learning.	 Enhancing policy, planning for adaptation measure Legal and regulatory Integration with development policies and planning Institutional mechanism, capacities and structures
Flexibility: How far can we adapt?	Climate change is uncertain, due partly to an incomplete understanding of climate science, and partly to the fact that climate change will impact upon a future world. The large uncertainty around climate change means that it is likely we will either do too much, or too little, adaptation.	Hazards risk Scientific and technical capacities and innovation
Equity: Inequality dimensions to adaptation	Adaptation aims to reduce vulnerability to climate change shocks and stresses. However, vulnerability also depends on socioeconomic factors, which implies that any given adaptation may reduce vulnerability inconsistently across groups. Adaptation can reinforce existing inequalities, or it could be designed in such a way as to protect especially vulnerable groups	 Impact data Environmental and natural resources Livelihood Culture, attitudes, education
Efficiency: Cost effectiveness	Efficiency or cost-effectiveness is typically used to compare the costs of alternative ways of producing the same or similar results, i.e. to assess the least-cost path to reaching a given target.	Financial instruments Cost recovery for adaptation
Sustainability: The wider implications of adaptation	Sustainability of an adaptation is concerned with looking beyond the immediate sphere of the intervention's impact. It considers the longer-term viability of the intervention (e.g. how far are the benefits of an activity likely to continue after donor funding has been used up or withdrawn). It also considers the broader environmental, social and economic impacts of implementing an intervention. Sustainable adaptation is likely to include strong elements of partnership-building, community engagement, education and awareness-raising, as well as focusing on interventions which are 'mainstreamed' into existing development processes and mechanisms, and cutting across key sectors (water management, enclude strong element processes and mechanisms,	 Public awareness, knowledge, skill Information management and sharing Learning and research

METHODOLOGY

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Research Approach and Framework



METHODOLOGY

Research Tasks

Data Collection

Development and spatial policy

Current adaptation measure, vulnerability mapping, climate proofing, socio and physic characteristics

Current adaptation measure in local level and household level

Baseline for Criteria of Evaluation (effectiveness, efficiency, equity, etc) based on literature review and stakeholders.

Successful criteria, current adaptation measure, current urban development

Successful criteria, current adaptation measure, current urban development planning, results of evaluation in adaptations

Task 1: To study urban development planning in Surabaya In term of adaptation measures

Research Tasks

Task 2 : To describe adaptation measure in household level and local level (Surabaya)

Task 3 : To select adaptation measure

Task 4 : To determine criteria of successful adaptation Task 5 : To evaluate the performance of adaptation MC4 measures

Task 6 : conclude and recommend successful adaptation

Objective 4

Document Review

interview.

Data Analysis

Objective 1

Stakeholders.

Stakeholders, literature review, Delphi objective 2

Objective 3

OVERVIEW OF STUDY AREA, FLOOD RISK, AND ITS VULNERABILITY

Overview of Surabaya City



- The coastal area of Surabaya consists of 11 districts, covering Benowo, Asemrowo, Krembangan, Semampir, Pabean Cantikan, Kenjeran, District Bulak, Sukolilo, Mulyorejo, Rungkut and Gunung Anyar. Most of the area in coastal Surabaya are low-lying lands.
- Topographic conditions in the study area varies in height 0-6 meters above sea level
- The soil type in Surabaya is hydro alluvial

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OVERVIEW OF STUDY AREA, FLOOD RISK, AND ITS VULNERABILITY (cont..)

Non Climate Factor That Cause Flood (Land Use Change)





the land use in Surabaya Coastal Area is dominated by water body since the main function is fisheries and have to rely on pond for their livelihood. Then, land use in Surabaya is used by housing with the total area is 47137, 96 hectare.

OVERVIEW OF STUDY AREA, FLOOD RISK, AND ITS VULNERABILITY (cont..)

Non Climate Factor (green space change)



2002





Decreasing green areas in the last 10 years an area of 43.2 Km²(12.9%) was lower than the 11 to 20

years ago an area of 81.4 Km² (24.2%), but the growth of urban areas is actually higher in the last 10 years (2000-

2009) covering an area of 27.4 Km₂ (8.2%) compared to the previous 10 years (1990-2000) covering an area of 18.1 Km (5.4%) of the area of

18.1 Km₂ (5.4%) of the area of the city.

Hasyim (2011)

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OVERVIEW OF STUDY AREA, FLOOD RISK, AND ITS VULNERABILITY (cont..)

Non Climate factor (BUILDING DENSITY)

The study area has 211.716 buildings with the building density of 205,06 buildings/ha.









OVERVIEW OF STUDY AREA, FLOOD RISK, AND ITS VULNERABILITY (cont..)

Climate Factors

1. Tidal

Based on data from the Maritime BMKG Surabaya, 2011 The average maximum height of tide in coastal areas Surabaya is 150-170 cm above sea level and shows a significant rise of sea level rise in Surabaya approximately 4.8 mm / year.

2. Rainfall

The average annual rainfall at Tanjung Perak Rain Station of the year 1955 - 1998 is 1560 mm, average of 90% occurs during the rainy season. The highest monthly rainfall occurs in January, which is more than 300 mm, while the lowest 23 mm in August (Spatial Plan of Surabaya, 2012)

year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
avarage	105.3	97.4	101.6	107.9	109.8	97.7	90.7	89.3	101.3	79.4
(mm)	7	7	1	0	0	4	0	0	8	0

Source: Department of Public Works-Water Resources Surabaya

OVERVIEW OF STUDY AREA, FLOOD RISK, AND ITS VULNERABILITY (cont..)



- people assume that flooding occurs as a common natural phenomenon (interview results, 2014).
- They no longer feel the flood as one of the threats, but they considered it as a matter limitations they face everyday.
- Although people think of flooding as a natural phenomenon and become part of the natural process that occurs due to the tide, but people feel the change of height of inundation.

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Overview of Flood Risk in Surabaya (cont..)

Based on interviews and field observations, as well as data from flooding due to sea level rise that occurred in the five villages have the following impacts:

A. In residential areas

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- Damage to the home such as walls, doors, and windows
- Damage to household furnishings and transportation
- Damage to the environment
- The emergence of long puddle in the road environment and drainage
- Trash were spread on homes that do not have sanitation
- Itching disease and diarrhea due to polluted environment
- B. in the area of ponds

Loss of fisherman due to crop failure. It happen because of the loss of fish or shrimp when the flood came in and the level of water reaches the limit of pond dikes. Based on interviews, losses can reach 50% to 90%.



Spatial distribution of zones level of floods vulnerability due to sea level rise on coastal areas along the coast of Surabaya, the areas at the highest level of vulnerability are the District Krembangan, , Pabenan cantikan, and Kenjeran.

EVALUATING ADAPTATION MEASURES

A. THE CURRENT ADAPTATIONS

According to document reviews of Coastal Zone Planning, General Spatial Plan, Detailed City Spatial Plan, and respondent's interview. The current adaptations has been identified as follows :

- 1. Build Long Storage and box culvert in coastal area
- 2. Mangrove Conservation Area
- 3. Enhance Soft Skill of Community (preparedness and entrepreneurship)
- 4. Restoration and Protect River and Canal
- 5. Modify Floor (Adding number of Floor)
- 6. Built Small Embankment in front House
- 7. Elevate the House Floor
- 8. Making artificial embankment of bamboo in pond
- 9. Maintenance mangrove in ponds

B. SELECTED ADAPTATION MEASURES FOR EVALUATION

The selected adaptation measures has been done by scoring analysis.

No	Adaptation Measure	S1	S2	S3	S4	S5	S6	S7	Results
1.	Build Long Storage and box culvert in coastal area	3	1	6	6	9	9	4	38
2.	Mangrove Conservation Area	2	2	1	1	3	1	1	11
3.	Enhance Soft Skill of Community (preparedness and entrepeneurship)	1	6	3	2	4	3	3	22
4.	Restoration and Protect River and Canal	8	3	7	7	7	7	8	37
5.	Modify Floor (Adding number of Floor)	5	7	5	4	6	8	9	44
6.	Built Small Embankment in front House	6	8	4	8	5	6	7	44
7.	Eletave the House	4	4	2	3	1	2	2	18
8.	Making artificial embankment of bamboo in pond	9	5	9	9	8	5	6	51
9.	Maintenance mangrove in pond	7	9	8	5	2	4	5	40

Note:

- S1 : Town Planning Agency
- S2 : City Department of Spatial Planning
- S3 : Regional Disaster Management Agencies
- S4 : Agency for Environmental Management
- S5 : Head of Krembangan
- S6 : Head of Pabean Catikan
- S7 : Head of Kenjeran

Mangrove Conservation Area



Based on data which got from Ecoton in 2002, the mangrove area in Surabaya coastal area is 3200 hectare. But, because of many activities around mangrove area so in 2008, its area is decreasing becoming 1180 ha.

Enhance Soft Skill of Community

The government has done a fishing community empowerment with the framework of Community-Based Fishing System Management. For the awareness, community gathered to get emergency response training for disaster. Department of Education in collaboration BPBD designed a program with the theme of Disaster Management School.

Elevating the Floor of House

The most common action done on their home is a raised floor for those who can afford so that the floor is higher than the road, or they make a small embankment in front of their homes. Elevating the foundation of the house by each individual or create a dike on the front porch that can impede water into the house.

C. DETERMINING EVALUATION CRITERIA USING DELPHI ANALYSIS



At this stage of the research is conducted (exploration) the opinion of the respondents about the evaluation criteria. The method used to obtain these criteria is through semi-structured interviews

According to the results of the first phase, there is an additional sub criterion in the evaluation from the opinion of the respondents. Phase II is the first iteration. This iteration is to reduce the sub-criteria necessary to obtain the agreement of the respondents

From the results of interviews Delphi Phase II there are sub criteria that have not reached a consensus and not agreed upon by all respondents, conducted more interviews processing phase III.

From the interview Delphi Phase III consensus obtained from the respondents regarding the adaptation criteria.

No	Main Criteria	Criterion Code	Sub-Criteria	Sub Criterion Code
1.	Effectiveness	C1	Enhancing policy, planning	SC1
R.			Legal and regulatory	SC2
			Integration with development policies and planning	SC3
			Institutional mechanism, capacities and structures	SC4
2	Flexibility	C2	Hazards risk	SC5
			Scientific and technical capacities and innovation	SC6
3.	Inequality	C3	Impact data for flooding	SC7
The		THE THE	Environmental and natural resources	SC8
			Livelihood to people surrounding	SC9
			Culture, attitudes, education conditions	SC10
4.	Efficiency	C4	Financial instruments	SC11
M)			Cost recovery for adaptation	SC12
			Maintenance and Operation Cost	SC13
5.	sustainability	C5	Public awareness, knowledge, skill to people surrounding	SC14
R/S			Information management and sharing	SC15
		h	Learning and research related to enhancing adaptation measure	SC16

Multi Criteria – AHP Analysis to Measure Successful of Climate Change Adaptation

Goal: The Success of Adaptation Measure



Degree of importanceDefinition1Equal importance (no preference)2Intermediate between 1 and 33Moderately more important4Intermediate between 3 and 55Strongly more important6Intermediate between 5 and 77Very strongly important8Extremely strongly more important1/2, 1/3, 1/4, 1/5, 1/6,Reciprocals of 2, 3, 4, 5, 6, 7, 8, and 91/7, 1/8, 1/9Intermediate of 2, 3, 4, 5, 6, 7, 8, and 9

In determining priority of criteria and sub-criteria analysis techniques is used AHP (Analythical Hierarchie Process) with individual pairwaise (of Expert Choice software 11). AHP technique to compare the level of interest among criteria and sub-criteria based on the expert opinion.

Combined weighting Criteria from Expert Choice results



From the analysis obtained the weight of each criteria and sub-criteria as follows:

1. Effectiveness

Priorities with respect to: Goal: The Success of Adaptation Measures >C1(Effectiveness)

.385

.167

.147

.300

SC1 SC2 SC3 SC4 Inconsistency = 0.00233 with 0 missing judgments.

> Sub- criterion : Enhancing policy, planning (0.385) Legal and regulatory (0.167) Integration with development policies and planning (0.147), Institutional mechanism, capacities and structures (0.3) with a value of 0.00023 which if inconsistency value <0.1 then it is considered valid criteria.

Combined

2. Flexibility

Priorities with respect to: Goal: The Success of Adaptation Measures >C2 (Flexibility)

.547

.453

.363

.176

.221

.240

SC5 SC6 Inconsistency = 0. with 0 missing judgments.

3. Inequality

Priorities with respect to: Goal: The Success of Adaptation Measures >C3 (Inequality)

SC7 SC8 SC9 SC10 Inconsistency = 0.00172 with 0 missing judgments.

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Combined

Combined



Weighting Sub-Criteria from Expert Choice result

Combined instance -- Synthesis with respect to: Goal: The Success of Adaptation Measures

Overall Inconsistency = .00





0.240

Goal



		Mangrove	Elevate Floor	Enhance Skill	
1.	Enhancing policy, planning	0.775	0.625	0.625	
2.	Legal and regulatory	0.85	0.575	0.625	4
3.	Integration with development policies and planning	0.725	0.575	0.6	2
4.	Institutional mechanism, capacities and structures	0.45	0.575	0.375	1
5.	Hazards risk	0.575	0.725	0.5	
6.	Scientific and technical capacities and innovation	0.55	0.65	0.475	
7.	Impact data for flooding	0.575	0.525	0.575	
8.	Environmental and natural resources	0.55	0.6	0.725	2
9.	Livelihood to people surrounding	0.6	0.625	0.675	
10.	Culture, attitudes, education conditions	0.425	0.625	0.425	2
11.	Financial instruments	0.525	0.55	0.525	
12.	Cost recovery for adaptation	0.525	0.5	0.5	
13.	Maintenance and Operation Cost	0.45	0.55	0.65	7
14.	Public awareness, knowledge, skill to people surrounding	0.575	0.725	0.7	X
15.	Information management and sharing	0.575	0.6	0.725	
16.	Learning and research related to enhancing adaptation measure	0.6	0.675	0.65	

Value will be used to calculate the percentage the success of adaptation measures. The value will be multiplied with weigh to get the percentage.

Source: Analysis Result, 2014

Weighting

0.385

0.147

0.300

0.547

0.363 0.176 0.221

0.240 0.537 0.230 0.233 0.336

0.258

Value

No	Criterion	Adaptation Measure							
	RIS SR	Mangrove (%)	Elevate Floor (%)	Enhance Soft Skill (%)					
1.	Effevtiveness	13.63	11.87	10.91					
2.	Flexibility	11.27	13.82	9.77					
3.	Inequality	10.80	11.69	11.75					
4.	Efficiency	10.15	10.77	10.97					
5.	Sustainability	11.71	13.46	13.74					
- 0	Total	57.58	61.61	57.14					



Threshold :

> 68% = the achievement of the criteria already achieved (green color)

52% to 68% = the achievement of adaptation measure is not achieved yet though the value is close to the target, so the parties concerned should be fastidiously with a variety of opportunities and threats (yellow color).

< 52% = the achievement of an adaptation program actually below the target set and require immediate repair (red color)

RECOMMENDATION TO ENHANCE ADAPTATION STRATEGIES

RECOMMENDATION

City Level

planning instrument : 1. Integrating adaptation application with the policy and actual condition of the area

- 2. Enhancing Spatial Plan
- 3. Reforestation and flood infrastructure redevelopment
- 4. Providing research related to flood risk

Household Level

economic development : 1. Promoting household income and creating other sources of income

2. Impelementing insurance mechanism

RECOMMENDATION TO ENHANCE ADAPTATION STRATEGIES (cont..)

A. Integrating adaptation application with the policy and actual condition of the area

- 1. the procurement monitoring and evaluation of programs for adaptation. The evaluation is done ex-ante and e-post in order to create an integrated adaptation
- 2. the Municipal Government should cooperate with NGOs (local and non-local) in emergency situations. Current actions of NGOs are not normally integrated with government activities
- **B. Enhancing Spatial Plan**

The spatial plan implementation involves controlling land use.

The land use control will regulate the mix of built-up areas and open space both in upstream areas and it will also prevent buildings and houses being located on risky land or in potentially inundated areas.

RECOMMENDATION TO ENHANCE ADAPTATION STRATEGIES (cont..)

- C. Reforestation and flood infrastructure redevelopment
- 1. Reforestation can be done with converting non-forest land use types or replanting the forest.
- 2. the adaptation of flood infrastructure redevelopment has consequences for the capacity of flood infrastructure. Infrastructure redevelopment will not reduce the amount of water but will manage the flowing water. The increase in embankment height will increase the river capacity

D. Providing research related to flood risk

develop researches related to flood risk which can improve proper handling of adaptation efforts and improving knowledge and awareness of disaster

RECOMMENDATION TO ENHANCE ADAPTATION STRATEGIES (cont..)

- E. Promoting household income and creating other sources of income Promoting income is proposed by creating alternative economic activities, particularly during floods and increasing productivity of current sources of income such as paddy and aquaculture.
- F. Implementing insurance mechanism
- Insurance helps community by providing money for their houses after flood events
- Insurance is still perceived as a luxury and new for most people especially the poor in developing countries
- Consequently, there is a need to promote the idea of sharing the risk within the community.
- One approach to communicating the idea of insurance is to draw an analogy with the tradition of 'lumbung padi' whereby villagers collect some of the harvest from the paddy field for public storage.

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

- Main findings : Problems include the fact that adaptation is still in an early stage of development and is not integrated with the planning systems.
- Surabaya government has spent big amount of money to do adaptation measure projects. They involve community from an early age, ranging from planning, implementation, and monitoring and evaluation program to be implemented.
- Criteria of effectiveness, efficiency, equity, flexibility and sustainability are said important in judging success. The sub-criteria that found in the literature is fifteen sub-criteria, but after conducted Delphi with three stages, agreement of stakeholders is found with one new sub-criterion (Maintenance and Operation Cost).
- The evaluation result shows the percentage of success for conservation mangrove, elevating floor, and enhancing soft skill are 57.57%, 61.61%, and 57.14% respectively.
- For recommendations, the need for a planning instrument and economic development are also regarded by key stakeholders as more important than an emergency system for anticipating routine hazards rather than just responding to incidental hazards

CONCLUSIONS AND RECOMMENDATIONS (cont...)

B. RECOMMENDATIONS

- Applications of research results :

Problems and condition of ongoing and past adaptation measure here can used by government as consideration in decision-making and monitoring process to face flood risk and it will improve the capacity of decisionmakers to minimize the impacts of future disasters.

The results of each criteria show in yellow indicators, it should be reviewed to know which adaptation measure is still integrated and good and which one is not good and doesn't fit with actual condition of the study area.

This study proposes a way of recommendations for adaptations under disaster risk management. Lack of integration that shows in this study's results can be suggestion to decision-makers.

CONCLUSIONS AND RECOMMENDATIONS (cont...)

Limitations of the results

- only local adaptation strategies are analyzed in this study. It will be good to also evaluate the regional and national adaptation strategies.
- Flood vulnerability mapping in this study is not enough to explain the extent of flood problems in urban area, because urban settlement has various object that can be influenced differently by flood.
- Most of the criteria in this research are qualitative. Measuring qualitative criteria in a quantitative manner may produce other errors in the results. Therefore, value is used for every qualitative variable. The use of grounded theory in analyzing the stakeholders' opinions can also increase the confidence of the results.

CONCLUSIONS AND RECOMMENDATIONS (cont...)

Further studies

- 1. explore about recommendation to improve adaptation strategies to deal with flood risk based on criteria results.
- 2. this research conducted in coastal area of Surabaya, with some adjustments this analysis can be applied to other case studies or hazard types with different types of climate change hazard in other areas.
- 3. Study about community's perception can be conducted to know in deep about how community face flooding and how they survive
- 4. Research by quantitative criteria in the next study can improve the results and may produce less error.

THANK YOU 😳