EPFL

SUSTAINABILITY ASSESSMENT OF URBAN SYSTEMS

HERUS

Normalization and weighting in multi-criteria assessment

Exercise 9
16.04.2025

Tasks

The purpose of this exercise is to test different methods of normalization and weighting by applying them to a toy data set. All of the necessary information to make the calculations are in the following slides.

Task 1 (normalization): Apply the four methods to normalize the data found in the impact matrix. Compare the results of the different methods. Get the spreadsheet from Moodle.

Q: Which normalization method would you use for this example?

Task 2 (weighting): Based on the normalized data, calculate the weighted-sum score for the three cities using both of the suggested weighting methods.

Q: What would be the arguments for and against of each of the two weighting methods?

1. Decision Matrix

IMPACT MATRIX

Dimensions	Indicators	Units	Obj	AMSTERDAM	FRANKFURT	STOCKHOLM
Social	**Average transport time**	minutes / km	↓	3	3.2	3.05
Social	**Social segregation**	subjective scale from 0 (very low) to 5 (very high)	↓	1	1	2
Economic	**Public transport accessibility**	100 [monthly public transport fee (€) / median income (€)]	↓	2.37	2.11	2.29
Economic	**Cycling path density**	number of cycle lanes (km) / km²	↑	2.75	1.01	4.04
Economic	**Public transportation capital**	100 M$USD	↑	710.6	767.2	231.8
Environmental	**Particulate Matter (PM)**	index annual mean value	↓	28	31	20
Environmental	**Azote dioxide (NO_2)**	index annual mean value	↓	15	22	18
Environmental	**Plume Air Quality Index**	index annual mean value	↑	33	38	31
Environmental	**CO_2 emitted by public transportation**	kg / capita	↓	1000	1750	1500

2. Normalization methods

METHOD 1: ***Standard deviation from the mean***

(imposing a standard normal distribution):

↑: $\left(\frac{actual\ value - mean\ value}{standard\ deviation}\right)$

↓: $-\left(\frac{actual\ value - mean\ value}{standard\ deviation}\right)$

METHOD 2: ***Distance from the group leader*** (it assigns 100 to the leading alternative while other alternatives are ranked as percentage points from the leader):

↑: $100\left(\frac{actual\ value}{best\ value}\right)$; ↓: $100\left(\frac{best\ value}{actual\ value}\right)$

METHOD 3: ***Distance from the mean*** (the mean value is given 100, and alternatives receive scores depending on their distance from the mean):

↑: $100\left(\frac{actual\ value}{mean\ value}\right)$;

↓: $100\left(1 - \frac{actual\ value - mean\ value}{mean\ value}\right)$

METHOD 4: ***Distance from the best and worst performers*** (positioning is in relation to the global maximum and minimum; the index takes values between 0 -*laggard*- and 100 -*leader*-):

$$100\left(\frac{actual\ value - worst\ value}{best\ value - worst\ value}\right)$$

Note: The "best" and "worst" value can either be the maximum or minimum value, depending on the objective of the indicator.

Note: For methods 2,3 and 4 the equation varies depending on whether the objective of the indicator at hand is to increase or to decrease.

3. Weighting

IMPACT MATRIX

Dimensions	Indicators	Units	Obj	Weight [%]	AMSTERDAM	FRANKFURT	STOCKHOLM
Social	**Average transport time**	minutes / km	↓	?			
Social	**Social segregation**	subjective scale from 0 (very low) to 5 (very high)	↓	?			
Economic	**Public transport accessibility**	100 [monthly public transport fee (€) / median income (€)]	↓	?			
Economic	**Cycling path density**	number of cycle lanes (km) / km²	↑	?			
Economic	**Public transportation capital**	100 M$USD	↑	?			
Environmental	**Particulate Matter (PM)**	index annual mean value	↓	?			
Environmental	**Azote dioxide (NO_2)**	index annual mean value	↓	?			
Environmental	**Plume Air Quality Index**	index annual mean value	↑	?			
Environmental	**CO_2 emitted by public transportation**	kg / capita	↓	?			

METHOD 1: Give equal weight to each *dimension*

METHOD 2: Give equal weight to each *indicator*