ICCG Webinar Series on Water and Climate Change

Urban Climate Resilience and Decision Making with Focus on Water

Stelios Grafakos – Erasmus University of Rotterdam

October 22, 2015

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Urban climate resilience and decision making with focus on water

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Outline of webinar

- Urban climate adaptation and resilience context
- Introduction to Multiple Criteria Analysis (MCA)
- Illustration of MCA through a case study
- Applications and lessons learned

Understanding risk in urban/rural areas

- Urbanization: Natural growth, migration, increasing populations moving from rural to urban areas

STRESS ⟶ RISK

- Megacities = hotspots of risk
- Small towns = less resources/poor planning and services
- Peri-Urban= random and fast transformation of land and population

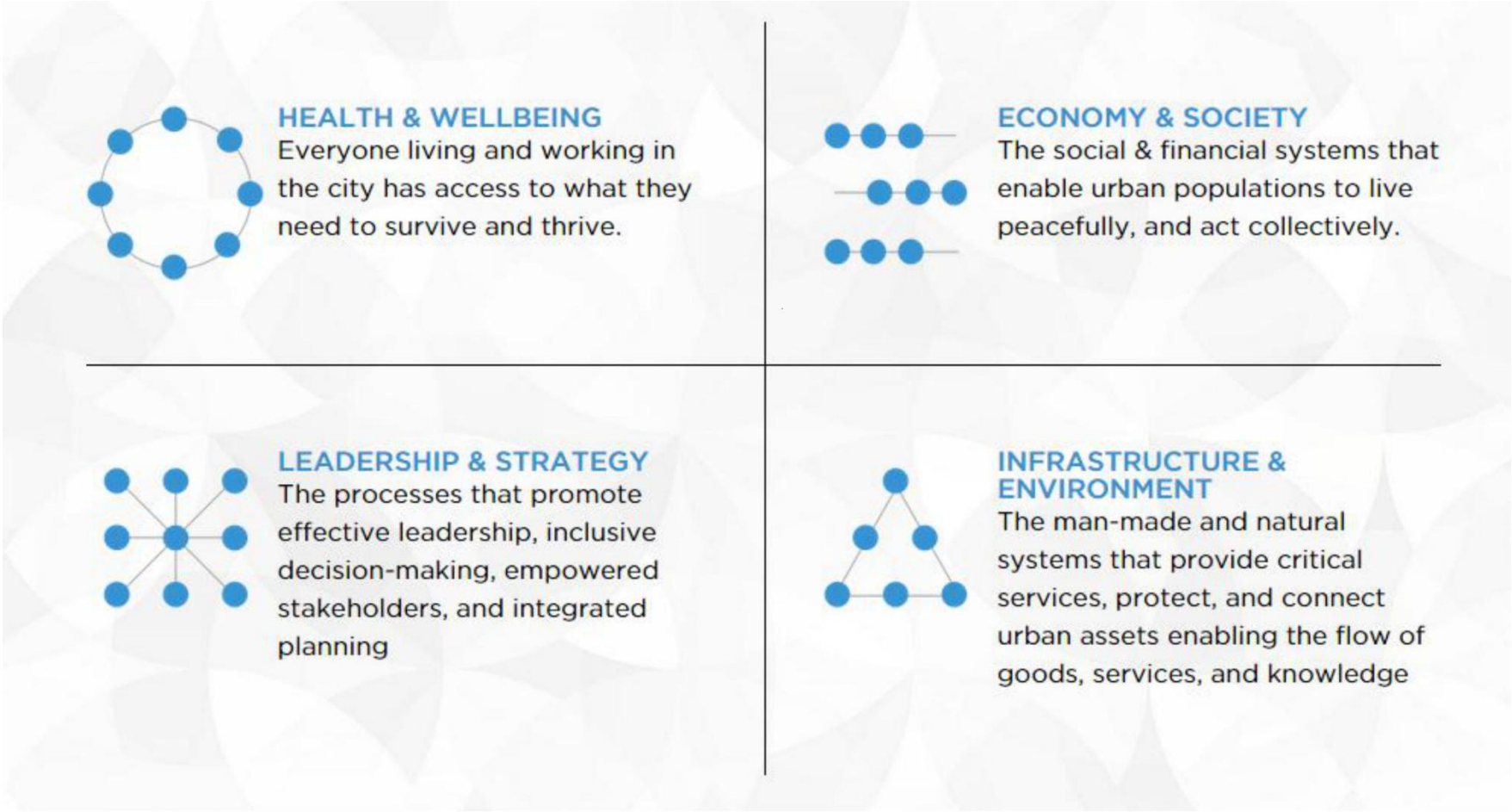
Defining Resilience (evolving)

The ability of a social, ecological or socio-ecological system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions, its capacity for self-organization, and the capacity to adapt to stress and change. (IPCC, 2014)

Responding to climate change
Dimensions of (urban) resilience

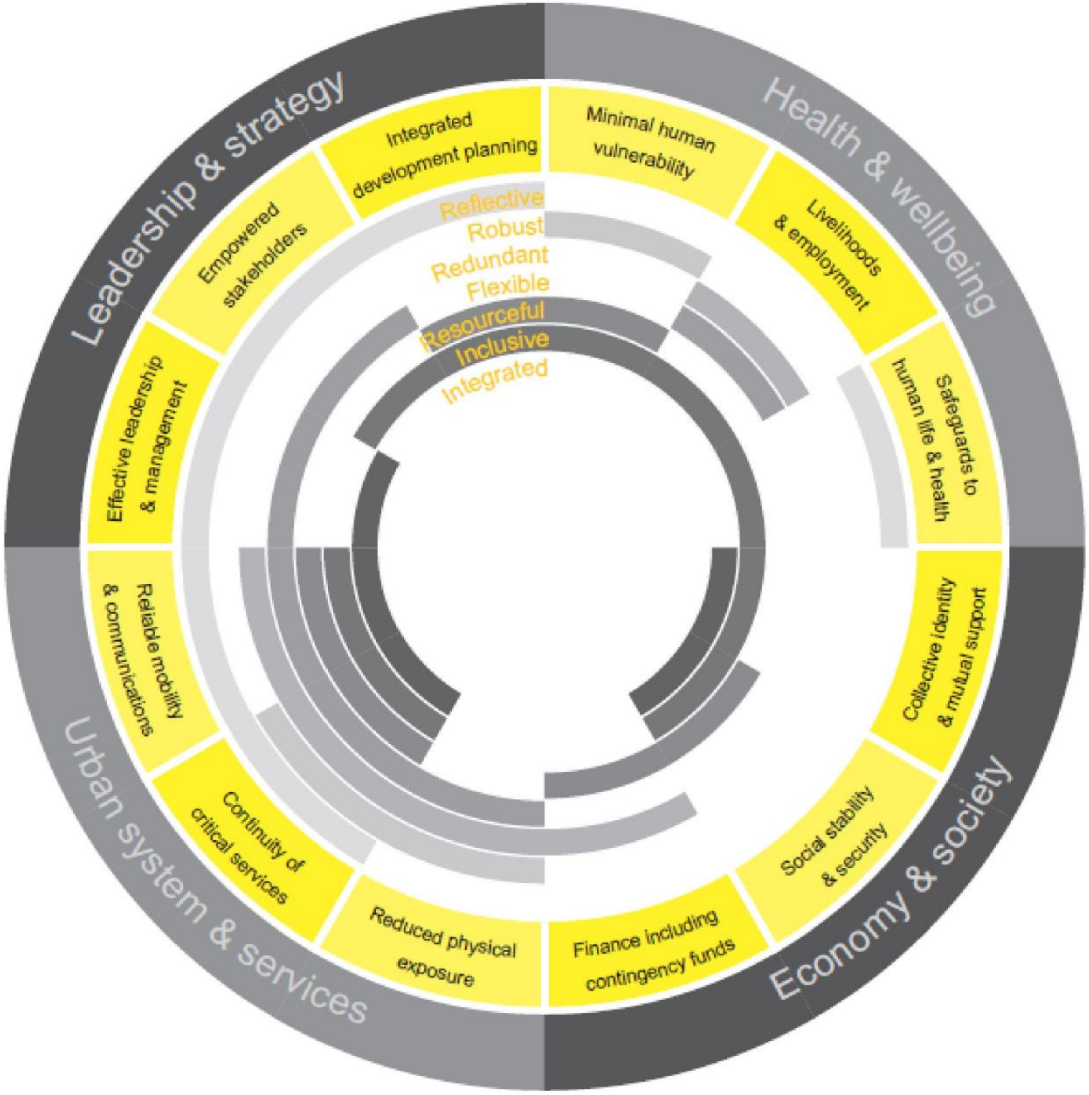
[Source: Asian Cities Climate Change Resilience Network / Resilience Alliance]

Dimensions of City Resilience
[Rockefeller Foundation – 100 Resilient Cities]



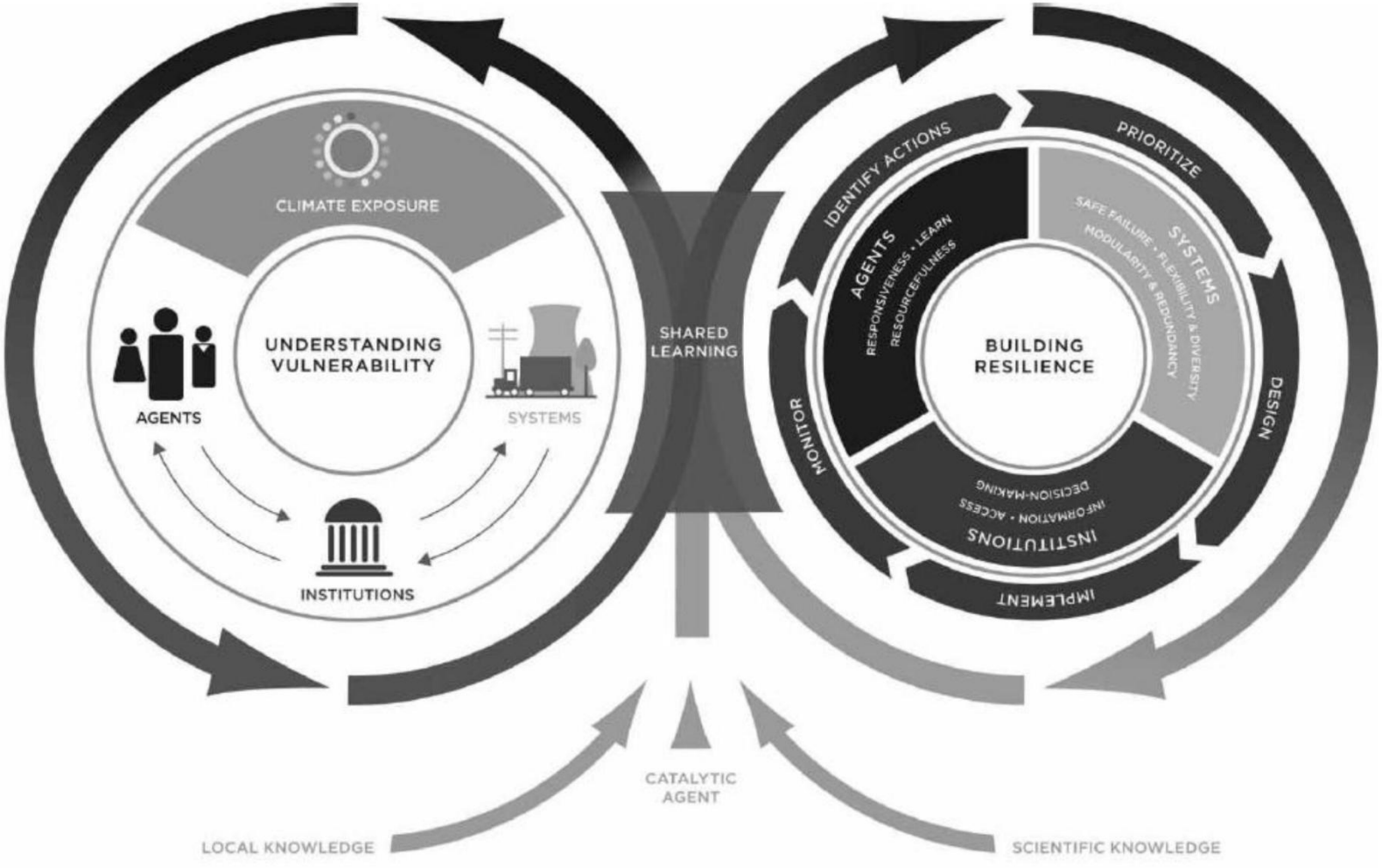
www.100resilientcities.org

City Resilience Framework [Arup]



[Source: Arup (2014). *City Resilience Framework*]

Responding to Climate Change
Towards Resilient Communities and Cities



[Source: Tyler S, Moench M (2012). 'A framework for urban climate resilience' *Climate and Development* 4(4): 311-326.]

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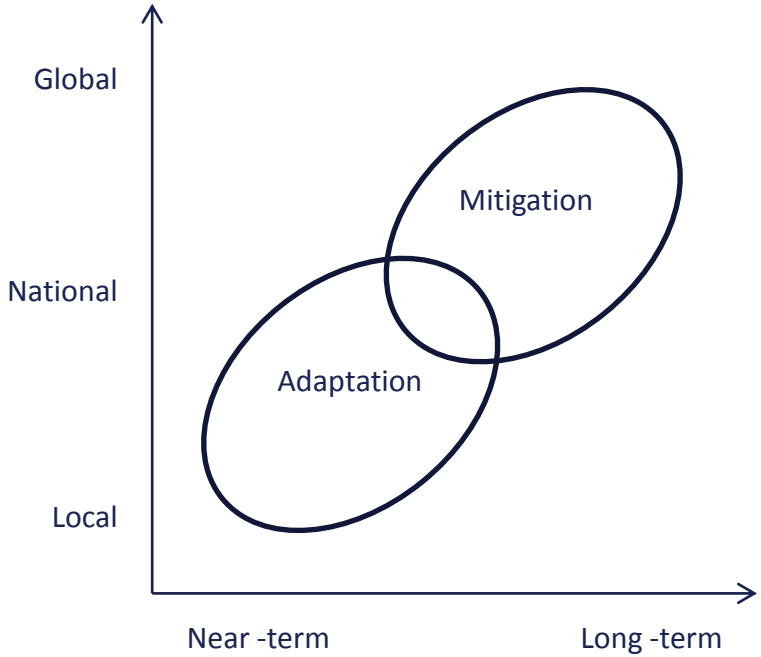
Spatial-Temporal scales of Adaptation vs Mitigation



Adapted from Moser, C. (2011)

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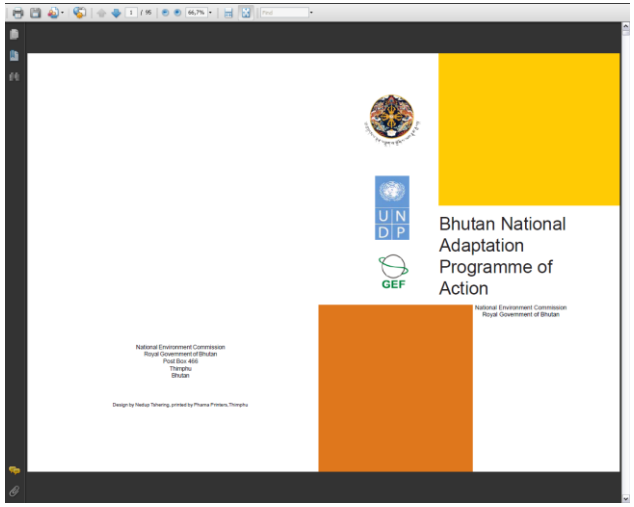
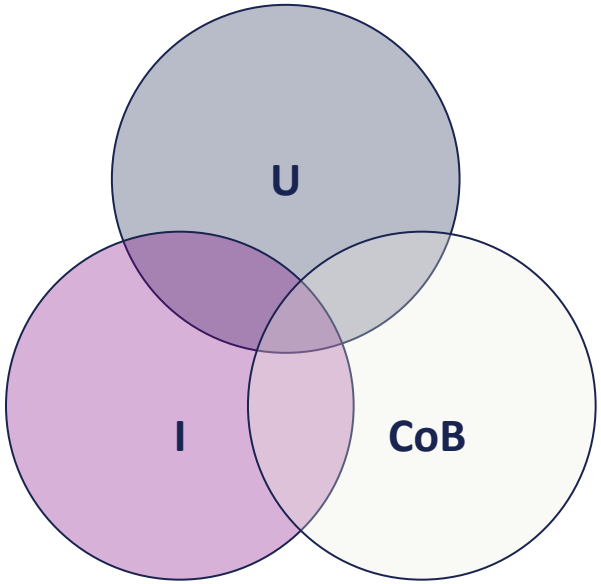
Adaptation Spatial Scales

- Global (IAM, GEM)
- National (NAPAs)
- Local (appraisal of vulnerability and adaptation measures)



Adaptation assessment challenges and characteristics

- Uncertainty
- Co-Benefits
- Inclusion
  - Equity



UNFCC, 2011

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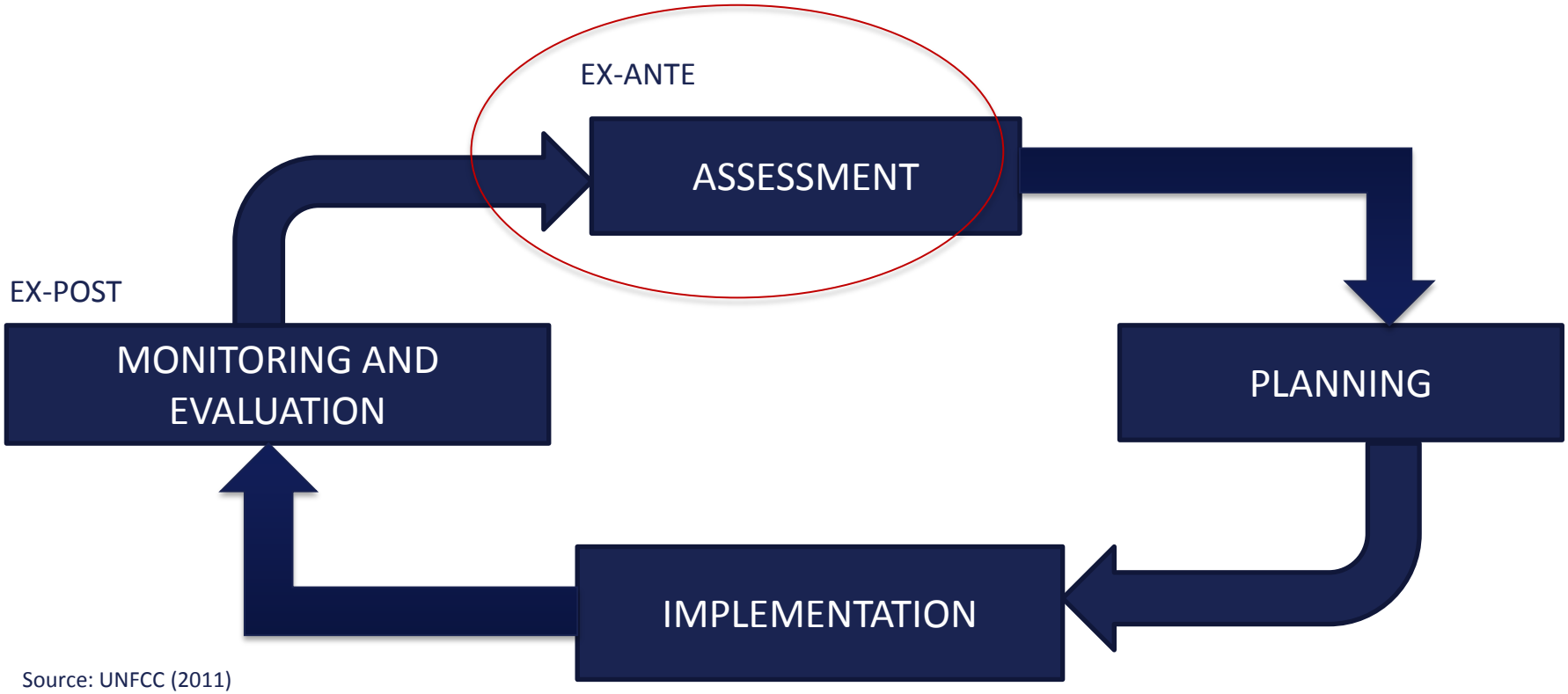
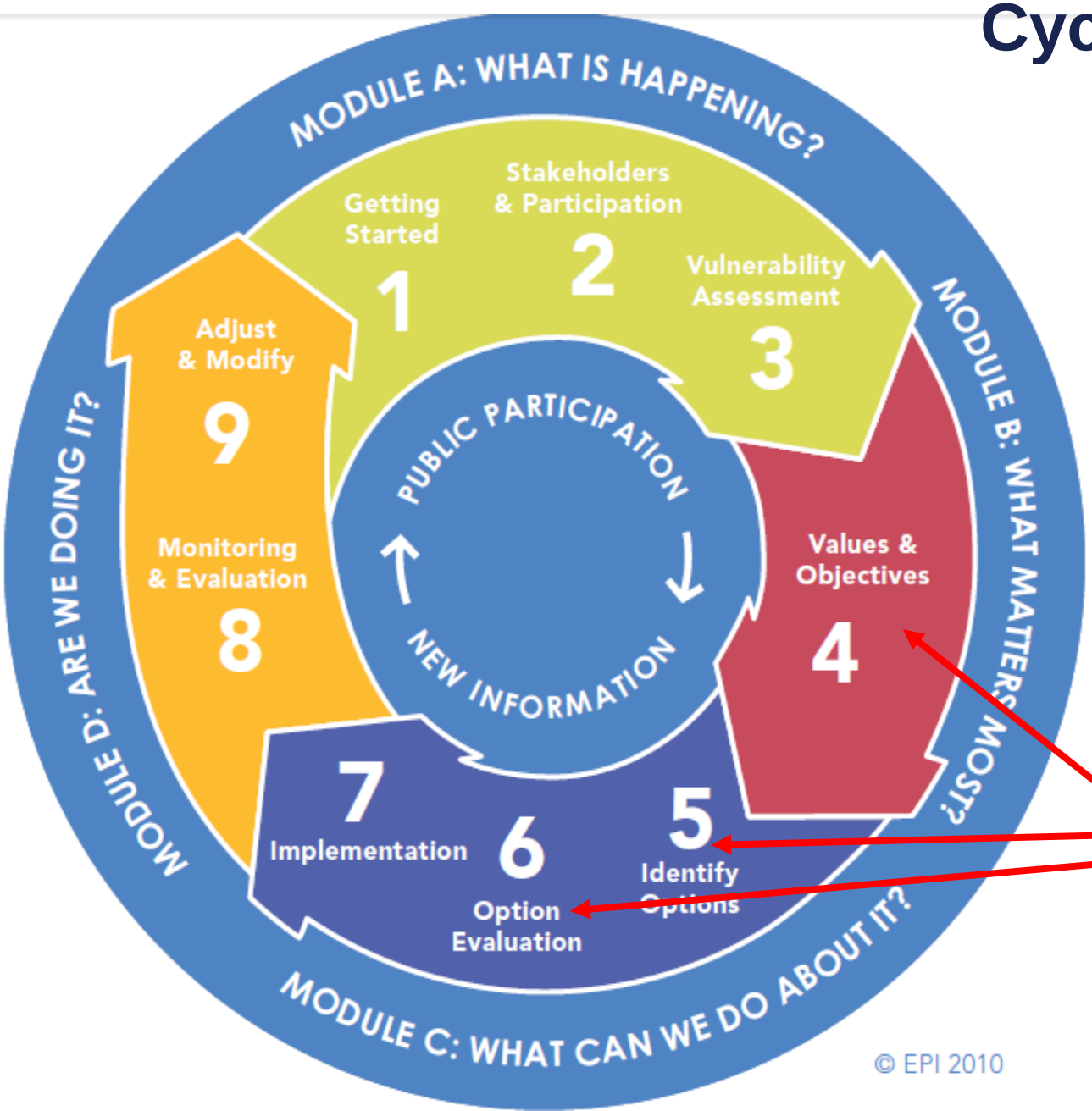
Climate change action planning process and its key components



Source: UNFCC (2011)

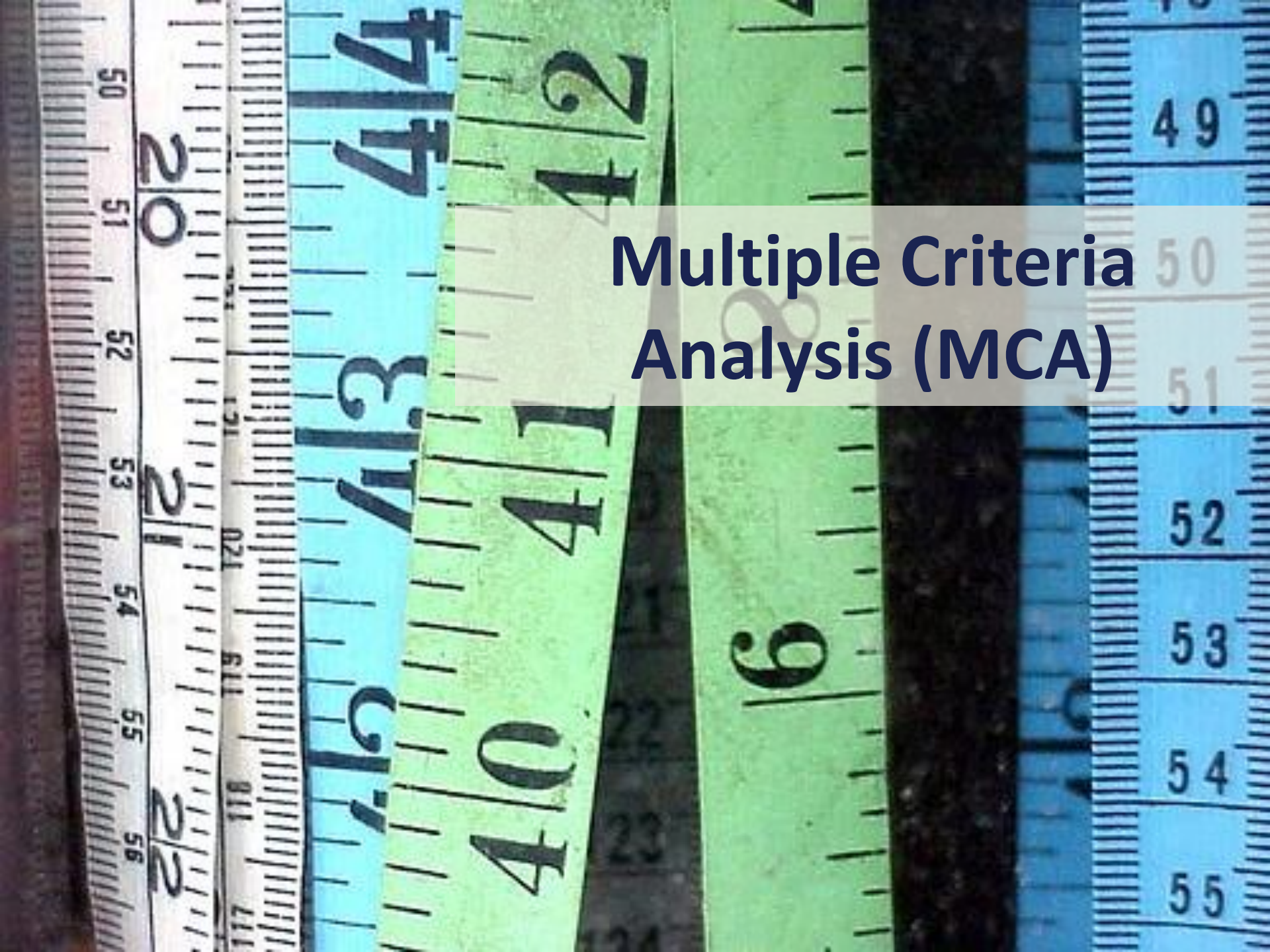
Climate Change Planning Cycle



Assessment

Decision Support and Assessment Tools for Climate Change Adaptation

- Cost Benefit Analysis (CBA)
- Cost Effectiveness Analysis (CEA)
- Multiple Criteria Analysis (MCA)



Multiple Criteria Analysis (MCA)

MCA: Background

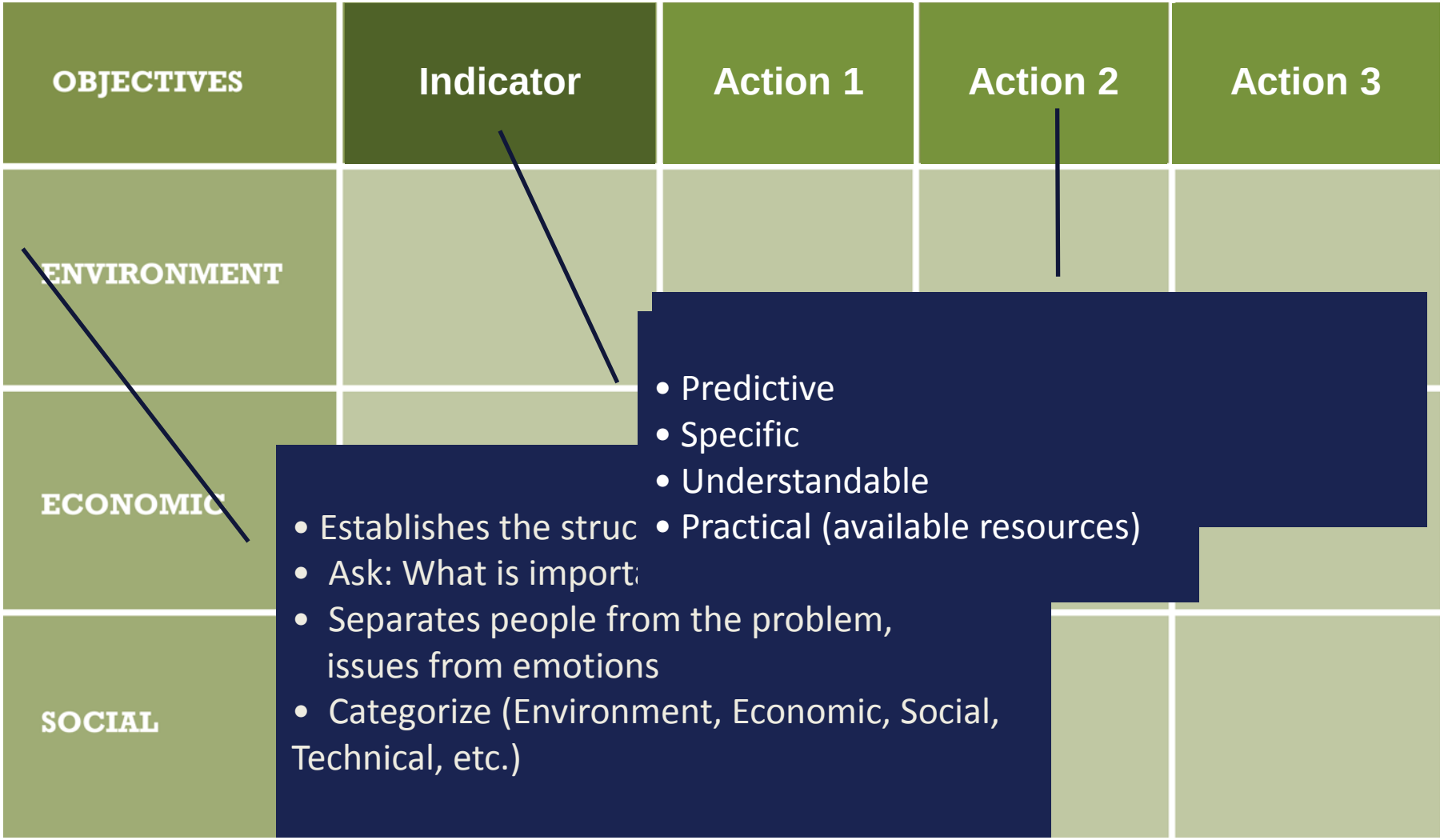
- Decision analysis
- Management science
- Operational research

Structural elements of MCA

- Multiple Alternatives (at least two)
- Multiple – and often conflicting- Criteria
- Policy makers or multiple stakeholders -

MCA: Main steps

Objectives & decision-making



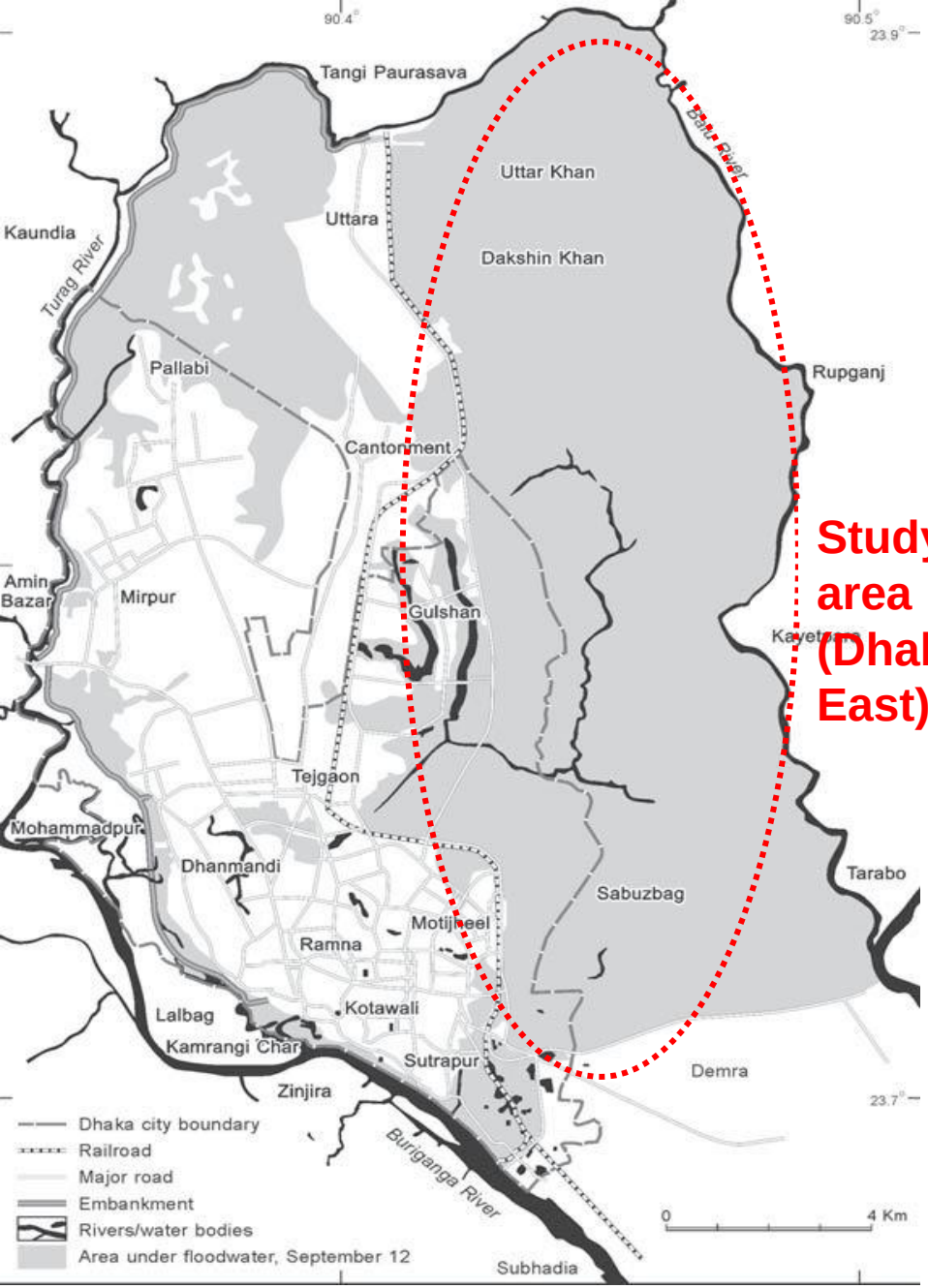
Inclusion of stakeholders and Weighting of criteria

- Workshops, stakeholers consultations
- Assign 100 points to criteria based on their relative importance (direct)
- How more important is x criterion than the y criterion? (pairwise)
- Swing, resistance to change, etc.

Dealing with uncertainty

- Different type of uncertainties
- Sensitivity analysis
- Scenario analysis
- Adaptive Management

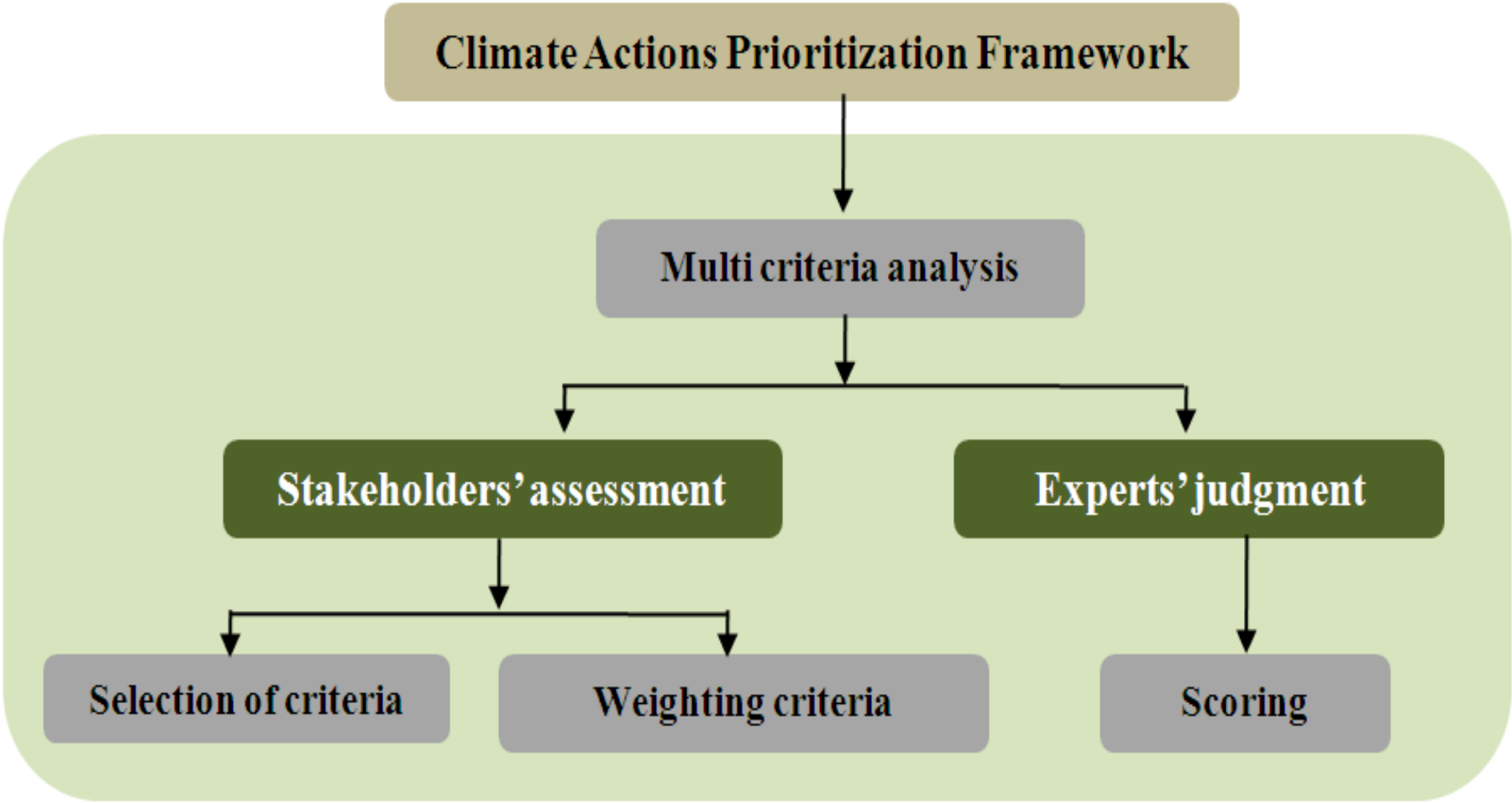
An illustration of MCA application to a flood management issue in the city of Dhaka



Study area (Dhaka East)

Figure 3: Disruption of communication due to flood
Source: The Daily Star, 15 August, 2005

Figure 1 : Flood map of Dhaka city during 1998 flood showing inundated study area
Source: Bangladesh Center for Advanced Studies


Climate Actions Prioritization Framework
Multi criteria analysis
Stakeholders' assessment
Experts' judgment
Selection of criteria
Weighting criteria
Scoring

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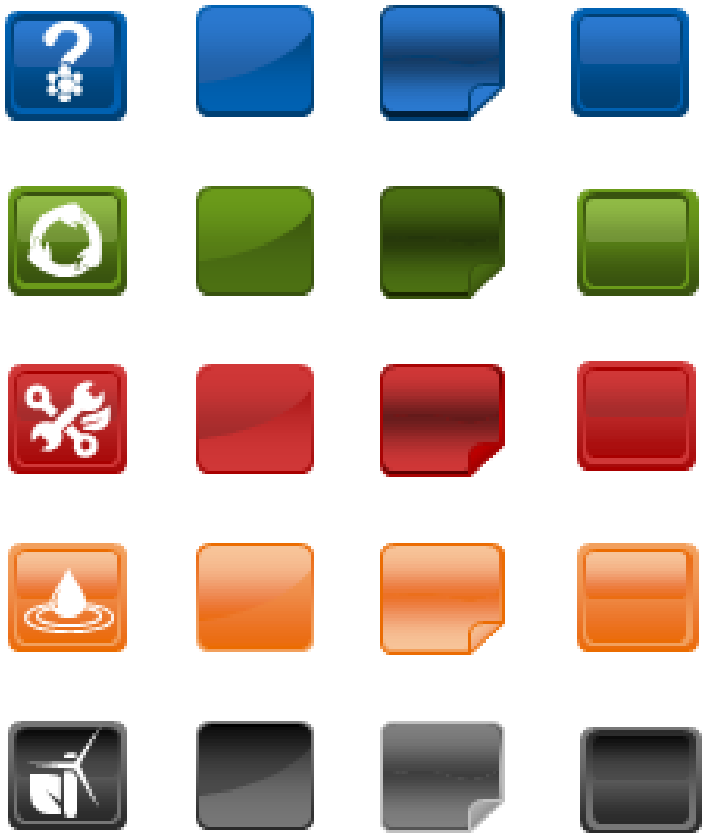
Climate Actions Prioritisation Tool

CLIMACT Prio



START

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STEP 2: Adaptation Actions

1) Specify actions, their type and sector
2) Provide time frame, brief description and source

Go to the next step (Criteria)

- Introduction
- Step1: Vulnerability
- Step 2: Actions
- Step 3: Criteria
- Step 4: Scores
- Step 5: Weights
- Step 6: Results
- Step 7: Sensitivity

No	Adaptation actions	Type	Focus	Time frame	Description	Source
1	Construction, retrofitting of drainage system	**structural**	Infrastructure	Long term		
2	Raised road	**structural**	Transport	Medium term		
3	Embankment	**structural**	Flood management	Medium term		
4	Flood wall	**structural**	Flood management	Medium term		
5	Protection of water retention areas	**non-structural**	Water management	Short term		
6	Canal Improvement	**non-structural**	Water management	Medium term		
7	Enhancing emergency	**non-structural**	Disaster	Short term		
8	Upgrading early warning system	**non-structural**	Disaster management	Short term		

STEP 3: CRITERIA identification

1. Define **evaluation criteria**
2. Specify their respective **category**
3. Speciy the **unit of measurement**
4. Specify the **direction of preference** (Min/Max)

Next Step (Scores)

- Introduction
- Step1: Vulnerability
- Step 2: Actions
- Step 3: Criteria
- Step 4: Scores
- Step 5: Weights
- Step 6: Results
- Step 7: Sensitivity

	Task 1	Task 2	Task 3	Task 4
	Criteria	Category of Criteria	Units	Min/Max
1	Vulnerability reduction	Climate	%	Max
2	Cost	Economic	euros	Min
3	Institutional and technical capacity	Feasibility	"1 - 5"	Min
4	Public and political acceptance	Social	"1 - 5"	Max
5	Achievement of MDG	Social	"1 - 5"	Max
6	Employment generation	Economic	"1 - 5"	Max
7	Enhancement of ecological condition	Environmental	"1 - 5"	Max

STEP 4: SCORING - Impact Assessment Matrix

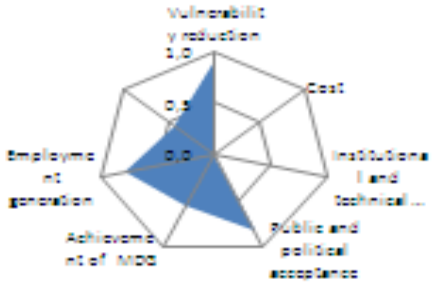
Indicate the scores for each alternative on every criterion

Next Step (Normalized Scores)

Options/Criteria	Vulnerability reduction	Cost	Institutional and technical capacity	Public and political acceptance	Achievement of MDG	Employment generation	Enhancement of ecological condition
Scale units	%	euros	"1 - 5"	"1 - 5"	"1 - 5"	"1 - 5"	"1 - 5"
Construction, retrofitting of drainage system	79	64	5	4	4	4	3
Raised road	64	4	4	4	3	3	2
Embankment	69	20	4	4	3	4	2
Flood wall	61	6	3	1	3	3	2
Protection of water retention areas	74	1	3	2	4	4	5
Canal Improvement	71	14	4	2	4	3	4
Enhancing emergency response mechanism	63	1	2	4	4	2	2
Upgrading early warning	81	2	4	4	5	2	3

Introduction
Step1: Vulnerability
Step 2: Actions
Step 3: Criteria
Step 4: Scores
Step 5: Weights
Step 6: Results
Step 7: Sensitivity

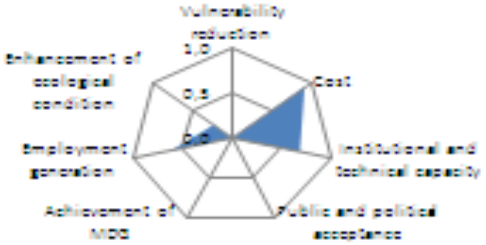
Construction, retrofitting of drainage system



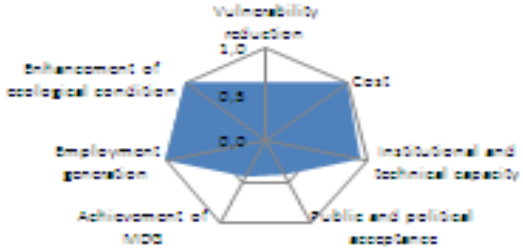
Raised road

Embankment

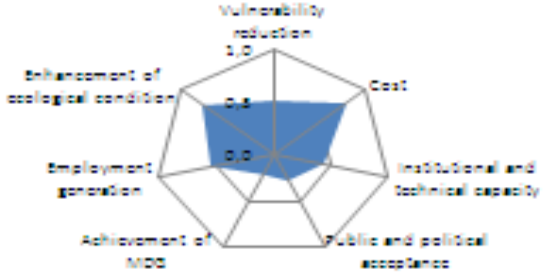
Flood wall



Protection of water retention areas



Canal Improvement



Enhancing emergency response mechanism

Upgrading early warning system

Next Step (Weight)

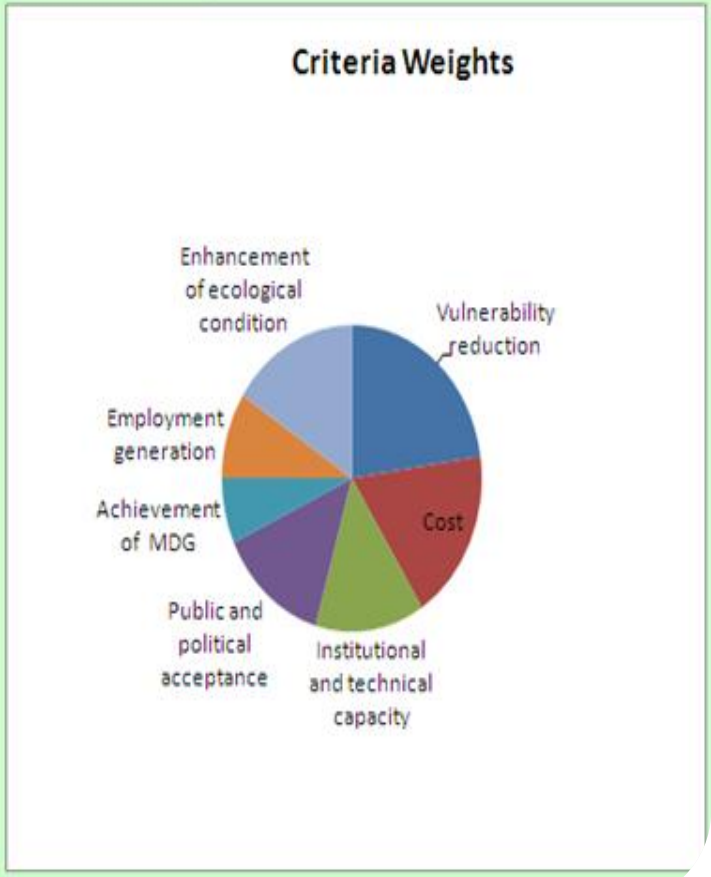
STEP 5: Criteria WEIGHTING

1. Indicate the level of importance of criteria verbally from "very low" to "very high"
2. Assign a value denoting relative importance of criteria

Go to the next step (Weighted Scores)

Introduction
Step1: Vulnerability
Step 2: Actions
Step 3: Criteria
Step 4: Scores
Step 5: Weights
Step 6: Results
Step 7: Sensitivity

			Task 1	Task 2		
Category of Criteria	Criteria	Rank	Importance	Values	Weights	Degree of Convergence
Climate	Vulnerability reduction	1	Very High	100	22,7%	Very High
Economic	Cost	2	Moderate	80	18,2%	Very High
Feasibility	Institutional and technical capacity	4	High	60	13,6%	Very High
Social	Public and political acceptance	4	Moderate	60	13,6%	Very High
Social	Achievement of MDG	7	Moderate	30	6,8%	Very High
Economic	Employment generation	6	Low	40	9,1%	Very High
Environmental	Enhancement of ecological condition	3	Low	70	15,9%	Very High



STEP 6: RESULTS - Ranking

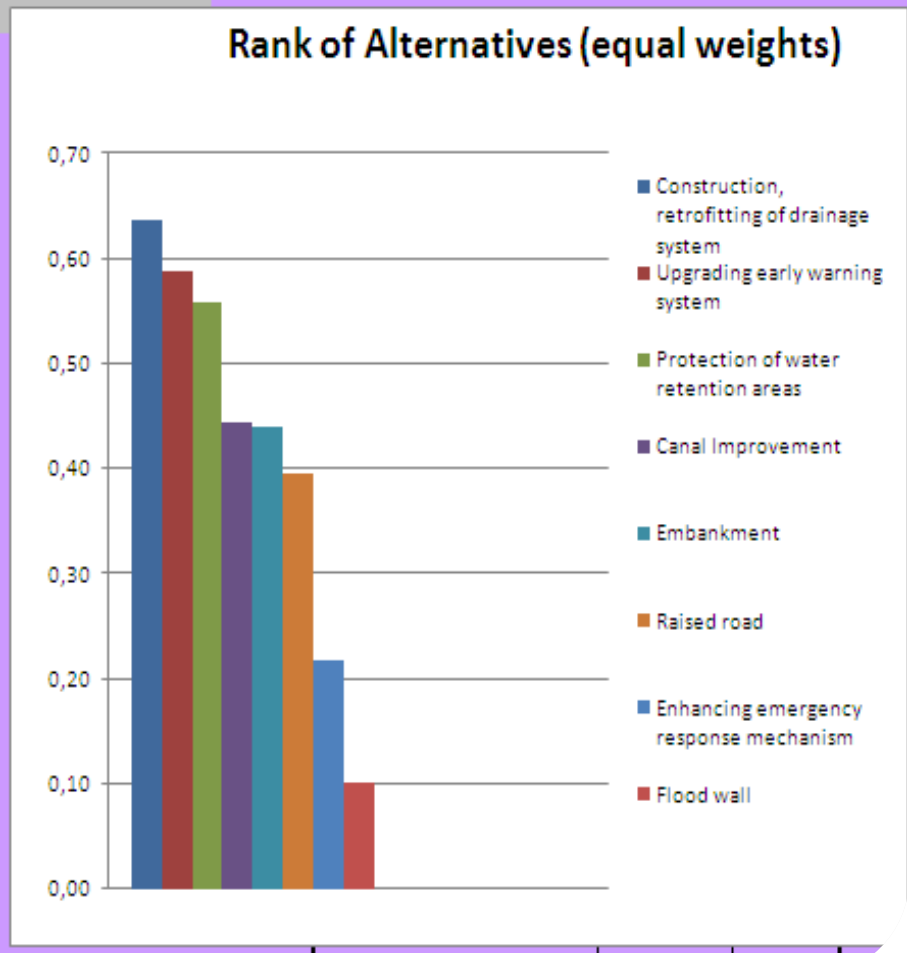
1. Press the button 'SORT Alternatives' for ranking alternatives according to assigned weights and 'Normalized Scores'

GO to the NEXT STEP

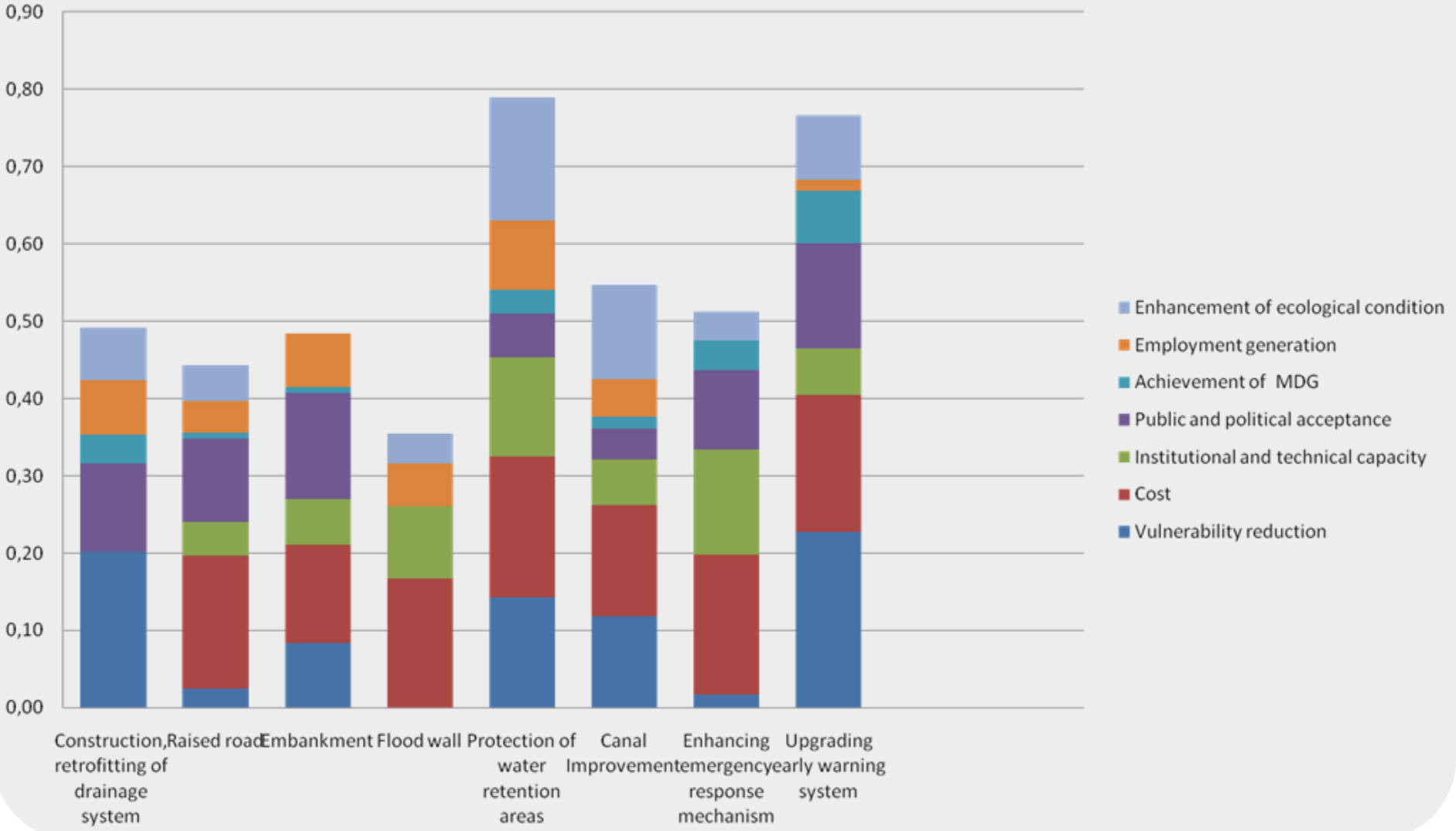
- Introduction
- Step1: Vulnerability
- Step 2: Actions
- Step 3: Criteria
- Step 4: Scores
- Step 5: Weights
- Step 6: Results
- Step 7: Sensitivity

Options	Score	Rank
Protection of water retention areas	0,79	1
Upgrading early warning system	0,77	2
Canal Improvement	0,55	3
Enhancing emergency response mechanism	0,51	4
Construction, retrofitting of drainage system	0,49	5
Embankment	0,48	6
Raised road	0,44	7
Flood wall	0,35	8

SORT Alternatives



Final Scores and Contribution of criteria



No.	Type of Evaluation	Author	Country	Country Status	Scope	Governance Level	Initiator	Sectoral Coverage	Sustainability Objectives (co-benefits)
1	**MCA**	Porthin, et al. (2013)	Finland	Developed Country	Urban	City (Local)	Researchers	Flood Management	Y
2	**MCA**	Haque, et al. (2012)	Bangladesh	Least Developed Country	Urban	City (Local)	Researchers	Flood Management	Y
3	**MCA**	Huntjens, et al. (2013)	Vietnam	Least Developed Country	Urban/Rural	Multi-level (Province, District, Commune)	Foreign Donors	River Basin Management	Y
4	**MCA**	Lewis (2011)	South Africa	Least Developed Country	Urban	City (Local)	Local Government	Multi - Sectoral	Y
5	**MCA**	Kubal, et al. (2009)	Germany	Developed Country	Urban	City (Local)	Researchers	Flood Management	Y
6	**MCA**	Debels, et al. (2007)	Chile	Least Developed Country	Urban			Disaster Management	Y

Adaptation and Mitigation Theme Reports

Adaptation

Click here to download detailed reports from each of our eight MCA4climate adaptation theme experts looking in more detail at key adaptation topics including health, coastal zone management and extreme weather events.

Mitigation

Click here to download detailed reports from our four MCA4climate mitigation theme experts. These papers look in more detail at key issues in mitigation and cover energy efficiency, fuel mix, carbon capture and storage and land use.

Back to list

Mitigation	Adaptation	Case Studies
Energy Efficiency	Costal Zone Management	Mumbai
Fuel Mix	Human Health	Sana'a Basin
Land Use Management	Agriculture	South Africa
Carbon Capture and Storage	Infrastructure	
	Water	
	Terrestrial Ecosystems	
	Marine Ecosystems	
	Extreme Weather Events	

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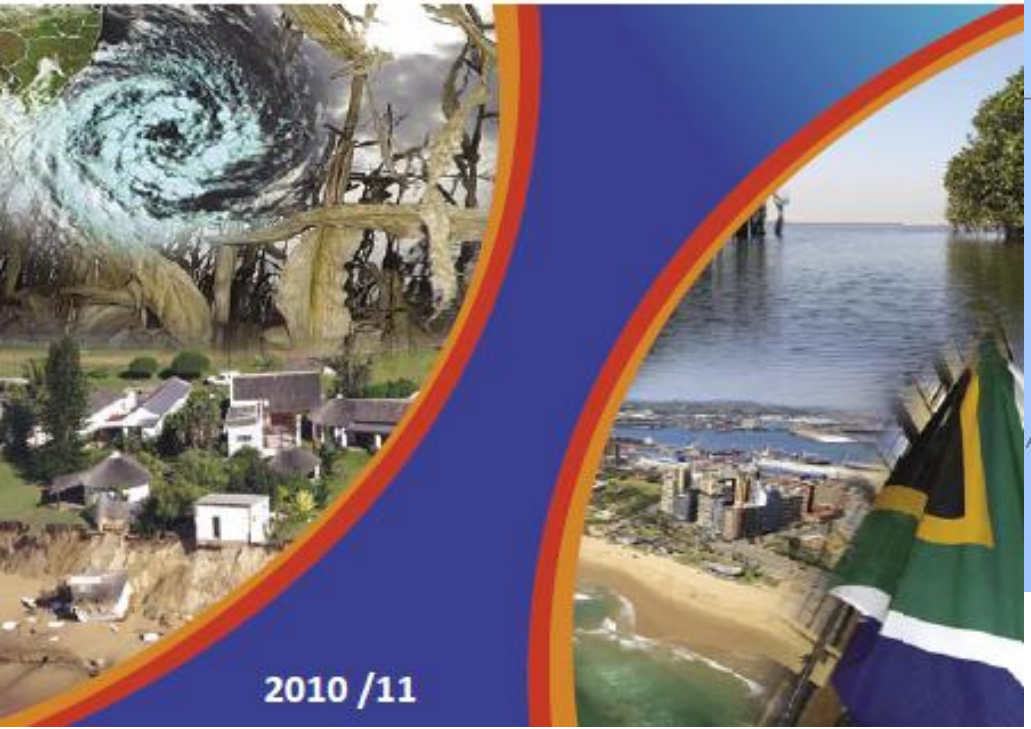
Technology Needs Assessment for Climate Change

ETHEKWINI MUNICIPALITY

Durban's Municipal Climate Protection Programme:

CLIMATE CHANGE ADAPTATION PLANNING

FOR A RESILIENT CITY



Impact on risk	The level of climate change risk that the intervention will reduce.
Ancillary Benefits	How beneficial is it to undertake this intervention regardless of climate change impacts, as the intervention promotes sustainable development.
Reversible or Flexible	Climate change science is not perfect and hence interventions that can be reversed or adjusted based on the latest science are better than those that cannot.
Impact on emissions	How does the intervention affect the amount of greenhouse gases in the atmosphere?
Allows complementary options	Are there complementary options in association with the intervention? Does the intervention reduce, retain or enhance the set of options available for responding to climate change.
Ease of implementation	Indicates the likelihood of the intervention being successfully implemented.
Institutional complexity	This criterion also indicates the likelihood of the intervention being implemented. If the intervention requires complex municipal processes and procedures and many departments working together, its likelihood of success is lessened.
Cost: benefit	A broad judgement of whether the intervention has 'high cost: low benefit' or 'high benefit: low cost.'
Risk of 'maladaptation'	Ill-considered implementation of an intervention is considered 'maladaptation' as it may have unintended adverse impacts.

Table 4 Multi-Criteria Assessment of the Adaptation Plan Interventions*

ef	Adaptation Category	Sub-category	Impact	Intervention	Impact on risk 3 = Risk reduced 2 = None 1 = Risk increased	Ancillary benefits 3 = Yes 2 = No	Reversible/ Flexible? 3 = Yes 2 = Neutral 1 = No	Impact on emissions 3 = Reduced 2 = None 1 = Increased	Allows complementary interventions 3 = Yes 2 = Neutral 1 = No	Ease of implementation 3 = Easy 2 = Neutral 1 = Difficult	Institutional complexity 3 = Simple 2 = Neutral 1 = Complex	Cost: Benefit 3 = Low cost/high benefit 2 = Neutral 1 = High cost/low benefit	Risk of maladaptation 3 = Low 2 = Medium 1 = High	Merit (sum of criteria)	Urgency 1 = Medium 2 = High 3 = Very High	Priority (Merit x Urgency) H = >45 M = 22 - 45 L = <22	
1	Water	Infrastructure Protection (New)	Flooding	Detailed analysis of latest rainfall/run-off projections and modelling of systems to be finalised.	2	3	3	2	3	3	3	3	3	25	3	75	H
2	Water	Infrastructure Protection (New)	Flooding	Revise rainfall data in line with latest projections (as of 30 September 2009) and review every 5 years.	2	3	3	2	3	3	3	3	3	25	3	75	H
9	Water	Infrastructure Protection (Existing)	Flooding	Protect and restore riparian vegetation so as to protect integrity of river banks and retain biological buffers against flooding.	3	3	3	3	3	2	2	3	3	25	3	75	H
5	Water	Infrastructure Protection (New)	Flooding	Develop Master Drainage Plans for all river catchments within eThekwini Municipal boundaries.	3	2	3	2	3	3	2	3	3	24	3	72	H
6	Water	Infrastructure Protection (New)	Sea Level Rise	Revise coastal set back lines.	3	3	3	2	3	3	1	3	3	24	3	72	H
1	Health	Disaster Management	All	Improve the ability of Health Care Systems to respond effectively during emergencies.	3	3	3	2	3	1	2	3	3	23	3	69	H
M2	Disaster	Disaster Management	All	Implement Disaster Risk Management Framework.	2	3	2	2	3	3	1	3	3	22	3	66	H
M3	Disaster	Disaster Management	All	Undertake a detailed assessment of all risks in Durban.	2	3	3	2	3	2	1	3	3	22	3	66	H
8	Water	Infrastructure Protection (New)	Sea Level Rise	Prepare Coastal Management Plans for entire Durban coastline.	3	3	3	2	3	1	1	3	2	21	3	63	H
17	Water	Water Security	Water Availability	Incorporate requirement that Umgeni Water consider the impact of climate change on rainfall and run-off into eThekwini Municipality's water purchase agreement.	2	3	3	2	3	1	1	3	3	21	3	63	H
18	Water	Water Demand Management	Water Availability	Develop an overarching Water Use Strategy which captures existing interventions being undertaken within the Municipality, identifies additional interventions, creates clear priorities and an implementation plan for responding to the challenges of a current water shortage impacted on by climate change and its further impact on water security.	3	3	2	2	3	2	1	3	2	21	3	63	H
M1	Disaster	Disaster Management	All	Secure additional resources for Disaster Management Unit.	3	3	2	2	2	1	2	1	3	19	3	57	H
M4	Disaster	Disaster Management	All	Revise Contingency Plans for key risk areas.	3	3	2	2	2	1	1	3	2	19	3	57	H
M5	Disaster	Disaster Management	All	Disaster Management Summit - to raise awareness of Disaster Management function and unit responsibilities - refer to hosting a successful FIFA 2010 World Cup™ and managing climate change risk.	3	3	3	1	3	1	1	3	1	19	3	57	H

CITY OF VANCOUVER

GREENEST CITY 2020
Climate Adaptation

CLIMATE CHANGE ADAPTATION STRATEGY

Category	Criteria	1 (low)	2 (medium)	3 (high)
Sustainability	Mitigation co-benefits	Result in increased GHG emissions	Would not affect GHG emissions	Would reduce greenhouse gas emissions
	Equity	Benefits to few people	Benefits to many people	Significant benefits to many people
	Implementation Cost	Cost is high relative to cost of inaction	Cost is moderate relative to cost of inaction	Cost is low relative to cost of inaction
Effectiveness	Robustness	Effective for a narrow range of plausible future scenarios	Effective across many plausible future scenarios	Effective across a wide range of plausible future scenarios
Risk and Uncertainty	Urgency	Risks are likely to occur in the longer term	Impacts are likely in the near to mid term	Impacts are already occurring
Opportunity	Ancillary benefits	Will contribute little if not at all to other City goals and programs	Will contribute somewhat to other City goals and programs	Will contribute significantly to other City goals and programs
	No Regret	Will have little or no benefit if climate change impacts do not occur	Will have some benefits regardless of actual climate change impacts	Will result in significant benefits regardless of actual climate change impacts
	Window of Opportunity	There is no window currently	A window of opportunity could be created	A window of opportunity exists to implement
Implementation	Funding Sources	External funding sources are required but have not been identified	External funding sources are required and likely to be secured	Funding is available externally or internally
	Institutional	Implementation requires coordination with, or action by other jurisdictions	Implementation requires external approval	Implementation is within local control

Opportunities

- Allows multiple **perspectives – views**
- Incorporates different **measurement scales**
- Provides **transparency** and **structure**
- Triggers **discussion** between stakeholders
- **Knowledge** generation

Challenges

- High degree of **subjectivity**
- Difficult to reach **consensus** on weighting of criteria
- Risk of **double counting**

Trends and lessons learned

- **Reasons to apply MCA**: Transparency, stakeholders engagement, conflict resolution, multiple objectives
- Use of **less complex MCA** methods as urban water/adaptation management decisions by non experts
- **Less on development** of MCA methods, but more on integrative frameworks
- **Increasing number of cities** using MCA in their Climate Change Resilience/Adaptation planning

Thank You

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Relevant Literature

- United Nations Framework Convention on Climate Change (UNFCCC) (2002), *A Guide to the Climate Change Convention and its Kyoto Protocol*.
- Haque, A., Grafakos, S., and Huijsman, M., (2011), Assessment of adaptation measures against flooding in the city of Dhaka, Bangladesh, Environment and Urbanization Vol. 24 (1),1:17
- E. Lai , S. Lundie & N. J. Ashbolt (2008) Review of multi-criteria decision aid for integrated sustainability assessment of urban water systems, Urban Water Journal, 5:4, 315-327, DOI: 10.1080/15730620802041038
- Fane et al, University of Technology Sydney, 2011, *Integrated resource planning for urban water—resource papers*, Waterlines report, National Water Commission, Canberra
- Yahaya, Sani, Ahmad, Noordin. and Abdalla, Rania Fadlallah (2009), "Multi criteria analysis for flood vulnerable areas in Hadejia- Jama' Are river basin, Nigeria", *European Journal of Scientific Research*, Vol 42, No. 1, pages 71- 83.
- Bell, M., Hobbs, B. and Ellis, H. (2003), "The use of multi-criteria decision-making methods in the integrated assessment of climate change: implications for IA practitioners", *Socio-Economic Planning Sciences*, Vol. 37, pp. 289-316.
- Kubal, C., Haase, D., Meyer, V. and Scheuer S. (2009), "Integrated urban flood risk assessment – adapting a multicriteria approach to a city*", Natural Hazards and Earth System Sciences*, Vol 9, November, pages 1881-189

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Additional sources

- www.mca4climate.info : Multi-Criteria Analysis for climate change: developing guidance for sound climate policy planning (UNEP)
- http://unfccc.int/ttclear/pdf/TNA%20HB%20version%2028May2010.pdf: Technology needs assessment for climate change
- UNFCCC (2012), Assessing the costs and benefits of adaptation options: An overview of approaches, http://unfccc.int/files/adaptation/nairobi_work_programme/knowledge_resources_and_publications/application/pdf/2011_nwp_costs_benefits_adaptation.pdf
- Grafakos, S. and Olivotto, V., (2012), Choosing the right adaptation assessment method, ICLEI resilient cities congress, http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient_Cities_2012/Program_Updates/Grafakos_and_Olivotto.pdf
- SUSTAIN project: www.sustainedu.com

Participatory integrated assessment of flood protection measures for climate adaptation in Dhaka

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ABSTRACT Dhaka is one of the largest megacities in the world and its population is growing rapidly. Due to its location on a deltaic plain, the city is extremely prone to detrimental flooding, and risks associated with this are expected to increase further in the coming years due to global climate change impacts as well as the high rate of urbanization the city is facing. The lowest-lying part of Dhaka, namely Dhaka East, is facing the most severe risk of flooding. Traditionally, excess water in this part of the city was efficiently stored in water ponds and gradually drained into rivers through connected canals. However, the alarming increase in Dhaka's population is causing encroachment of these water retention areas because of land scarcity. The city's natural drainage is not functioning well and the area is still not protected from flooding, which causes major threats to its inhabitants. This situation increases the urgency to adapt effectively to current flooding caused by climate variability and also to the impacts of future climate change. Although the government is planning several adaptive measures to protect the area from floods, a systematic framework to analyze and assess them is lacking. The objective of this paper is to develop an integrated framework for the assessment and prioritization of various (current and potential) adaptation measures aimed at protecting vulnerable areas from flooding. The study identifies, analyzes, assesses and prioritizes adaptive initiatives and measures to address flood risks in the eastern fringe area, and the adaptation assessment is conducted within the framework of multi-criteria analysis (MCA) methodology. MCA facilitates the participation of stakeholders and hence allows normative judgements, while incorporating technical expertise in the adaptation assessment. Based on the assessment, adaptive measures are prioritized to indicate which actions should be implemented first. Such a participatory integrated assessment of adaptation options is currently lacking in the decision-making process in the city of Dhaka and could greatly help reach informed and structured decisions in the development of adaptation strategies for flood protection.

KEYWORDS assessment / climate adaptation / Dhaka / flood protection / multi-criteria analysis / options prioritization

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