Transportation and Community Livability: How Do We Measure Progress and Success?

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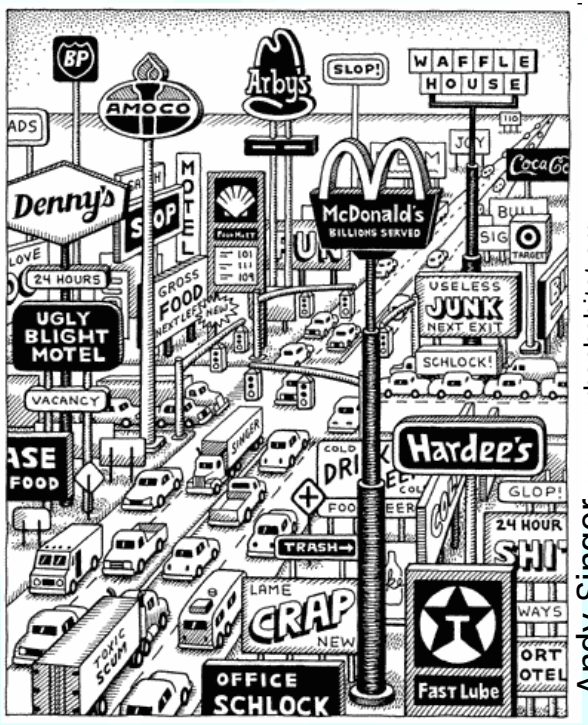
Introduction

- Transportation and community livability
  - Transportation is a key shaper of communities
  - Communities vary with respect to livability
  - Appropriate measures of transportation-related livability
    - Quantifiable – can be used in policy and project evaluation
    - Legitimate – transparent
    - Robust – flexible



Andy Singer www.urbanhabitat.org

Introduction

- Livability and sustainability indicators
  - A large literature has emerged on how to measure quality of life and sustainability
  - Question: What is the appropriate way to construct these measures?
    - Not what is livability or sustainability

- Objectives
  - Review recent research on how to construct livability/sustainability measures
  - Suggest enhancements for transportation project evaluation

Measuring livability

- Common properties of indicators (Munda 2005)
  1. High-level dimensions
     - Social, economic, environmental
  2. Objectives within each dimension
     - Maximize productivity, minimize inequities, minimize environmental impacts
  3. Indicators reflecting performance relative to objectives
     - Transport cost, affordability, air quality
  4. Variables for measuring each indicator
     - Logistics costs relative to revenue, housing cost relative to income, PM10 and CO2
  5. Possible aggregation of indicators to create an overall measure

Measuring livability – Types of indicators

- Simple (non-aggregated) indicators
  - Indicator sets
    - Single or array of individual measures
    - Hard to comprehend when set is large
  - Integrated indicators
    - Multiple indicators measured in a common unit
    - Hard to express diverse indicators in the same unit

- Composite indicators (CI)
  - Synthesizes an overall indicator from the individual indicators
    - Provides a summary, facilitates rankings
    - Misleading if the indicator is poorly constructed
  - Very popular!

Measuring livability – CI methods

- Direct method
  - Obtain the CI from a theoretical framework
    - *Data envelopment analysis* (DEA)
  - Advantage: Objective
  - Disadvantage: Strong assumptions, technocratic

- Indirect method
  - Construct CI by weighting and combining indicators
    - *Multicriteria analysis* (MCA)
  - Disadvantage: Can be subjective
  - Advantage: Allows input into the process

Constructing composite indicators (CIs)

- Major steps
  1. Identifying objectives, indicators and weights
  2. Normalization of variables
  3. Aggregation of weighted variables
  4. Sensitivity and uncertainty analysis

  – These can be executed in a non-linear manner with feedback
  – Decision support systems (DSS) are software environments to facilitate these tasks

Constructing CIs - Deriving objectives and indicators

- Typically: Informal or semi-structured process
  - Interviews and “brain-storming”
  - Examine policy statements and secondary information sources
  - Role playing exercises

- Properties of good indicators
  - Comprehensible – clearly indicates performance
  - Measurable – can be mapped to a number
  - Complete – covers all relevant aspects
  - Operational – practical to collect data, etc
  - Decomposable – performances are independent across indicators
  - Nonredundant – no “double-counting”
  - Minimal – set should be as small as possible

Constructing CIs - Deriving weights

- Scale-free measures reflecting the relative importance of each indicator

- Methods
  - Analytical hierarchy process (AHP)
    - Conduct pairwise comparison of indicators
    - Derive weights and consistency index
  - Fuzzy structure modeling (FSM)
    - Handles ambiguous relationships among dimensions, indicators and objectives
  - Others: PROMETHEE, ELECTRE, etc

$$0 \le w_j \le 1$$

$$\sum_{j=1}^{n} w_j = 1$$

Constructing CIs - Normalization

- Convert variables to scale-free measures
  - Z-score transformations
  - Linear normalization
  - Distance from the best and worst performer

$$\left(\frac{x_i - x_i^{\min}}{x_i^{\max} - x_i^{\min}} \right)$$

  - Do we measure relative or absolute performance?
    - If relative, don't we want ideal performance?
    - If absolute, what is ideal performance?

Constructing CIs – Indicator aggregation

- Simple weighted aggregation (SAW)
  - Very common method, but:
  - Assumes compensatory indicators
    - Weights are trade-off ratios
    - Livability may be non-compensatory
  - Assumes preference independence
    - No conflicts or synergies among indicators

$$I_i = \sum_{j=1}^{n} w_j x_{ij} \qquad i = 1, \ldots, m$$

- Other methods
  - Weighted product (WP) – non-compensatory
  - Weighted displaced ideal – non-linear
  - Outranking methods – ordinal only

Constructing CIs — Uncertainty/sensitivity analysis

- Sources of uncertainty
  - Selection of indicators
  - Data selection and cleaning
  - Normalization
  - Weighting method (e.g., AHP, FSM)
  - Weight value
  - Aggregation method (e.g., SAW versus WP)

- Methods
  - Simple perturbation of inputs
  - Error propagation methods (Saisana, Saltelli and Tarantola 2005)
    - Weighting methods, weights & normalization
  - Information loss measure (Zhou, Ang and Poh 2006)
    - Aggregation method

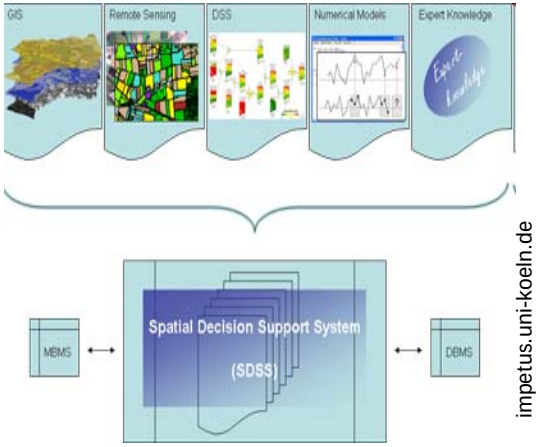
Livability indicators for transportation

- Characteristics of transportation
  - There is a wide spectrum of diverse stakeholders
    - Sometimes they don't agree!
  - Benefits, costs, preferences and appropriate solutions are context-specific
    - Can vary by geography at a fine-grain

- How can we capture these properties in livability measures?

Livability indicators for transportation

- Spatial decision support systems (SDSS)
  - Digital map linked with MCA techniques
  - Explore spatial dimensions of livability during construction, evaluation and application of indicators



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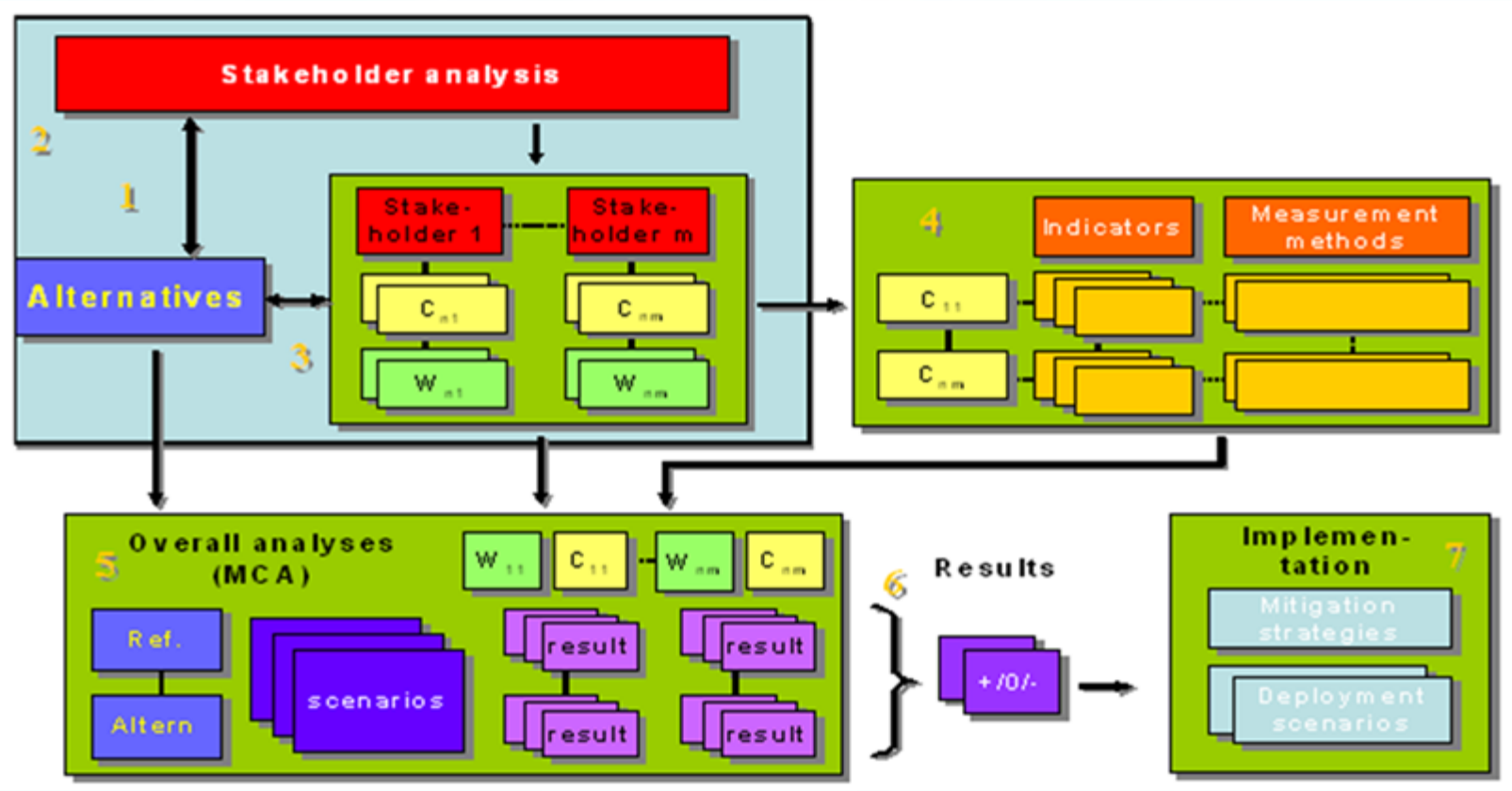
- Collaborative SDSS
  - Same location/time – Digitally-enhanced meetings
  - Same location/different times – Collaborative work environments
  - Different locations/same time – Teleconferences
  - Different locations/times – Internet, Web 2.0

Livability indicators for transportation

- Multi-agent multicriteria analysis (MAMCA) Macharis, De Witte, and Ampe (2009)
  - Maintain stakeholder viewpoints throughout process
    - Stakeholders get overall weight and own indicator weights
  - Multiple solutions at each step
    - Overall solution and stakeholder solutions
  - Why?
    - Better understanding of the stakeholders' objectives
    - Motivation to make more reasonable assessments
    - Insights into tradeoffs

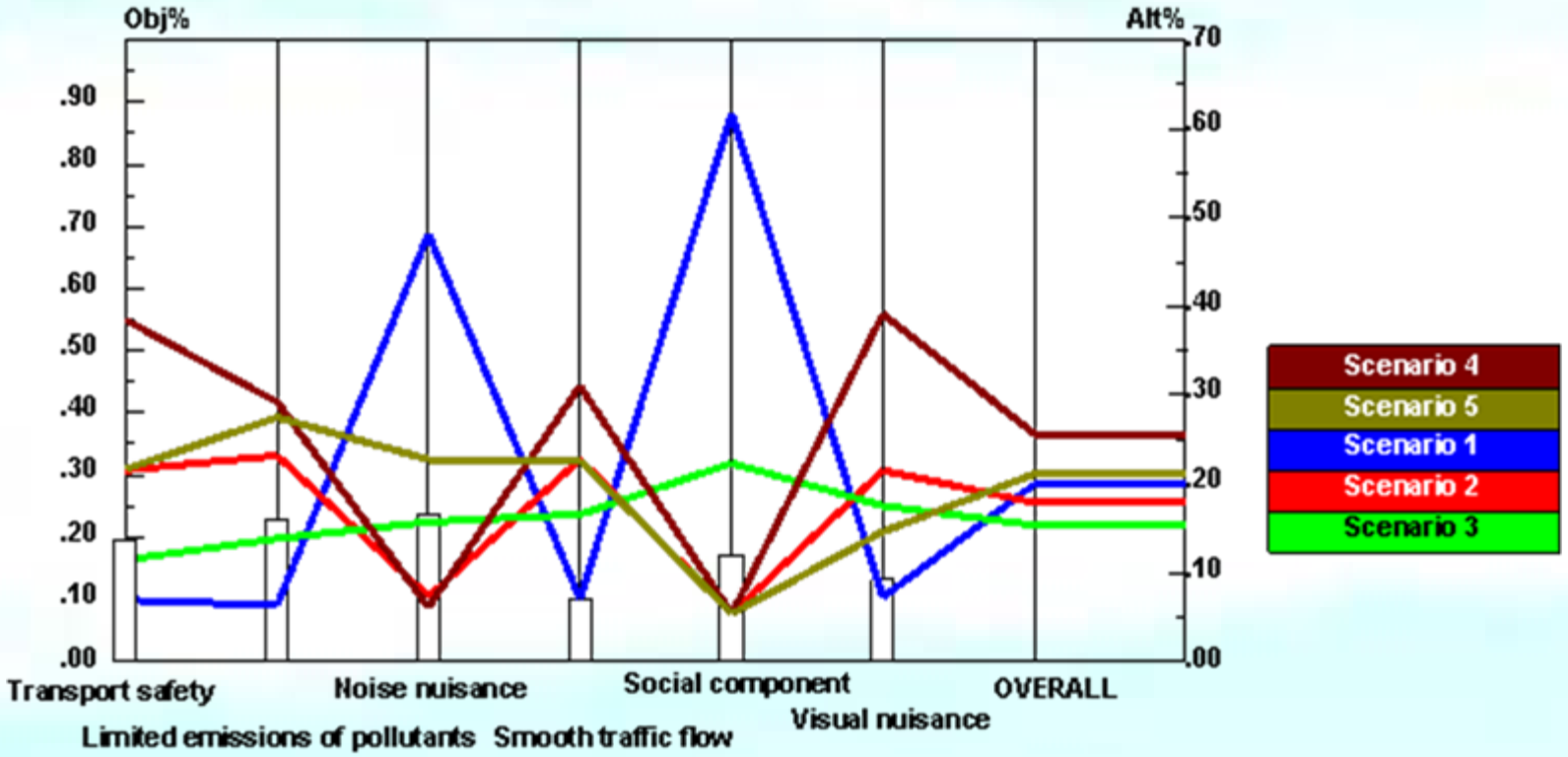
Livability indicators for transportation



MAMCA methodology overview

Macharis, De Witte and Ampe (2009)

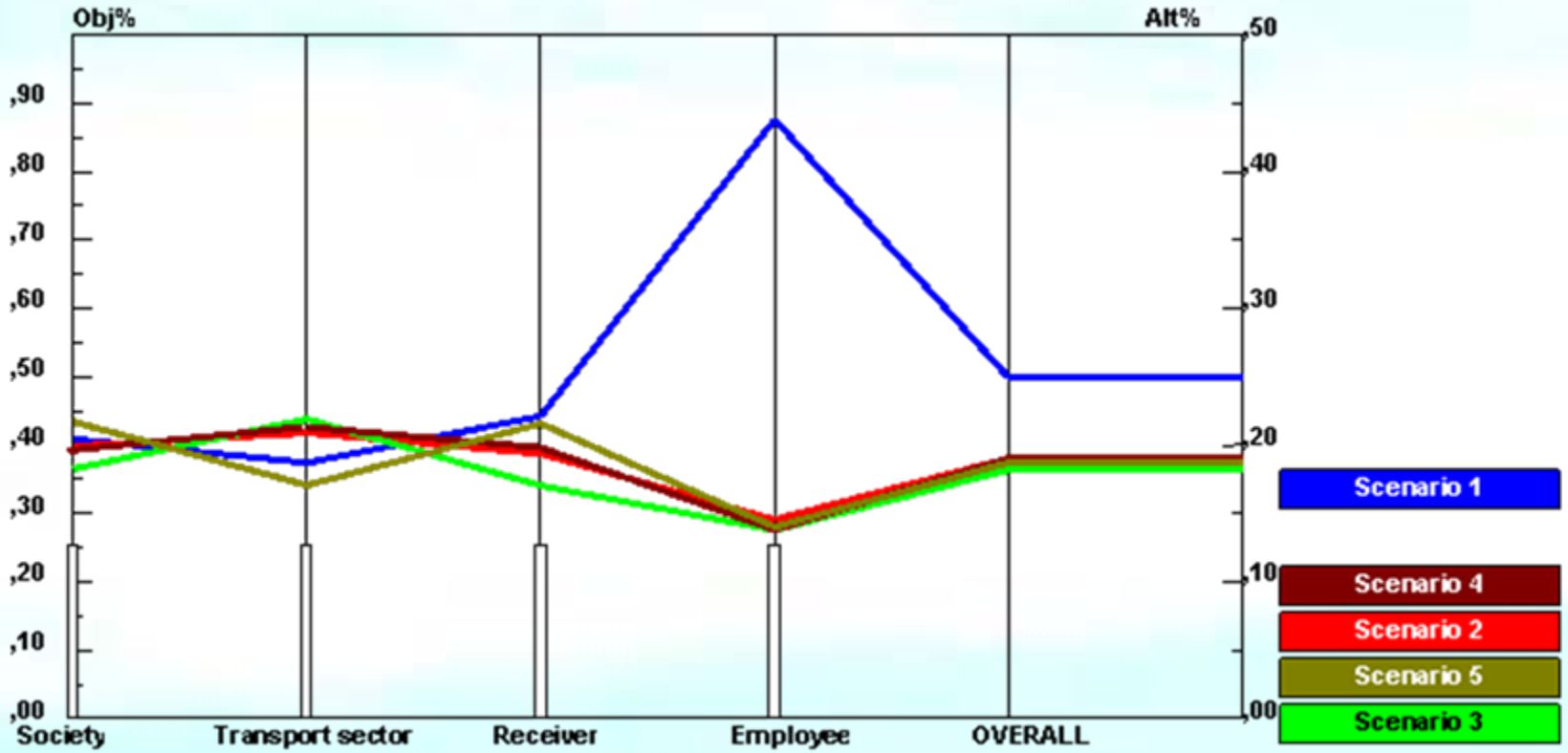
Livability indicators for transportation



MAMCA – Scenario analysis for a logistics project

Source: Cathy Macharis and Frank Witlox

Livability indicators for transportation



MAMCA – Stakeholder analysis for a logistics project

Source: Cathy Macharis and Frank Witlox

Context-aware livability indicators

- Integration of SDSS and MAMCA
  - GIS-centered livability construction and evaluation
  - Maintain viewpoints based on status and location
    - Global weights: Professional stakeholders - Based on expertise, authority, responsibility
    - Local weights: Citizens - Based on geographic relationship with transportation project
- Modes
  - Professionals: Enhanced meetings, digital work environments, teleconferences
  - Citizens: Enhanced meetings, Web 2.0

Context-aware livability indicators

- Some caveats and pre-emptive responses
  - We are not saying that livability is purely a social construct
    - Rather: the importance of its dimensions and objectives can vary from place to place
    - Livability indicators should be flexible and adaptable - to some degree
  - We are not advocating “mob rule” for livability measurement
    - Greater weights could be given to experts, government – especially regulatory authorities
    - Local, spatially-based input **adjusts** stakeholder-derived global livability definitions

Conclusion

- We have not told how to measure livability
  - Sorry!
- We have told how to develop a livability measurement process
  - Internally consistent with respect to assumptions and methods
  - Externally valid with respect to capturing a wide range of inputs in a structured and transparent manner

- Context-aware livability measurement
  - Top-down: Expert/agency/professional
  - Bottom-up: Citizen adjustment based on local setting
  - Exploit digital and geospatial technologies, including Web 2.0

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