Prioritization of technologies/Infrastructure

Multi Criteria Decision Analysis

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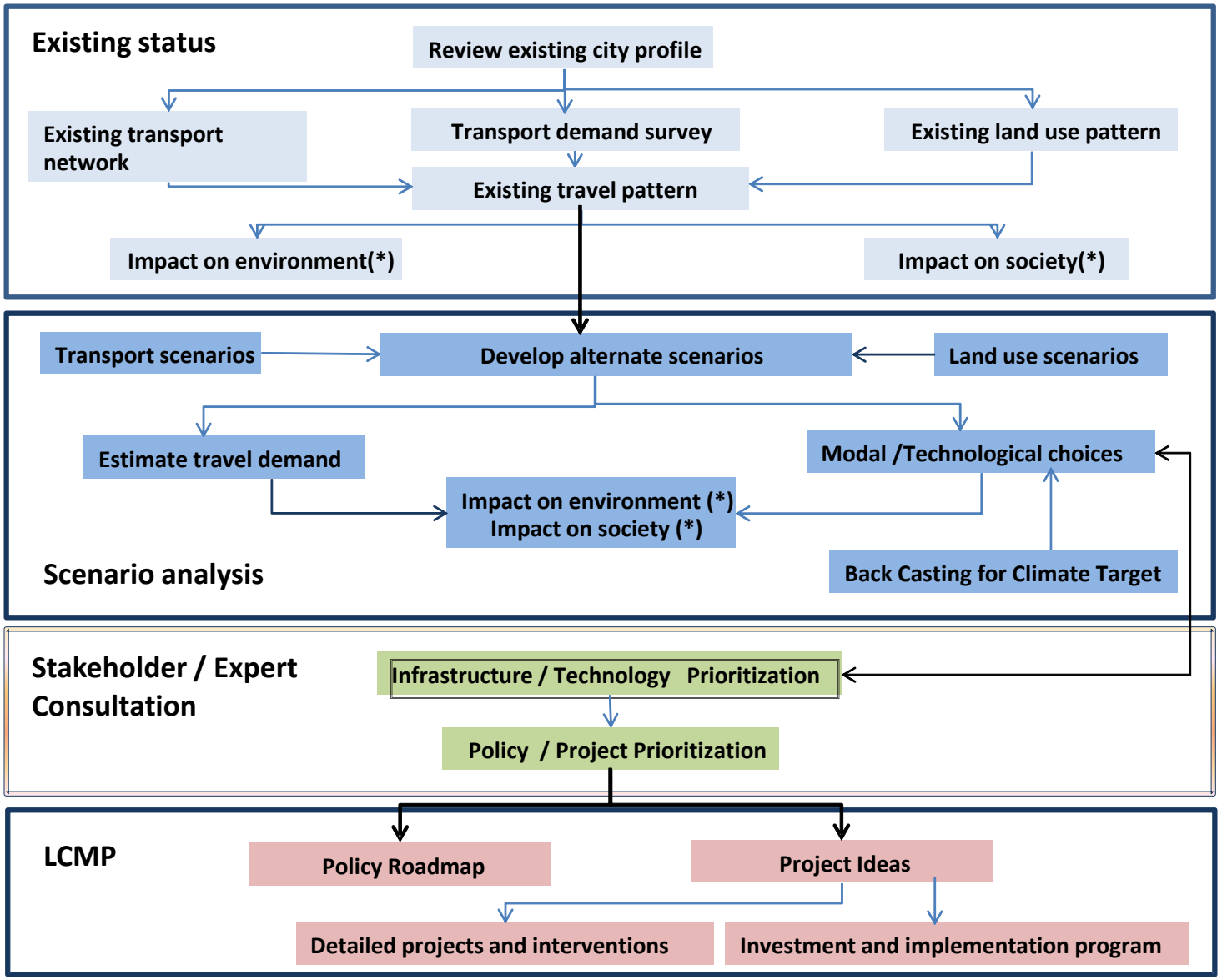
Outline

- Overview of MCA
- Steps in Applying MCDA
- MCA in prioritizing options for LCMP
- Scoring
- Weight

A simple hypothetical example entwined with the explanation of the steps

Methodology framework for LCMP



What is MCA?

- A Decision Analysis Technique
- It is a subjective analysis based on:
  - Criteria, scores and weights;
  - Human judgment in determining the criteria, scores and weights
  - Documented process to enable ex-post review and could be used for public scrutiny of assessment
- Allows comparison of apples and oranges.

Detailed Steps in MCA

1. **Establish the decision context.**
   - 1.1 Establish aims of the MCDA, and identify decision makers and other key players.
   - 1.2 Design the socio-technical system for conducting the MCDA.
   - 1.3 Consider the context of the appraisal.
2. **Identify the options to be appraised.**
3. **Identify objectives and criteria.**
   - 3.1 Identify criteria for assessing the consequences of each option.
   - 3.2 Organise the criteria by clustering them under high-level and lower-level objectives in a hierarchy.
4. **'Scoring'. Assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion.**
   - 4.1 Describe the consequences of the options.
   - 4.2 Score the options on the criteria.
   - 4.3 Check the consistency of the scores on each criterion.
5. **'Weighting'. Assign weights for each of the criterion to reflect their relative importance to the decision.**
6. **Combine the weights and scores for each option to derive an overall value.**
   - 6.1 Calculate overall weighted scores at each level in the hierarchy.
   - 6.2 Calculate overall weighted scores.
7. **Examine the results.**
8. **Sensitivity analysis.**
   - 8.1 Conduct a sensitivity analysis: do other preferences or weights affect the overall ordering of the options?
   - 8.2 Look at the advantage and disadvantages of selected options, and compare pairs of options.
   - 8.3 Create possible new options that might be better than those originally considered.
   - 8.4 Repeat the above steps until a 'requisite' model is obtained.

MCDA: The Decision Context

- The Context: Urban population growth and resultant demand for mobility a challenge now and into the future.
- AIM: Recommend to urban authorities prioritized options for safe access and economic mobility with minimal environmental impacts.
- Setting up the system for conducting MCD
  - Process steps
    - Information package for assessment – who and how
    - Whom to and how to consult
  - Who's perspective and who decides
    - Decision makers
    - Stakeholders

Identifying options

- General criteria for selecting options:
  - be comprehensive in assessing the options.
  - be open to possibility of adding dropping options.
  - contribute to the objectives
- Source of options identification:
  - Primarily will come from the needs of mobility/accessibility to addressed based on analysis
  - Relevant literature, e.g., GIZ literature on issue, Publication on options for mitigating emissions from transport sector by UNEP Risoe
  - Expert Judgment

The Objective and Criteria

- A clear objective most critical to a clear framework for assessment.
- Objectives define the criteria which are the measures to assess or evaluate the contribution of option to the objective.
- Criteria should be operational – specific and measurable
- Options that
  - provide easy access and economic mobility;
  - safe and secure travel;
  - minimal environmental impacts; and
  - least carbon footprint

Criteria for Evaluation

Costs

Cost
- Cost per passenger.kilometer

Mobility and Accessibility

Modal shares
- by trip purpose
- by social groups

Average Travel time
- By trip purpose
- Trip purpose by social groups

Average Trip length
- by frequency distribution
- Mode wise & disaggregated by social groups
- Trip purpose wise by social groups

Affordability
- Of PT and para-transit fare by social group
- Cost of commuting

Infrastructure and Land Use

Infrastructure quality
- Average speed on roads
- Percentage of Household within 10 min. walking distance of PT and para-transit stop
- Average number of interchanges per PT trip
- Accessibility of disadvantage groups by different modes

Land use parameters
- Land use mix intensity
- Income level heterogeneity
- Kernel density of roads, junctions and PT stop

Safety and Security

Safety
- Risk exposure mode wise
- Risk imposed by modes
- Overall safety
- Speed limit restrictions
- Quality of footpath infrastructure

Security
- Percentage of road lighted
- Percentage of footpaths lighted
- Percentage of people feeling safe to walk/cycle and use PT in city by gender

Environmental impacts

Emissions
- GHG emissions
- Lifecycle cost of different modes

Depletion of land resource
- Per capita consumption of land for transport activity
- Land consumed for different transport activities

Health hazards
- Percentage of population exposed to air pollution
- Percentage of population exposed to noise levels > 50 dB

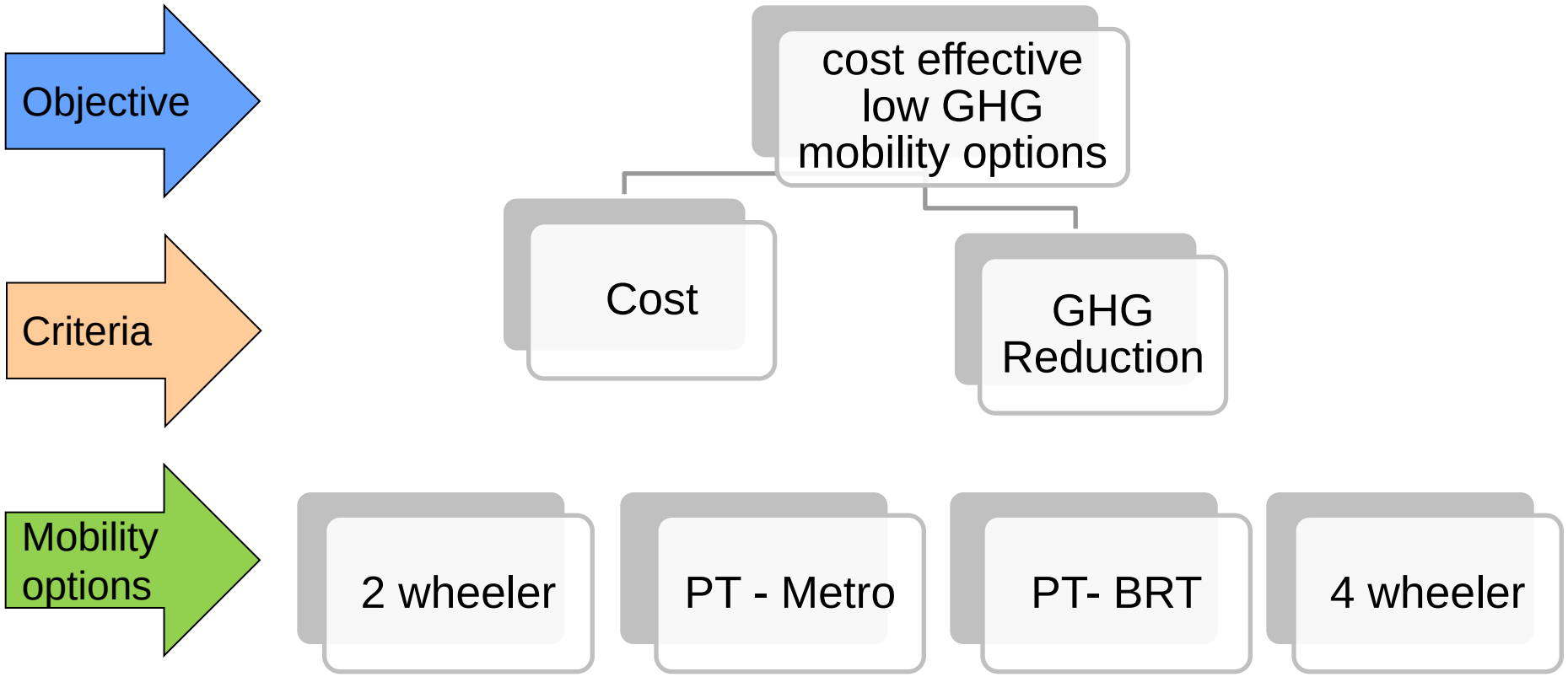
Economic (Response indicators)

Investment
- Trend in investments for development of infrastructure for various modes

Cost borne by operators
- Tax burden mode wise
- Fuel prices at pumps by fuel type
- Other charges levied as applicable at city level disaggregated by modes

Fare policy
- Percentage of subsidies granted
- Percentage of population owning passes

Example


Objective
Criteria
Mobility options
cost effective low GHG mobility options
Cost
GHG Reduction
2 wheeler
PT - Metro
PT- BRT
4 wheeler

Assessing the options

- Evaluate each option on the identified criteria and sub-criteria
- Evaluation could be monetary, non-monetary, or qualitative
- A starting point for assessment could be qualitative description of each option on all criteria
- An evaluation summary sheet of each option could be useful
  - in providing a comprehensive information to policy/decision makers.
  - enhancing the transparency of the process.

Scoring the options

- First step in comparing apples and oranges: assigning scores.
- Score based on scale representing preference of option wrt a criteria: normally scale is 0 - 100
  - 100 – Most preferred option
  - 0 – Least preferred option
  - Other options are relatively ranked – linear or non-linear
- Scoring dependent on qualitative or quantitative assessment of options on a criteria.
- Process
  - Record individual scores.
  - Analyse extreme scores to understand the reasons and develop consensus

Scoring

- Input data that can be accommodated in MCDA:
  - Monetary data
  - Non-monetary data (without unit)
  - Percentage
  - Qualitative data
  - Rating scales, i.e., 1 (not at all important) to 5 (very important) scale
  - Directly assessed preferences
  - Model derived performance measures

Example: Assessment Table

	Cost (cents/km)	GHG Reduction (gm CO_2e/km)
Two wheeler	1.2	15
PT – Metro	1.3	4
PT - BRT	0.8	6
4 wheeler	1.7	35

Example: Scoring

56 = 100 x (1.7 – 1.2) / (1.7 – 0.8)

65 = 100 x (35 – 15) / (35 – 4)

	Cost (cents/km)	GHG Reduction (gm CO_2e/km)
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4 wheeler	1.7	35

45 = 100 x (1.7 – 1.3) / (1.7 – 0.8)

94 = 100 x (35 – 6) / (35 – 4)

Cost:
The most preferred option: PT -BRT → Score: 100
The least preferred option: 4 wheeler → Score: 0

GHG Reduction:
The most preferred option: PT – Metro → Score: 100
The least preferred option: 4 wheeler → Score: 0

Weighting Criteria

- Weights to criteria enables all scores to be converted to a common scale.
- Weights reflect both the relative importance of criteria as well as difference in unit of preference on different scales.
- Swing weighting: Equating the units is accomplished by judging the relative swing in preference from the bottom to the top of one preference scale as compared to another.

Weighting Criteria

- Weighting can be done as follows:
  - Compare the difference between the least and the most preferred options.
  - Low weight will be given to a criteria if the difference between the lowest and the highest options is small.
  - Compare the difference in absolute value
  - The highest difference is given 100. The rest is calculated based on the absolute value compared to the highest value
  - Ask the stakeholders or judged by the groups

- Intuitive, ad hoc approach

Example: Weighting

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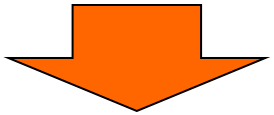
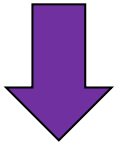


	Cost (cents/km)	GHG Reduction (gm CO_2e/km)
Most preferred option	PT – BRT	PT - Metro
Least preferred option	4 wheeler	4 wheeler

Difference in Cost: 0.9



Difference in GHG Reduction: 31

Example: Weighting

Swing Weighting

	Cost (cents/km)	GHG Reduction (gm CO_2e/km)
Swing	(1.7 – 0.8)/0.8 = 1.125	(35 - 4)/4 = 7.75
Weight	0.145	1
Normalized weight	0.126	0.874

=1.125/7.75

=1.125/(1.125 + 7.75)

=7.75/(1.125 + 7.75)

- Assuming equal weight to both criteria

=2*1.125/(2*1.125 + 7.75)

	Cost (cents/km)	GHG Reduction (gm CO_2e/km)
Swing	(1.7 – 0.8)/0.8 = 1.125	(35 - 4)/4 = 7.75
Normalized weight	0.25	0.75

- Assuming cost twice as important as GHG

Overall Weighted Scores

	Weight		Overall Weighted Scores	Prioritization
	Cost (0.25)	GHG Reduction (0.75)		
Two wheeler	56	65	63	III
PT – Metro	45	100	86	II
PT - BRT	100	94	96	I
4 wheeler	0	0	0	IV

some issues

- Significant subjective judgment involved – process/measures to bring enhanced understanding of individuals scoring important.
- Whose judgment and perspective – important at start to define actors who will be involved in the process.
- Important to ensure common information base among all participants.
- Sensitivity analysis important – can also address assessing uncertainties.
- Applicable to options that are mutually independent.

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Thank You!

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