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
Urban climate resilience and decision making with focus on water

Stelios Grafakos,
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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  \rightarrow  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

- Redundancy
- Flexibility
- Capacity to Reorganize
- Capacity to Learn

[Source: Asian Cities Climate Change Resilience Network / Resilience Alliance]
Dimensions of City Resilience
[Rockefeller Foundation – 100 Resilient Cities]

**HEALTH & WELLBEING**
Everyone living and working in the city has access to what they need to survive and thrive.

**ECONOMY & SOCIETY**
The social & financial systems that enable urban populations to live peacefully, and act collectively.

**LEADERSHIP & STRATEGY**
The processes that promote effective leadership, inclusive decision-making, empowered stakeholders, and integrated planning.

**INFRASTRUCTURE & ENVIRONMENT**
The man-made and natural systems that provide critical services, protect, and connect urban assets enabling the flow of goods, services, and knowledge.

[www.100resilientcities.org](http://www.100resilientcities.org)
City Resilience Framework [Arup]

[Source: Arup (2014). City Resilience Framework]
Responding to Climate Change
Towards Resilient Communities and Cities

Spatial-Temporal scales of Adaptation vs Mitigation

Adapted from Moser, C. (2011)
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
Climate change action planning process and its key components

EX-ANTE

ASSESSMENT

MONITORING AND EVALUATION

EX-POST

IMPLEMENTATION

PLANNING

Source: UNFCC (2011)
Climate Change Planning Cycle

Module A: What is happening?
1. Getting Started
2. Stakeholders & Participation
3. Vulnerability Assessment

Module B: What matters most?
4. Values & Objectives

Module C: What can we do about it?
5. Identify Options
6. Option Evaluation
7. Implementation
8. Monitoring & Evaluation
9. Adjust & Modify

Public Participation

New Information

© EPI 2010

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

1. Define Alternatives
2. Define criteria/objectives
3. Quantify impacts / assign scores
4. Normalize scores
5. Weight evaluation criteria
6. Rank options

Stakeholders
- Expert Judgments
- Stakeholders
### Objectives & decision-making

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>Indicator</th>
<th>Action 1</th>
<th>Action 2</th>
<th>Action 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVIRONMENT</td>
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<tr>
<td>ECONOMIC</td>
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<td></td>
</tr>
<tr>
<td>SOCIAL</td>
<td></td>
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</tr>
</tbody>
</table>

#### Actions
- Establishes the structure
- Ask: What is important?
- Separates people from the problem, issues from emotions
- Categorize (Environment, Economic, Social, Technical, etc.)

#### Indicators
- Predictive
- Specific
- Understandable
- Practical (available resources)
Inclusion of stakeholders and Weighting of criteria

- Workshops, stakeholders 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
Figure 1: Flood map of Dhaka city during 1998 flood showing inundated study area (Dhaka East)

Source: Bangladesh Center for Advanced Studies

Figure 3: Disruption of communication due to flood

Source: The Daily Star, 15 August, 2005
<table>
<thead>
<tr>
<th>No.</th>
<th>Adaptation actions</th>
<th>Type</th>
<th>Focus</th>
<th>Time frame</th>
<th>Description</th>
<th>Source</th>
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<tbody>
<tr>
<td>1</td>
<td>Construction, retrofitting of drainage system</td>
<td>structural</td>
<td>Infrastructure</td>
<td>Long term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Raised road</td>
<td>structural</td>
<td>Transport</td>
<td>Medium term</td>
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<td></td>
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<tr>
<td>3</td>
<td>Embankment</td>
<td>structural</td>
<td>Flood management</td>
<td>Medium term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Flood wall</td>
<td>structural</td>
<td>Flood management</td>
<td>Medium term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Protection of water retention areas</td>
<td>non-structural</td>
<td>Water management</td>
<td>Short term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Canal Improvement</td>
<td>non-structural</td>
<td>Water management</td>
<td>Medium term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Enhancing emergency</td>
<td>non-structural</td>
<td>Disaster</td>
<td>Short term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Upgrading early warning system</td>
<td>non-structural</td>
<td>Disaster management</td>
<td>Short term</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### STEP 3: CRITERIA identification

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Category of Criteria</th>
<th>Units</th>
<th>Min/Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vulnerability reduction</td>
<td>Climate</td>
<td>%</td>
<td>Max</td>
</tr>
<tr>
<td>Cost</td>
<td>Economic</td>
<td>euros</td>
<td>Min</td>
</tr>
<tr>
<td>Institutional and technical capacity</td>
<td>Feasibility</td>
<td>&quot;1-5&quot;</td>
<td>Min</td>
</tr>
<tr>
<td>Public and political acceptance</td>
<td>Social</td>
<td>&quot;1-5&quot;</td>
<td>Max</td>
</tr>
<tr>
<td>Achievement of MDG</td>
<td>Social</td>
<td>&quot;1-5&quot;</td>
<td>Max</td>
</tr>
<tr>
<td>Employment generation</td>
<td>Economic</td>
<td>&quot;1-5&quot;</td>
<td>Max</td>
</tr>
<tr>
<td>Enhancement of ecological condition</td>
<td>Environmental</td>
<td>&quot;1-5&quot;</td>
<td>Max</td>
</tr>
</tbody>
</table>
### STEP 4: SCORING - Impact Assessment Matrix

Indicate the scores for each alternative on every criterion

<table>
<thead>
<tr>
<th>Options/Criteria</th>
<th>Vulnerability</th>
<th>Cost</th>
<th>Institutional and technical capacity</th>
<th>Public and political acceptance</th>
<th>Achievement of MDG</th>
<th>Employment generation</th>
<th>Enhancement of ecological condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>euros</td>
<td>&quot;1 - 5&quot;</td>
<td>&quot;1 - 5&quot;</td>
<td>&quot;1 - 5&quot;</td>
<td>&quot;1 - 5&quot;</td>
<td>&quot;1 - 5&quot;</td>
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<td>Scale units</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Construction, retrofitting of</td>
<td>§9</td>
<td>64</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>drainage system</td>
<td>§4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raised road</td>
<td>64</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Embankment</td>
<td>69</td>
<td>20</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Flood wall</td>
<td>61</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Protection of water retention areas</td>
<td>74</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Canal Improvement</td>
<td>71</td>
<td>14</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Enhancing emergency response mechanism</td>
<td>63</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Upgrading early warning</td>
<td>81</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
### 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

<table>
<thead>
<tr>
<th>Category of Criteria</th>
<th>Criteria</th>
<th>Rank</th>
<th>Importance</th>
<th>Values</th>
<th>Weights</th>
<th>Degree of Convergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>Vulnerability reduction</td>
<td>1</td>
<td>Very High</td>
<td>100</td>
<td>22.7%</td>
<td>Very High</td>
</tr>
<tr>
<td>Economic</td>
<td>Cost</td>
<td>2</td>
<td>Moderate</td>
<td>80</td>
<td>16.2%</td>
<td>Very High</td>
</tr>
<tr>
<td>Feasibility</td>
<td>Institutional and technical capacity</td>
<td>4</td>
<td>High</td>
<td>60</td>
<td>13.6%</td>
<td>Very High</td>
</tr>
<tr>
<td>Social</td>
<td>Public and political acceptance</td>
<td>4</td>
<td>Moderate</td>
<td>60</td>
<td>13.6%</td>
<td>Very High</td>
</tr>
<tr>
<td>Social</td>
<td>Achievement of MDG</td>
<td>7</td>
<td>Moderate</td>
<td>30</td>
<td>6.8%</td>
<td>Very High</td>
</tr>
<tr>
<td>Economic</td>
<td>Employment generation</td>
<td>6</td>
<td>Low</td>
<td>40</td>
<td>9.1%</td>
<td>Very High</td>
</tr>
<tr>
<td>Environmental</td>
<td>Enhancement of ecological condition</td>
<td>3</td>
<td>Low</td>
<td>70</td>
<td>15.9%</td>
<td>Very High</td>
</tr>
</tbody>
</table>

#### Criteria Weights

- Enhancement of ecological condition
- Vulnerability reduction
- Employment generation
- Achievement of MDG
- Institutional and technical capacity
- Public and political acceptance
- Cost
### STEP 6: RESULTS - Ranking

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

<table>
<thead>
<tr>
<th>Options</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection of water retention areas</td>
<td>0.79</td>
<td>1</td>
</tr>
<tr>
<td>Upgrading early warning system</td>
<td>0.77</td>
<td>2</td>
</tr>
<tr>
<td>Canal Improvement</td>
<td>0.55</td>
<td>3</td>
</tr>
<tr>
<td>Enhancing emergency response mechanism</td>
<td>0.51</td>
<td>4</td>
</tr>
<tr>
<td>Construction, retrofitting of drainage system</td>
<td>0.49</td>
<td>5</td>
</tr>
<tr>
<td>Embankment</td>
<td>0.48</td>
<td>6</td>
</tr>
<tr>
<td>Raised road</td>
<td>0.44</td>
<td>7</td>
</tr>
<tr>
<td>Flood wall</td>
<td>0.35</td>
<td>8</td>
</tr>
</tbody>
</table>

**Rank of Alternatives (equal weights)**

![Bar chart showing rank of alternatives](image_url)
Final Scores and Contribution of criteria

- **Construction, Raised road embankment, Flood wall retrofitting of drainage system**
  - Enhancement of ecological condition: 0.50
  - Employment generation: 0.10
  - Achievement of MDG: 0.20
  - Public and political acceptance: 0.05
  - Institutional and technical capacity: 0.05
  - Cost: 0.10
  - Vulnerability reduction: 0.05

- **Protection of water retention areas**
  - Enhancement of ecological condition: 0.70
  - Employment generation: 0.10
  - Achievement of MDG: 0.10
  - Public and political acceptance: 0.05
  - Institutional and technical capacity: 0.05
  - Cost: 0.05
  - Vulnerability reduction: 0.05

- **Canal improvement**
  - Enhancement of ecological condition: 0.30
  - Employment generation: 0.20
  - Achievement of MDG: 0.20
  - Public and political acceptance: 0.10
  - Institutional and technical capacity: 0.10
  - Cost: 0.10
  - Vulnerability reduction: 0.10

- **Enhancing emergency response mechanism**
  - Enhancement of ecological condition: 0.20
  - Employment generation: 0.20
  - Achievement of MDG: 0.20
  - Public and political acceptance: 0.10
  - Institutional and technical capacity: 0.10
  - Cost: 0.10
  - Vulnerability reduction: 0.10

- **Upgrading early warning system**
  - Enhancement of ecological condition: 0.30
  - Employment generation: 0.10
  - Achievement of MDG: 0.10
  - Public and political acceptance: 0.10
  - Institutional and technical capacity: 0.10
  - Cost: 0.10
  - Vulnerability reduction: 0.10
<table>
<thead>
<tr>
<th>No.</th>
<th>Type of Evaluation</th>
<th>Author</th>
<th>Country</th>
<th>Country Status</th>
<th>Scope</th>
<th>Governance Level</th>
<th>Initiator</th>
<th>Sectoral Coverage</th>
<th>Sustainability Objectives (co-benefits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MCA</td>
<td>Porthin, et al. (2013)</td>
<td>Finland</td>
<td>Developed Country</td>
<td>Urban</td>
<td>City (Local)</td>
<td>Researchers</td>
<td>Flood Management</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>MCA</td>
<td>Haque, et al. (2012)</td>
<td>Bangladesh</td>
<td>Least Developed Country</td>
<td>Urban</td>
<td>City (Local)</td>
<td>Researchers</td>
<td>Flood Management</td>
<td>Y</td>
</tr>
<tr>
<td>4</td>
<td>MCA</td>
<td>Lewis (2011)</td>
<td>South Africa</td>
<td>Least Developed Country</td>
<td>Urban</td>
<td>City (Local)</td>
<td>Local Government</td>
<td>Multi-Sectoral</td>
<td>Y</td>
</tr>
<tr>
<td>5</td>
<td>MCA</td>
<td>Kubal, et al. (2009)</td>
<td>Germany</td>
<td>Developed Country</td>
<td>Urban</td>
<td>City (Local)</td>
<td>Researchers</td>
<td>Flood Management</td>
<td>Y</td>
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<tr>
<td>6</td>
<td>MCA</td>
<td>Debels, et al. (2007)</td>
<td>Chile</td>
<td>Least Developed Country</td>
<td>Urban</td>
<td></td>
<td>Disaster Management</td>
<td></td>
<td>Y</td>
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</tbody>
</table>
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.
Durban’s Municipal Climate Protection Programme:

CLIMATE CHANGE ADAPTATION PLANNING

FOR A RESILIENT CITY

2010 /11
<table>
<thead>
<tr>
<th>Impact on risk</th>
<th>The level of climate change risk that the intervention will reduce.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancillary Benefits</td>
<td>How beneficial is it to undertake this intervention regardless of climate change impacts, as the intervention promotes sustainable development.</td>
</tr>
<tr>
<td>Reversible or Flexible</td>
<td>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.</td>
</tr>
<tr>
<td>Impact on emissions</td>
<td>How does the intervention affect the amount of greenhouse gases in the atmosphere?</td>
</tr>
<tr>
<td>Allows complementary options</td>
<td>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.</td>
</tr>
<tr>
<td>Ease of implementation</td>
<td>Indicates the likelihood of the intervention being successfully implemented.</td>
</tr>
<tr>
<td>Institutional complexity</td>
<td>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.</td>
</tr>
<tr>
<td>Cost: benefit</td>
<td>A broad judgement of whether the intervention has ‘high cost: low benefit’ or ‘high benefit: low cost.’</td>
</tr>
<tr>
<td>Risk of ‘maladaptation’</td>
<td>Ill-considered implementation of an intervention is considered ‘maladaptation’ as it may have unintended adverse impacts.</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------</td>
</tr>
<tr>
<td>1</td>
<td>Water</td>
</tr>
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<td>2</td>
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<td>Category</td>
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<td>--------------------------------------------------------------------------</td>
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<tr>
<td>Sustainability</td>
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<td>Equity</td>
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<td>Implementation Cost</td>
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<tr>
<td>Effectiveness</td>
<td>Robustness</td>
</tr>
<tr>
<td>Risk and Uncertainty</td>
<td>Urgency</td>
</tr>
<tr>
<td>Opportunity</td>
<td>Ancillary benefits</td>
</tr>
<tr>
<td></td>
<td>No Regret</td>
</tr>
<tr>
<td></td>
<td>Window of Opportunity</td>
</tr>
<tr>
<td>Implementation</td>
<td>Funding Sources</td>
</tr>
<tr>
<td></td>
<td>Institutional</td>
</tr>
</tbody>
</table>
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

s.grafakos@ihs.nl
Relevant Literature

Additional sources

- www.mca4climate.info: Multi-Criteria Analysis for climate change: developing guidance for sound climate policy planning (UNEP)
- SUSTAIN project: www.sustainedu.com
Participatory integrated assessment of flood protection measures for climate adaptation in Dhaka

ANIkA NAStRA HAQUE, STELIOS GRAKAKOS AND MARIJK HUIJSMA

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

I. INTRODUCTION

There is a global inequality between those cities causing climate change and those that are at high risk from its effects but hardly contribute to overall greenhouse gas (GHG) emissions. The latter are mostly located in the Global South.
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