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Department of Economics, and Interdepartmental Centre VICCS (Venice Centre for Climate Studies)

DELTAS IN TIMES OF CLIMATE CHANGE II

OPPORTUNITIES FOR PEOPLE, SCIENCE, CITIES AND BUSINESS

INTERNATIONAL CONFERENCE

ROTTERDAM, THE NETHERLANDS 24 – 26 SEPTEMBER 2014

Robust Management of Flood Risk under Deep Uncertainty: an Application to Dhaka City

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Decision Making and Uncertainty

- Socio-economic as well as climatic changes are the main drivers of uncertainty in long term environmental risk assessment and flood in particular
- Since we have not experienced and undergone those changes before and our knowledge is limited we have no notion of probabilities of future [combined] events
- Optimality as a decision criterion is not informative and helpful for decision-makers with unknownprobabilities.

Many questions arise:

- How should we explore and possibly model/assess uncertainty about the future?
- How should decision making take uncertainty about future into consideration?
- How can alternative solutions be compared and ranked under such conditions?

VM 2

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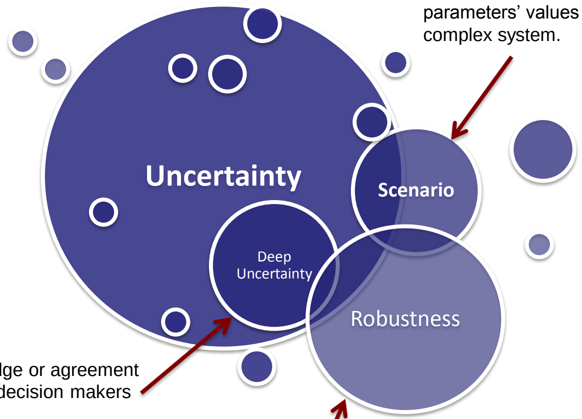
Robust Decision Making Under Deep Uncertainty

A full description of what may happen in future based on a meaningful synthesis of parameters' values of the complex system.



No knowledge or agreement by experts/decision makers over
① probability distributions
② Model
③ Desirability of outcome

Robust decision performs relatively welL, compared to alternatives across a wide range of plausible futures

VM 3

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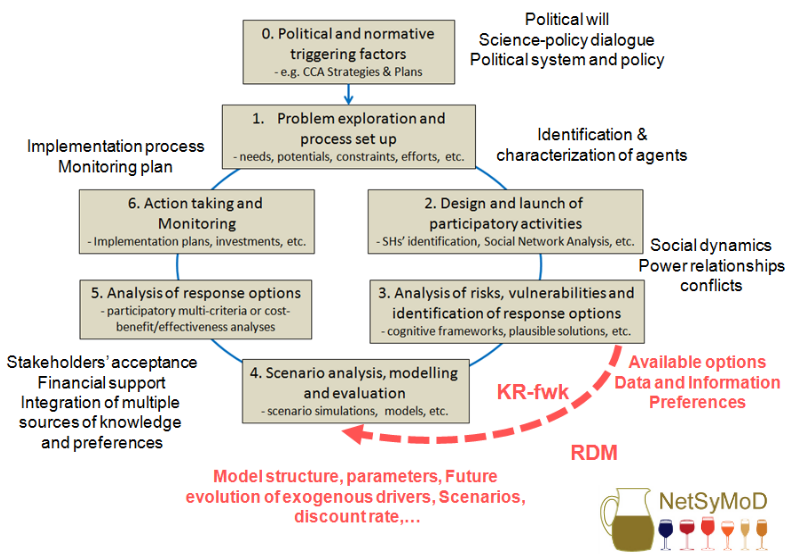
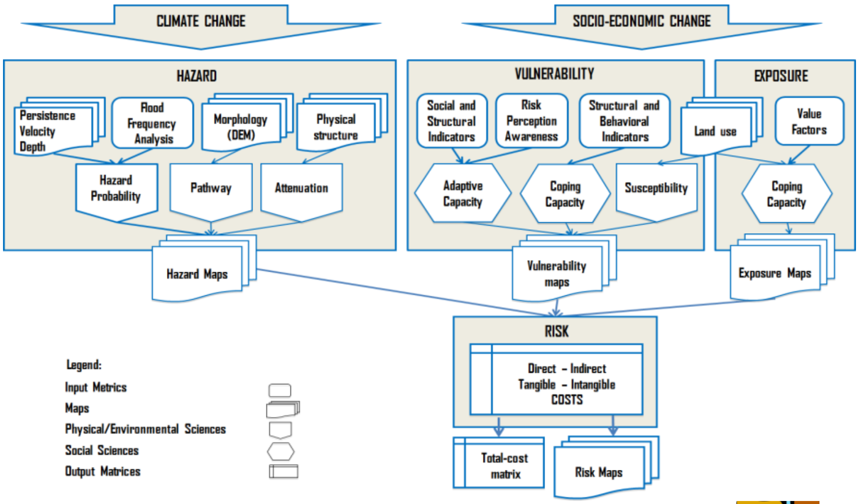
RDM framework for CCA



VM 4

The KR-FWK for integrated risk assessment



VM 5

Operational Steps

a. Identification of **key uncertain parameters and variables**, considered in the three components of **risk** (**hazard, vulnerability and exposure**);

b. Identification of the **exploration boundaries** and **distributions** for the key variables through a participatory process using experts' and stakeholders' opinions;

c. Constructing future **plausible scenarios**, by sampling the variable space defined through internally consistent combinations of values considering the non-parametric correlations;

d. **Robustness analysis** of risk reduction measures through their performances over a widest range of future plausible states of the world;

e. Determining the measures' **vulnerabilities** by determining under which range of variables they fails and possible iterations to revise the set of measures to be considered and possible avenues for **adaptation**.

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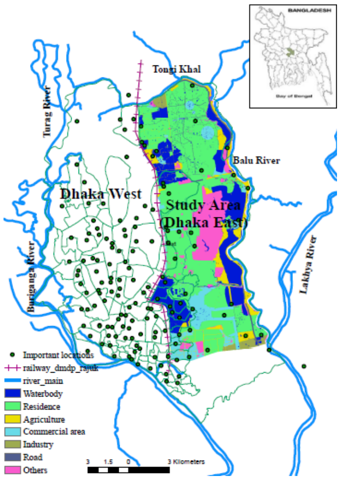
Eastern Dhaka City



Land-use map

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Uncertainty of Risk Scenarios

R=f(H,V,E)

Hazard
- Floods characterized by depth, velocity, and debris (FS)
- different return periods 10 to 1000 years

Vulnerability
- Two Baseline scenarios
- 3 Alternative Scenarios

Exposure
- Number of people

1000 scenarios was developed based on the meaningful combination of parameters.

Uncertainty Matrix

Location	Variables	Range	Nature	Degree
Hazard	Depth (meter)	[0.1,2]	Aleatory	Deep
	Velocity (m/s)	[1,4]		
	Debris Factor (binary)	0.5 or 1		
Vulnerability	Dependency Ratio (%)	[15.59,51.59]	Epistemic	Deep
	Literacy Ratio (%)	[42.62, 81.24]		
	Income (% dependence on Agriculture)	[19.41, 59.59]		
Exposure	Number of People	[103,000, 150,000]	Epistemic	Deep

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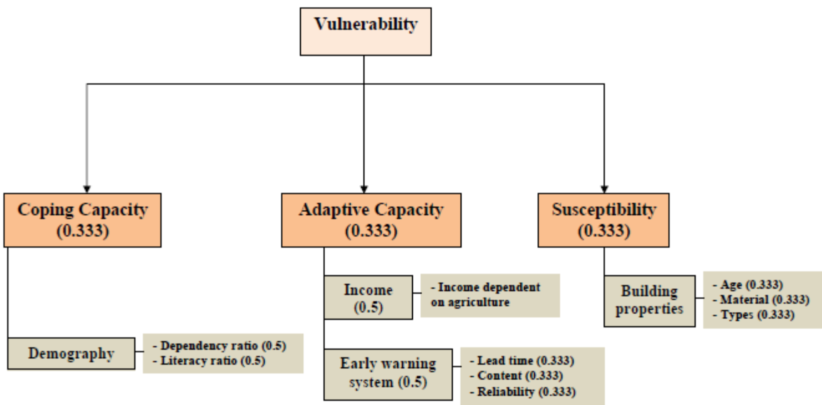
Vulnerability for a Single Receptor (People)



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Risk Reduction Measures

	Baseline	RRM Option 1	RRM Option 2	RRM Option 3
a) Adaptive Capacity (EWS)				
Lead-Time	0.5	0.75	0.5	---
Content& extension	0.25	0.25	1	---
Reliability	0.25	0.5	0.25	---
b) Susceptibility				
Building Type	0.4	---	---	0.2
Building Material	0.5	---	---	0.2
Building Age	0.45	---	---	0.35

- Options 1 and 2 are represent non-structural RRMs (EWS)
- Option 3 represents structural RRM (building codes)

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Robustness: % of runs meeting the targets (1000 scenarios)

	Baseline	RRM Option 1	RRM Option 2	RRM Option 3
Injuries	54.7%	60.2%	62.4%	71.5%
Lives at risk	60.4%	63.2%	64.6%	68.8%

The decision makers desired outcome:

- Less than 400 lives at risk
- Less than 5860 injury

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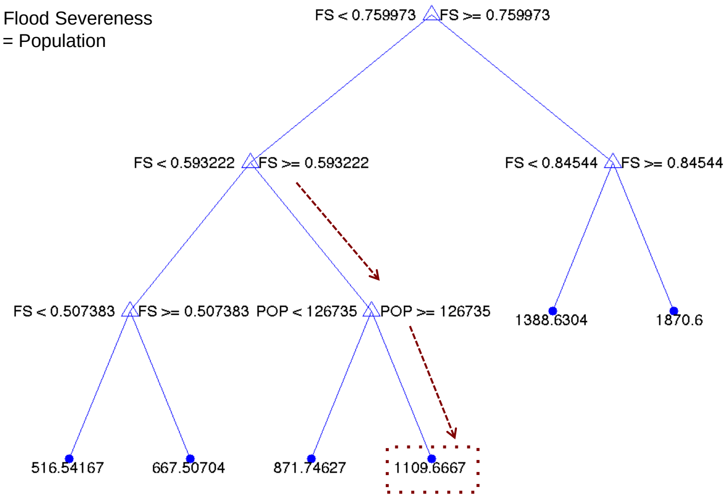
Options' Vulnerability: e.g. categorization of undesired results after implementing option 1

FS = Flood Severeness
POP = Population



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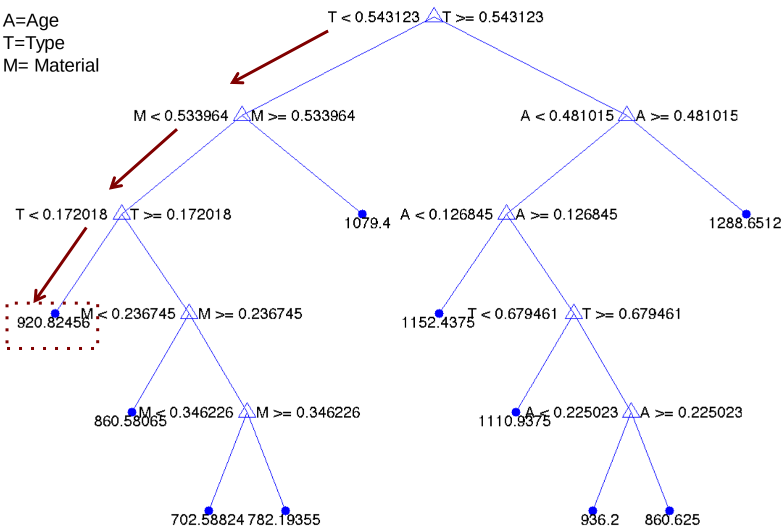
Options' Vulnerability: e.g. categorization of undesired results after implementing option 1

A=Age
T=Type
M= Material



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Concluding remarks

- ⇨ **Deterministic decision** is not a reliable criterion when decision-makers face deep uncertainty
- ⇨ **Deep Uncertainty** analysis is a gradual assessment requiring prudent reckon on probability distribution based on historical information
- ⇨ **Natures, locations, and degree** of uncertainty at **each step** of the decision support/making processes should be identified through participatory process
- ⇨ **Adaptive robust decision making** provides us with the exploration capability and the flexibility required for Climate Change Adaptation

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Thanks for your attention!

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Assessment of risk

The simulated values of hazard will be converted into a single index "flood severeness" following the method presented in DEFRA (2006) and Mojtahed et al (2013).

$$FS = \frac{(d \times (v + 0.5) + DF)}{10} \quad \text{(Eq. 4)}$$

where d_i is the depth of water measured in meter, v_i is the velocity of flood (m/s) and DF_i is presence of debris factor (1= Urban, 0.5 = Woodland) considered for aggregated study area. The above formula is estimated for human receptor based on field experiments and the coefficients are subject to variations based on characterization of body masses of the samples. Following the characterization of flood severeness, we identify the number of people exposed to risk, *n.p.r* by

$$n.p.r = N \times FS \times Vul \ , \quad \text{(Eq. 5)}$$

where N is the number of people, and Vul is the vulnerability index in the Eastern Dhaka. The number of injuries, *n.inj*, is calculated following equation below

$$n.inj = n.p.r \times \alpha \times Vul \ , \quad \text{(Eq. 6)}$$

where α is calibrated based on the average of historical data of floods with different RTs, and then rounded to the closet integer. The number of deaths is calculated by,

$$n.dth. = \frac{(n.inj. \times \beta + FS)}{10} \quad \text{(Eq. 7)}$$

where β is also calibrated by historical data. For this assessment, we usedα =1 and β=1.5.

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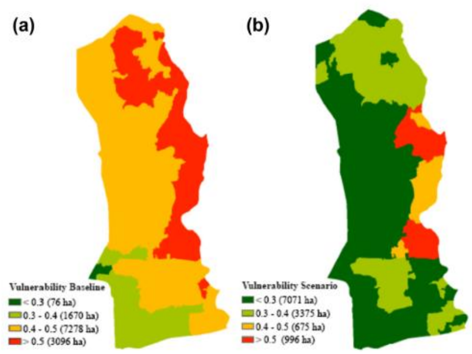
Eastern Dhaka City

Vulnerability map



a) Baseline b) Alternative scenario

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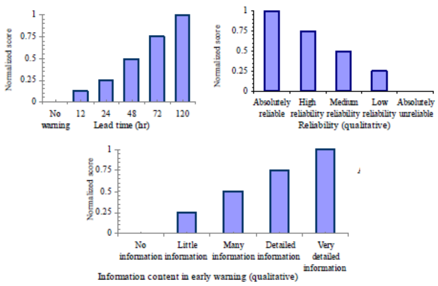
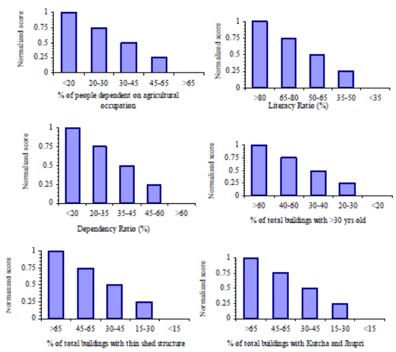
Normalization of Social Indicators



Adaptive Capacity
(Early Warning System)

Coping Capacity

Susceptibility



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