

Developing a Sustainability Indicator Weighting Scheme for Integrated Urban Modelling and Health Outcomes in SMARTPLANS

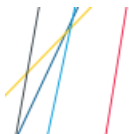
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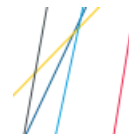
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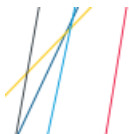
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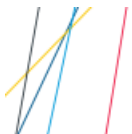


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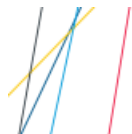


Introduction

- Sustainability definitions: Brundtland Commission
 - “Development that meets the **needs of the present** without compromising the ability of future generations to meet their own needs”
 - “**the process of people maintaining change** in a balanced environment, in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations”
- Sustainability indicators
 - Chapter 40 of Agenda 21: “indicators of SD need to be developed to provide solid bases for decision making at all levels and to contribute to a self-regulatory sustainability of integrated environment and development systems”
 - *Integrating; Forward-looking; Distributional; Developed with input from stakeholders in community*



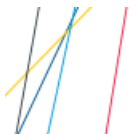
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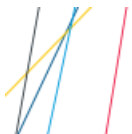


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Objectives

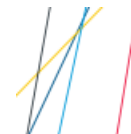
1. Critical feedback and potential improvements on proposed indicators from experts and stakeholders in the Canadian context, and
2. Determine indicator weights within and between themes for sustainability index



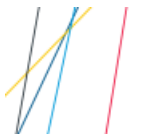
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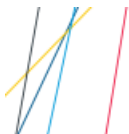
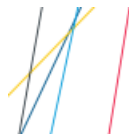
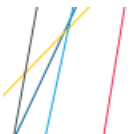


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Methods

- Phase 1
 - Designed to understand if additional indicators should be included, as well as to get feedback on the proposed metrics and their representation in SMARTPLANS
 - Proposed indicators based on sustainability indicators from previous IUMs, health and economic outcomes of the Air Quality Benefits Assessment Tool (AQBAT) developed by Health Canada
 - Experts and potential end-user of the platform were asked to complete an online survey



Methods

Table 1: Proposed SMARTPLANS indicators

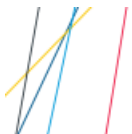
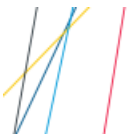
THEME	INDICATOR	DEFINITION
Transportation and Mobility	Vehicle kilometers traveled (VKT)	Total VKT per 1000 residents
	Vehicle minutes traveled (VMT)	Total VMT per 1000 residents
	Accessibility to CBD	Average travel time to city centre
	Congestion index	Average level of congestion in the city
Air Quality	Fine particulate matter (PM _{2.5})	Dissemination Block average (µg/m ³) and total level per 1000 residents (kg)
	Ozone (O ₃)	Dissemination Block average (µg/m ³) and total level per 1000 residents (kg)
	Volatile organic compounds (VOC)	Dissemination Block average (µg/m ³) and total level per 1000 residents (kg)
	Nitrogen oxides (NO _x)	Dissemination Block average (µg/m ³) and total level per 1000 residents (kg)
	Sulphur dioxide (SO ₂)	Dissemination Block average (µg/m ³) and total level per 1000 residents (kg)
Environment	Greenhouse gases	Total level of carbon dioxide emissions
	Energy use from fossil fuels	Liters of gasoline and diesel consumed per 1000 residents
	Consumption of greenspace	Arable land (km ²) converted for urban land uses
Health and Wellbeing	Air Quality Health Index (AQHI)	Total exposed to air pollution levels with moderate, high and very high levels of risk per 1000 residents
	Vulnerability AQHI	Risk estimates weighted geographically by number of children and elderly
	AQBAT health effects	Health outcomes estimated with concentration response functions from Air Quality Benefits Assessment Tool
	Walkability index	Average and area specific levels of walkability from land use
	Traffic injuries	Number of traffic injures per 1000 residents
	Traffic deaths	Number of deaths per 1000 residents
	Accessibility to health services	Average potential accessibility
Economic	Transport commuting costs	Overall costs of commuting
	Transport external costs	Total dollars due to externalities associated with health
	AQBAT health valuations	Economic costs of air quality associated with health care utilization and lost productivity

Methods

- Phase 2
 - Potential participants for online survey were identified in the SMARTPLANS stakeholder database developed for Phase 1
 - Expert and stakeholder priorities in the Canadian context
 - Analytic Hierarchy Process (AHP) to develop ‘intensity matrices’ based on pairwise preference for indicators and themes (Saaty, 2008).

Table 2: AHP judgement values and qualities

Verbal Judgement	Numeric Value
Extremely Important	9
Very Strongly More Important	8
Strongly More Important	7
Moderately More Important	6
More Important	5
Equally Important	4
Less Important	3
Very Weakly More Important	2
Equally Important	1

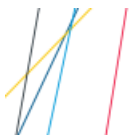


Results – Phase 1

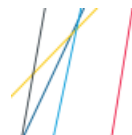
- 109 recruitment letters; 37 individual responded.
- 43% responded that proposed indicators provide comprehensive measures of health and sustainability impacts of urban change.
- Feedback from remaining respondents mixed in detail and content.
 - Additional indicators and critical feedback on how existing and/or additional indicators should be included in SMARTPLANS.

Table 3 – Stakeholder Survey Respondents by Sector

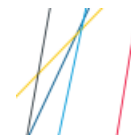
<i>Sector</i>	<i>Count</i>	<i>Percent</i>
Academic	8	21.6
Federal Government	7	18.9
Municipal government	18	48.6
Provincial government	2	5.4
Regional Health Authority	2	5.4



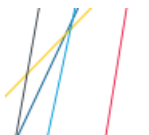
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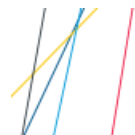
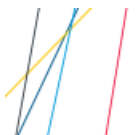
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Results – Phase 1

Table 4: Overview of SMARTPLANS indicators that were added, removed or modified

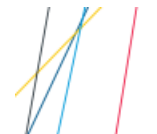
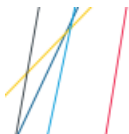
INDICATOR	ACTION	INDICATOR	ACTION
Congestion index	Modified	All Air Quality indicators	Modified
Consumption of greenspace	Modified	Volatile organic compounds (VOC)	Removed
Traffic composition	Added	Mortality	Added
Consumption of agricultural land	Added	Hospital Morbidity	Added
GHG Change	Added	Restricted Activity and Symptom Days	Added
Residential Density	Added	Bronchitis	Added
Mixed Land Use Index	Added	Air Quality Health Index (AQHI)	Removed
Congestion Costs	Added	Vulnerability AQHI	Removed
Infrastructure Costs	Added	AQBAT health effects	Removed
Traffic Accident Costs	Added	Accessibility to health services	Removed



Results – Phase 2

Table 5: Air quality and environmental indicator weights

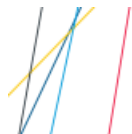
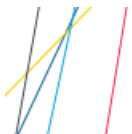
Theme	Indicator	Definition (Phase 1)	Weight (Phase 2)
Air Quality	CO	Total concentrations and road link vehicular emissions	12%
	NO _x	Total concentrations and road link vehicular emissions	25%
	O ₃	Total secondary ozone from precursors	11%
	PM 2.5	Total concentrations and road link vehicular emissions	39%
	SO ₂	Total concentrations and road link vehicular emissions	13%
Environmental	CO ₂	Total change in GHG emissions from transportation and land use change	29%
	Energy Consumption	Total litres of consumed gasoline due to vehicular mobility	14%
	Green Space Consumption	Forest and vegetation land (km ²) converted for urban land uses	11%
	Agricultural Land Consumption	Arable land (km ²) converted for urban land uses	12%
	Mixed Land Use Index	Diversity and proportion of land use categories	22%
	Residential Density	Proportion of residential land use	12%



Results – Phase 2

Table 6: Health indicator weights

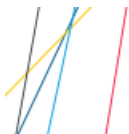
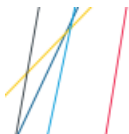
Theme	Indicator	Definition (Phase 1)	Weight (Phase 2)
Health	Traffic Accidents	Number of traffic injures per 1000 residents	13%
	Traffic Deaths	Number of traffic deaths per 1000 residents	26%
	Walkability Index	Zone and study area walkability scores from land use	12%
	Mortality	Air pollution exposure mortality estimated based on Health Canada’s Air Quality Benefits Assessment Tool (AQBAT)	21%
	Hospital Morbidity	Health care utilization from air pollution exposure estimated based on Health Canada’s Air Quality Benefits Assessment Tool (AQBAT)	11%
	Restricted Activity and Symptom Days	Restricted activity and respiratory symptom days from air pollution exposure estimated based on Health Canada’s Air Quality Benefits Assessment Tool (AQBAT)	8%
	Bronchitis	Bronchitis episodes (child) and cases (adult) from air pollution exposure estimated based on Health Canada’s Air Quality Benefits Assessment Tool (AQBAT)	9%



Results – Phase 2

Table 7: Economic and mobility indicator weights

Theme	Indicator	Definition (Phase 1)	Weight (Phase 2)
Economic	Commuting Cost	Overall costs of commuting based on vehicle kilometers traveled (VKT)	12%
	Congestion Cost	Total dollars based on congestion index (ratio of volume to capacity)	18%
	Infrastructure Cost	Total dollars of building or maintaining road infrastructure	20%
	Traffic Accident Cost	Total dollars associated with traffic injuries and deaths	23%
	Air Pollution Health Costs	Economic costs of air quality associated with mortality, morbidity, health care utilization, and lost productivity based on Health Canada's Air Quality Benefits Assessment Tool (AQBAT) Health Valuations	27%
Transit and Mobility	VKT	Total vehicle kilometers traveled	15%
	VMT	Total vehicle minutes traveled	22%
	Congestion Index	Average level of congestion in zones and study area	20%
	Traffic Composition	Proportion of passenger and freight vehicle counts in zones and study area	26%
	Accessibility to CBD	Average travel time to city centre	17%

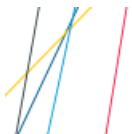


Results – Phase 2

- Averaged judgement weights <1 if the row indicator was judged less important than the column indicator, and conversely >1 if the row indicator was judged as more important than the column indicator.

Table 8: Composite Indicator judgements and Weights

Indicator	Air Quality	Economic	Environment	Health	Transport	Weights
Air Quality	1.00	2.78	3.33	0.78	2.11	25%
Economic	0.78	1.00	0.83	0.76	1.33	13%
Environment	0.71	2.33	1.00	0.72	1.33	16%
Health	2.78	2.89	3.22	1.00	2.33	32%
Transport	0.86	0.96	0.96	0.83	1.00	13%



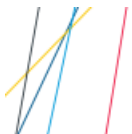
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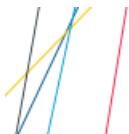


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Discussion and Conclusions

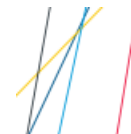
- Small sample, consistency indices and sensitivity analyses
- Distinct differences between priorities for outcomes from experts vs. end users
 - Expert input consistent with literature (e.g., air quality)
 - End users concerned with holistic/integrated measures
- Index included as guide for users
 - Open access to weighting parameters
 - Context dependent priorities
- Opportunity to benchmark against more comprehensive international indices, but limited 'standardization'
 - E.g., Global City Indicators Program, Tool for Rapid Assessment of City Energy (TRACE)



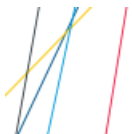
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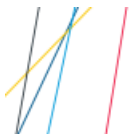
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Questions?

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