EURO PhD Summer School on MCDA/MCDM

Chania, Greece
July 23-August 3, 2018

School Case Study
Urban Sustainability Assessment

http://www.mcda-school18.tuc.gr/casestudy.zip

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1. Introduction

The Brundtland Report recognizes sustainable development as distinct from environmental protection, and suggests that economic development should be ecologically viable and that environmental protection does not preclude economic development. In this context, the report defines sustainable development as *"development which meets the needs of the present without compromising the ability of future generations to meet their own needs"* (UNEP, 1987). Sustainable development, i.e., the achievement of economic growth that improves the lives of the people without exhausting the environment or other resources, is especially critical in developing countries, where mass urbanization is taking place at a time when man's impact on the environment has reached a critical juncture.

Sustainability assessment in different levels and decision making frameworks (e.g., country sustainability, energy systems sustainability, economic sustainability) has been widely studied by numerous researchers, particularly during the recent years. When dealing with sustainability issues neither an economic reductionism nor an ecological one is possible. In general, economic sustainability has an ecological cost and ecological sustainability has an economic cost. Therefore, an integrated framework such as multicriteria evaluation is needed for tackling sustainability issues properly (Munda, 2016).

Urban areas are recognized as having a major influence towards sustainable development, and thus it is essential to develop robust and comprehensive decision making tools for the assessment of sustainability in the urban context. Such tools may be used by urban decision makers such as planners, architects, engineers and managers.

The present global urban population of about 4 billion people is expected to reach 6.5 billion by 2050. The impact of such an enormous concentration of people calls for a more integrated study not only of ecological processes but also of socioeconomic and managerial processes related to the function of cities. Put differently, urban sustainability ought to view urban functions from an ecological but also socioeconomic perspective (Phillis et al., 2017).

Evaluating urban sustainability in a set of cities may provide a valuable tool to identify best practices (i.e., models for sustainable urbanization development) which can serve as points of reference for crafting future urban policies. Moreover, such an approach can also identify current advantages and disadvantages of the examined cities and evaluate the potential impact and effectiveness of development policies.

2. Developing a sustainability assessment framework

The concept of sustainability does not have a universally accepted definition. The alternative evaluation approaches that have been proposed may also be viewed as frameworks for defining sustainability. Despite the lack of a clear definition, it is evident that sustainability should be treated holistically considering ecological, social, and economic components. These three major pillars of sustainability are shown in Figure 1.

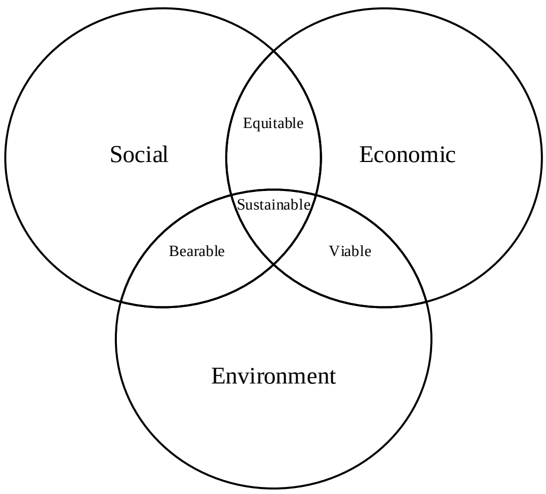

Figure 1. The three major pillars of sustainability

In the context of urban sustainability, there are several alternative methodological frameworks, including the following (although some of them focus on particular aspects of urban sustainability):

- The Urban Sustainability Index (USI) developed by the Urban China Initiative with the collaboration of McKinsey & Co (http://www.urbanchinainitiative.org/en/research/usi.html).
- The Sustainable Cities Index (SCI) developed by Arcadis Design and Consultancy (https://www.arcadis.com/en/global/our-perspectives/sustainable-cities-index-2016/#).
- The Global City Indicators supported by the University of Toronto's Global City Indicators Facility (http://www.globalcitiesinstitute.org/).
- The European Green City Index (EGCI) developed by the Economist Intelligence Unit and sponsored by Siemens (http://perspectives.eiu.com/sustainability/european-green-city-index).
- The Sustainable Cities Index developed by the Forum for the Future (https://www.forumforthefuture.org/project/sustainable-cities-index/overview).
- The Urban Sustainability Indicators developed by the European Foundation for the Improvement of Living and Working Conditions (https://www.eurofound.europa.eu/publications/report/1999/urban-sustainability-indicators).
- The Global Power City Index (GPCI) developed by the MORI Memorial Foundation (http://mori-m-foundation.or.jp/english/index.shtml).

Other relevant initiatives and research efforts include: US EPA Green Communities, UK Eco Town Standards, China Eco City Development Indicators, etc.

Although the aforementioned evaluation frameworks adopt different approaches, all of them consider the three main pillars of sustainability, i.e., environment, society, and economy. The evaluation of urban sustainability is mainly based on a set of indicators available from national/international statistics and databases. Although differences may be observed between cities in developed and developing countries, usually these indicators are competitive. For example, economic development may increase the income of the urban population, but at the same it may increase also harmful emissions.

In any case, the main aim of the previous urban sustainability evaluation frameworks is to provide a comprehensive analysis of the sustainability shifts taking place across cities. Any set of sustainability indicators should be able to provide a comprehensive assessment of a city's sustainability performance across the three main sustainability pillars.

In the context of urban sustainability, a typical set of evaluation dimensions may include the following:

a) Social welfare

Employment and adequate healthcare and education are priority needs that help sustain an urban population.

b) Cleanliness

Lessening exposure to harmful pollutants and improving waste management efficiency helps induce cleaner urban environments.

c) Built environment

Increased livability and efficiency of communities comes with equitable access to green space and public transportation, as well as dense and efficient buildings.

d) Economic development

Economic development should serve improvements on quality of life as a result of higher per capita disposable income, employment, investments, etc.

e) Resource utilization

Efficient use of water and energy as well as effective waste recycling, contribute to functional resource management, providing benefits in both urban and rural areas.

Based on the above points, a proper methodology should be developed by the student groups for the sustainability evaluation of cities. Although alternative MCDA tools may be used, particular attention should be paid in modeling the decision making problem. For example, the general modeling methodology outlined by Roy (1996) may be adopted: i) Object of the decision, ii) Consistent family of criteria, iii) Preference modeling; and iv) Decision-aid.

3. Urban sustainability indicators and data

There are several indicators that may be used in urban sustainability evaluation. Below a typical list of such indicators is provided:

i. **Employment**

Employment share (%); it is calculated as the ratio of the employed population to the total urban population

ii. **Doctor resource**

Number of doctors per capita (number of doctors per thousand urban population)

iii. **Education**

Number of middle school students share (% of middle school students in young urban population aged 0 to 24)

iv. **Pensions**

Pension security coverage (% of people with pension coverage to total urban population)

v. **Healthcare**

Healthcare security coverage (% of people with healthcare security to total urban population)

vi. **Air pollution**

Concentration of NO2 (mg per cubic meter)

Concentration of SO_2 (mg per cubic meter)

Concentration of PM10 (mg per cubic meter)

vii. Industrial pollution

Industrial air pollution SO_2 per unit GDP (tons of SO_2 per billion US dollars)

viii. Air qualified days

Air qualified days per year (% of air qualified[1] days equal or above level II in a year)

ix. Wastewater treatment

Wastewater treatment rate (%)

x. Household waste management

Domestic waste treated (%)

xi. Urban density

Urban population density (number of persons per square kilometer of urban area)

xii. Mass transit usage

Passengers using public transit (number of public transit used per urban person)

xiii. Public green space

Coverage of public green space (% of public green space in city built area)

xiv. Public water supply

Public water supply coverage (% of population with access to public water supply)

xv. Internet access

Household access to Internet (% of households using broadband internet access)

xvi. Income level

Disposable income per urban capita (thousands US dollars)

xvii. Reliance on heavy industry

Service share in GDP (% GDP from service industry)

xviii. Capacity investment

Government investment in R&D (US dollars per capita)

xix. Energy consumption

Energy consumption per unit GDP (TSCE[2] per thousand US dollars)

[1] Air qualified days is defined as the number of days qualified equal or above Air Pollution Index Level II. There are six levels by API. Level II means that air quality is general acceptable to public, except for especially sensitive population.

[2] Tons of Standard Coal Equivalent

xx. Power efficiency

Residential power consumption (kwh per capita)

xxi. Water efficiency

Total water consumption (liters per unit of GDP)

4. Application

The main aim of the case study is the application of an urban sustainability evaluation methodology to a set of selected cities worldwide, taking into account the framework presented in the previous sections, as well as available sustainability data.

The examined cities are Beijing, Berlin, Copenhagen, Hong Kong, London, New York, Paris, Prague, Seoul, Shanghai, Stockholm, Tokyo, and Warsaw. Figure 1 presents a brief profile (population) of these cities, while Table 1 presents the available data for the urban sustainability indicators given in section 3.

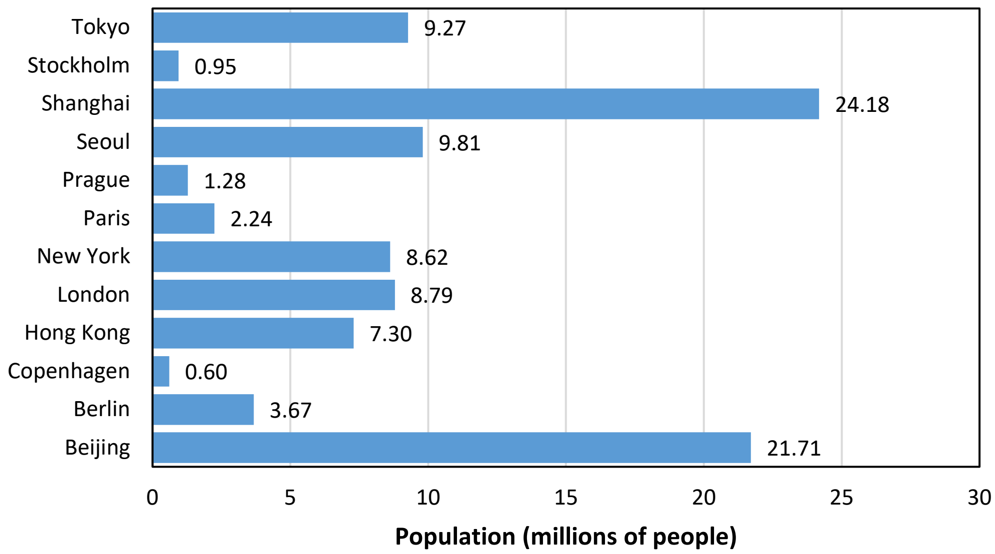

Figure 2. Profile of examined cities

Table 1. Sustainability data on selected cities

	Employment share	Number of doctors per capita	Middle school students share	Pension security coverage	Healthcare security coverage	Concentration of NO2	Concentration of SO2	Concentration of PM10
Beijing	0.530	3.45	0.162	0.54	0.59	0.056	0.028	0.113
Berlin	0.500	8.15	0.620	1.00	0.99	0.032	0.003	0.024
Copenhagen	0.520	4.84	0.160	1.00	1.00	0.054	0.001	0.035
Hong Kong	0.502	1.80	0.275	0.85	1.00	0.009	0.052	0.062
London	0.514	2.77	0.279	1.00	1.00	0.067	0.003	0.027
New York	0.540	2.77	0.209	1.00	0.88	0.047	0.003	0.021
Paris	0.678	7.42	0.126	1.00	0.99	0.040	0.010	0.025
Prague	0.515	7.50	0.205	1.00	1.00	0.029	0.003	0.028
Seoul	0.623	2.72	0.254	0.56	0.96	0.030	0.005	0.041
Shanghai	0.470	1.84	0.159	0.39	0.41	0.051	0.029	0.080
Stockholm	0.520	3.75	0.240	1.00	1.00	0.043	0.001	0.025
Tokyo	0.501	3.15	0.299	1.00	1.00	0.025	0.002	0.020

Table 1. Sustainability data on selected cities (continued)

	Industrial air pollution SO2	Air qualified days per year	Wastewater treatment rate	Domestic waste treated	Urban population density	Passengers using public transit	Coverage of public green space
Beijing	8.018	0.876	0.817	0.982	13537.2	256.48	0.52
Berlin	1.919	0.953	0.996	1.000	3785.2	386.00	0.31
Copenhagen	1.305	0.910	1.000	1.000	8103.0	380.00	0.40
Hong Kong	2.468	0.880	0.930	0.500	6544.0	262.39	0.40
London	2.738	0.953	1.000	0.932	5283.0	307.23	0.60
New York	2.181	0.899	1.000	1.000	10518.0	283.81	0.25
Paris	2.738	0.647	1.000	0.920	21196.4	474.50	0.23
Prague	2.738	0.965	1.000	0.865	2503.0	889.83	0.14
Seoul	0.413	0.927	0.986	1.000	17255.1	298.23	0.28
Shanghai	22.824	0.923	0.844	0.610	14826.6	121.49	0.43
Stockholm	0.639	0.890	1.000	1.000	3597.0	840.00	0.40
Tokyo	0.351	0.953	0.995	1.000	14440.0	1051.20	0.22

Table 1. Sustainability data on selected cities (continued)

	Public water supply coverage	Household access to Internet	Disposable income per urban capita	Service share in GDP	Government investment in R&D	Energy consumption per unit GDP	Residential power consumption	Total water consumption
Beijing	1.000	0.720	32.903	0.761	932.99	4.590	0.699	0.029
Berlin	0.996	0.793	23.562	0.826	181.90	0.007	8.900	1.787
Copenhagen	1.000	0.970	26.969	0.800	672.00	0.015	5.950	0.552
Hong Kong	0.999	0.779	29.288	0.919	10.79	0.159	1.594	2.358
London	1.000	0.740	33.052	0.890	405.00	0.035	3.988	1.234
New York	1.000	0.670	31.417	0.810	21.92	0.060	2.600	0.746
Paris	1.000	0.820	31.661	0.737	0.00	0.021	11.200	0.622
Prague	0.997	0.660	14.200	0.837	538.35	0.201	1.153	2.766
Seoul	1.000	0.966	32.791	0.910	0.00	0.086	1.283	3.123
Shanghai	1.000	0.665	36.230	0.583	873.14	6.180	0.757	0.071
Stockholm	1.000	0.960	30.500	0.580	480.00	0.041	6.750	1.187
Tokyo	0.999	0.762	51.097	0.900	0.00	0.014	2.376	1.088

5. Modeling issues and guidelines

The modeling issues that student groups have to approach are the following:

1. Who may be interested in evaluating urban sustainability? Who may be the **decision maker (DM)/evaluator**? Of course, in the frame of the Summer School this DM is not available. Consequently, one or some students of each group should act as the DM/Evaluator for this specific evaluation problem.
2. **Problem statement:** Each student group should provide an evaluation result that has one of the three alternative forms:
   a. A global score for each city measuring its overall sustainability.
   b. A complete ranking of the cities
   c. An assignment of each city to (ordered) sustainability categories (e.g., strong, moderate, weak sustainability, etc.)
3. **Criteria modeling:** Each student group should model a consistent family of criteria from all pillars of sustainability (Figure 1).
4. **Methodology:** The student groups should use MCDA models and methods that are suitable for the chosen decision problematics. Guidance and feedback will be available from the professors during the Summer School.

At the end of the Summer School (Friday, August 3) each student group should present a report and/or a PowerPoint presentation of the case study modeling, methodology, and results.

References

Munda, G. (2016). Multiple criteria decision analysis and sustainable development, in: S. Greco, M. Ehrgott, and J. Figueira (eds.), *Multiple criteria analysis: State of the art surveys*, 2nd edition, Springer, New York, 1235-1267.

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UNEP (1987). *Our common future: The world commission on environment and development*, Oxford University Press, Oxford.