Case Studies: Multi Criteria Decision Analysis of the Cooking and Buildings Sector
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Introduction

• Collaboration between CPR and Prayas (Energy Group) with input from ERC
• Two case studies: cooking and buildings
  – Reflect development needs and understudied sectors
  – Why cooking?
  – Why buildings?
• Draw on IESS version 2, yet to be launched
• Demonstrate and test MCDA
  – Preliminary case study results
  – Vetted by experts, not from wide stakeholder consultations
• Cases have different scopes and time dimensions to show range of MCDA applicability
Case: Cooking

MCDA Question:
“Comparing different options of providing rural households with access to modern cooking fuels, in the context of achieving developmental goals in a climate constrained world”
Case: Buildings

MCDA Question:
“Which policy options, focused on building envelope efficiency, provide maximum multiple benefits from India’s residential real estate transformation?”

- Policy options: Same technology with different policy choices
- Timeframe: 2022
Steps towards Multi Criteria Analysis

• Step 1: Structure the question
• Step 2: Select objectives or criteria for evaluation
  – “Branches:” economic, social, environmental, institutional
  – “Leaves:” cost saved to the economy, impact on import bill, GHG saved
• Step 3: Select possible policy options to address the question
• Step 4: Construct matrix to evaluate each policy against chosen criteria at the leaf level
  – Quantitative or qualitative
• Step 5: Create “value functions” to normalize across criteria
• Step 6: Weight criteria to aggregate values and rank policy options
Case: Cooking

- MCDA Question (Step 1)
  “Comparing different options of providing rural households with access to modern cooking fuels in the context of achieving developmental goals in a climate constrained world”

- Policy options
  Promotion of different (relatively) clean cooking fuels — one policy option for each fuel

- Timeframe
  2013-2032 (Base year: 2012)
Cooking: Objectives Hierarchy

- **Policy Options**
  - **Social (Affordability, Drudgery)**
    - Upfront expenditure
    - Recurring expenditure
    - Time spent
    - Households with bad air quality
  - **Environmental**
    - CO2-e emissions
    - Energy import bill
    - Subsidy burden
  - **Economic**
    - Energy import bill
    - Subsidy burden
  - **Institutional**
    - Political economy (ex-ante)
    - Transaction costs (ex-post)
Buildings: Objectives Hierarchy

Policy Options

- Environmental
  - CO₂-e emissions saved
  - Urban PM emissions saved

- Economic
  - Power saved
  - Diesel saved
  - Jobs created

- Social (Affordability)
  - Upfront cost spent
  - Running cost saved

- Institutional
  - Political economy (ex-ante)
  - Transaction costs (ex-post)
## Cooking Step 3: Policy Options

<table>
<thead>
<tr>
<th>Policy Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>Policies continue as they have over the past decade or so. Subsidies taper off over 20 years.</td>
</tr>
<tr>
<td>LPG</td>
<td>Increased rural dealerships/Ease of getting connections/LPG Availability. LPG subsidy to continue at current levels, stove subsidy for 30% households. Smaller cylinder sizes.</td>
</tr>
<tr>
<td>Induction</td>
<td>100% Access. Quality day/evening supply. Subsidized tariffs, Subsidy on stoves, utensils for 30% households.</td>
</tr>
<tr>
<td>Improved Cookstoves</td>
<td>Local entrepreneurs/servicing. Functioning pellet/woodchip market.</td>
</tr>
</tbody>
</table>
Cooking Step 4: Constructing the Matrix

• Build the reference (BAU) scenario
  – Assumptions
    • Fuel penetration trajectories
    • Fuel and O&M costs (2012)
    • Annual useful energy requirement
  – Determine how scores for each criterion will be calculated
    • Upfront and running costs to the consumer aggregated over 20 years
    • Drudgery hours averaged over number of households

• Construct each policy scenario
  – Determine inputs that need to change across policies
    • Penetration levels and subsidies
  – Calculate scores for each criterion similar to reference scenario
## Cooking Step 4: Constructing the Matrix

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Criteria</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>Upfront costs</td>
<td>000 Rs/HH</td>
</tr>
<tr>
<td></td>
<td>Running costs</td>
<td>000 Rs/HH</td>
</tr>
<tr>
<td></td>
<td>Hours of drudgery</td>
<td>Hrs/week/HH</td>
</tr>
<tr>
<td>Environmental</td>
<td>Households affected by indoor air quality</td>
<td>Million HH</td>
</tr>
<tr>
<td></td>
<td>CO₂-e Emissions</td>
<td>MT</td>
</tr>
<tr>
<td>Economic</td>
<td>Impact on subsidy burden</td>
<td>Trillion Rs</td>
</tr>
<tr>
<td></td>
<td>Impact on import bill</td>
<td>Trillion Rs</td>
</tr>
<tr>
<td>Institutional</td>
<td>Political economy – stakeholder will/opposition</td>
<td>High, med, low</td>
</tr>
<tr>
<td></td>
<td>Transactional/Institutional costs incl. capacity/leakages</td>
<td>High, med, low</td>
</tr>
</tbody>
</table>

Qualitative criteria in **colour**
Cooking Step 4: Constructing the Matrix

<table>
<thead>
<tr>
<th></th>
<th>Social</th>
<th>Environmental</th>
<th>Economic</th>
<th>Institutional (Normalized)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital Expenditure (000 Rs/HH)</td>
<td>Running expenses (000 Rs/HH)</td>
<td>Time spent (hrs/wk/HH)</td>
<td>HHs affected by air pollution (Million)</td>
</tr>
<tr>
<td>Reference</td>
<td>14.1</td>
<td>263</td>
<td>2.25</td>
<td>316</td>
</tr>
<tr>
<td>LPG</td>
<td>12.4</td>
<td>233</td>
<td>1.88</td>
<td>237</td>
</tr>
<tr>
<td>Biogas</td>
<td>11.8</td>
<td>245</td>
<td>1.88</td>
<td>237</td>
</tr>
<tr>
<td>Induction</td>
<td>13.5</td>
<td>233</td>
<td>1.88</td>
<td>237</td>
</tr>
<tr>
<td>Improved Cook stoves</td>
<td>13.6</td>
<td>235</td>
<td>2.16</td>
<td>346</td>
</tr>
</tbody>
</table>
Cooking Step 5: Value Functions and Normalization

- Normalize criteria scores to a common range – 0-100
- For each criterion,
  - Assign value of 0 to the policy option with the worst score (say A1) and 100 to the policy option with the best score (say B1)
  - Draw the function graph mapping scores to values between 0 and 100
    - Pick the halfway point between the worst and best scores (say C1)
    - Then ask how going from A1 to C1 compares with going from C1 to B1
    - If both are the same, then C1 gets a value of 50
    - If A1 to C1 is more valuable, C1 gets a value between 50 and 100, say 70
    - If C1 to B1 is more valuable, C1 gets a value between 0 and 50, say 30
    - Iterate through these steps for subsequent halfway points (between A1-C1, and C1-B1 and so on)
  - Apply the value function graph to the criteria scores
  - Similar process for qualitative criteria as well
# Cooking Step 5: Value Functions and Normalization (Social)

<table>
<thead>
<tr>
<th></th>
<th>Capital Expenditure (Rs/HH)</th>
<th>Running expenses (000 Rs/HH)</th>
<th>Time spent (hrs/wk/HH)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Value (50)</td>
<td>Score</td>
</tr>
<tr>
<td>Ref</td>
<td>14.1</td>
<td>0</td>
<td>263</td>
</tr>
<tr>
<td>LPG</td>
<td>12.4</td>
<td>76</td>
<td>233</td>
</tr>
<tr>
<td>Biogas</td>
<td>11.8</td>
<td>100</td>
<td>245</td>
</tr>
<tr>
<td>Induction</td>
<td>13.5</td>
<td>26</td>
<td>233</td>
</tr>
<tr>
<td>Improved</td>
<td>13.6</td>
<td>19</td>
<td>235</td>
</tr>
</tbody>
</table>

**Household Capital expenditure Value Function**

**Running expenses to consumer Value Function**
Cooking Step 6: Weighting

• Combine values of different criteria to arrive at a score for the next higher branch using trade-off weighting
  – Identify the “most important” criterion. Say, $C_2$.
  – For each of the other criteria, assuming $C_2$ is at normalized value 100 and $C_x$ is at value 0, how much of $C_2$ are you willing to give up to get $C_x$ all the way to 100.
  – If the amount you are willing to give up is $g_x$, then basically a value of $g_x$ for $C_2$ is equal to a value of 100 for $C_x$
  – This trade-off is typically done using actual values as substitution may not make sense with normalized values
  – Weight of $C_x$ is calculated thus: $w_x = g_x / \sum g_x$, where $g_2 = 100$
  – Score for each policy option: $\sum (v_x w_x)$, where $v_x$ is normalized value for $C_x$
## Cooking Step 6: Weighting (Social)

<table>
<thead>
<tr>
<th></th>
<th>Capital Expenditure (000 Rs/HH)</th>
<th>Running expenses (000 Rs/HH)</th>
<th>Time spent (hrs/wk/HH)</th>
<th>Branch Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Value</td>
<td>Score</td>
<td>Value</td>
</tr>
<tr>
<td>Ref</td>
<td>14.1</td>
<td>0</td>
<td>263</td>
<td>0</td>
</tr>
<tr>
<td>LPG</td>
<td>12.4</td>
<td>76</td>
<td>233</td>
<td>100</td>
</tr>
<tr>
<td>Biogas</td>
<td>11.8</td>
<td>100</td>
<td>245</td>
<td>84</td>
</tr>
<tr>
<td>Induction</td>
<td>13.5</td>
<td>26</td>
<td>233</td>
<td>100</td>
</tr>
<tr>
<td>Improved</td>
<td>13.6</td>
<td>19</td>
<td>235</td>
<td>99</td>
</tr>
</tbody>
</table>

\[
\mathcal{G}_x = 27, \quad \mathcal{W}_x = 0.16
\]

\[
\mathcal{W}_x = 0.61, \quad \mathcal{W}_x = 0.22
\]

- Willing to pay Rs 15000 in running expenses over 20 years to save Rs 2200 in upfront expenses
- Willing to pay Rs 19000 in running expenses to reduce drudgery by 0.37 hrs/week (or 380 hrs)
Preliminary Results: Cooking

- Modern fuels score higher considering all criteria
- Tradeoffs are primarily with respect to institutional and economic considerations
- All policy options score well in social criteria with respect to reference
  - Due to subsidies assumed and time saved
- Policies promoting modern fuels score well in environmental criteria
  - Household air pollution weighted higher than GHG emissions
- All policies score lower than reference on economic and institutional
  - BAU is path of least resistance and lowest subsidies
Preliminary Results: Buildings

- **Question Structuring**: Single technology choice with different policy options. Can extend to evaluate across technologies and building sectors.

  - End-user financial incentives score high on three objectives, but with significant institutional challenges

    - Requires some sacrifice of economic and environmental performance – an enhanced weighting exercise would identify priorities between objectives

    - In short term, horizontal construction offers more opportunities than high-rise buildings

  - Trade-offs are mainly institutional and social

    - Codes do well, but unless the institutional issue is addressed separately are not feasible

    - Ratings and BAU perform poorly, with least resistance
Using MCDA to Inform Policy

• MCDA provides a structured process to operationalize a multiple objectives approach

• Forces us to ask policy-relevant questions, identify implicit trade-offs and complementarities

• Based on a deliberative and transparent stakeholder-driven process

• Internalizes quantitative and qualitative criteria, and feasibility of implementation

• Allows for differences in scope of question, timescales, relative vs. absolute analysis
Looking Forward

Challenges in context of taking MCDA forward

• What role does MCDA have in informing multiple objectives based policy?
  – At what scale? National or sub-national?
• Who are the likely users?
• What supporting tools and enabling conditions are required?
  – Technical and data requirements
• How feasible is a stakeholder consultation dependent process?
• How are the results used and communicated?