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Comparative Sustainability Assessment: Rome, Italy and São Paulo, Brazil

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Abstract

Rome and São Paulo share many cultural similarities, there are in São Paulo metropolitan area (M.A.) 6 million people from Italian descendancy, being the Italian population in São Paulo M.A. bigger than Rome's. This study develops a sustainability assessment (S.A.) to obtain a comprehensive framework to assess the sustainability performance of both cities, compare them and propose a solution. Five metrics on which based the S.A. were chosen according to the results of a survey with São Paulo and Rome residents.

To validate the effectiveness of these indicators two focus groups were conducted, then the indicators were valued, and a Sustainability Solution Space was applied to identify their interactions. A Multi-Criteria Analysis was carried out to assess which of the cities has currently the highest performance in terms of sustainability. Rome had a higher sustainability ranking than Sao Paulo, nevertheless both cities should improve corruption scores to improve their ranking.

Keywords: sustainability assessment, sustainability solution space, multi-criteria analysis, Sao Paulo, Rome

1. Introduction

Rome and São Paulo share many cultural similarities, there are in São Paulo metropolitan area (M.A.) 6 million people from Italian descendancy (World Population Review, 2017), being the Italian population in São Paulo m.a. bigger than Rome's. This study develops a sustainability assessment (S.A.) to obtain a comprehensive framework to assess the sustainability performance of both cities, compare them and propose a solution for their sustainable development.

Sustainability in this case is defined by how the city is measured within the indicators of each one of the five metrics represented by the pillars on figure 1.

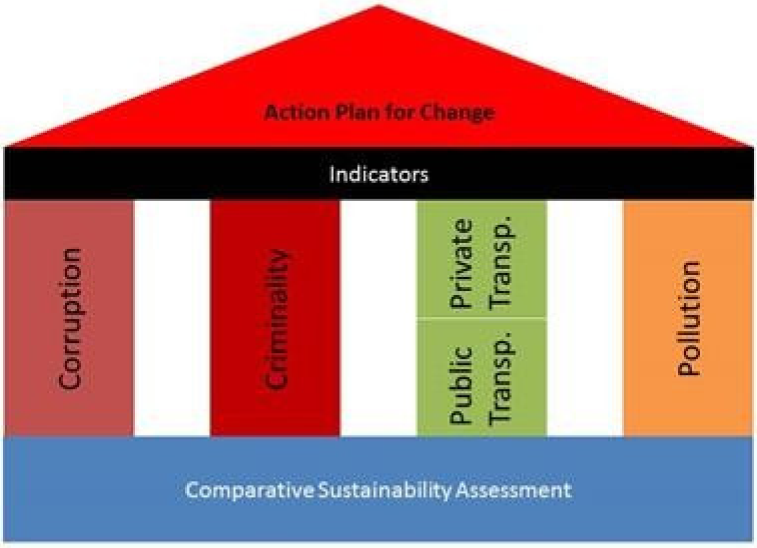

Figure 1. Metrics temple (produced by the authors, 2017)

The pillars have been chosen based on a survey realized with 67 people that lived in São Paulo, Rome or both. The key societal activities (Baccini & Brunner, 1991) were the foundation for the questions that addressed people's main problems related to sustainability and better quality of life in those cities.

A bottom-up approach (Spohn, 2004) was used on the S.A. development. Firstly, for the metrics a quantitative analysis on the survey results was done, followed by a quantitative analysis with focus groups, in which the people perception of the indicators that were firstly chosen by the authors was assessed. Finally, a pertinence analysis of the responses obtained was carried out, thus arriving to the final form of the indicators.

According to Bebbington et al. (2007) "there is a widely recognized need for individuals, organizations and societies to find models, metrics and tools for articulating the extent to which, and the ways in which, current activities are unsustainable", recognizing the importance of the sustainability assessment, which was performed to analyze and compare cities with similar cultural backgrounds, in different continents, but similar economic scenarios and corruption perception. The system analysis reported on figure 2 allows to understand the interactions between the metrics and indicators of the system this study refers to.

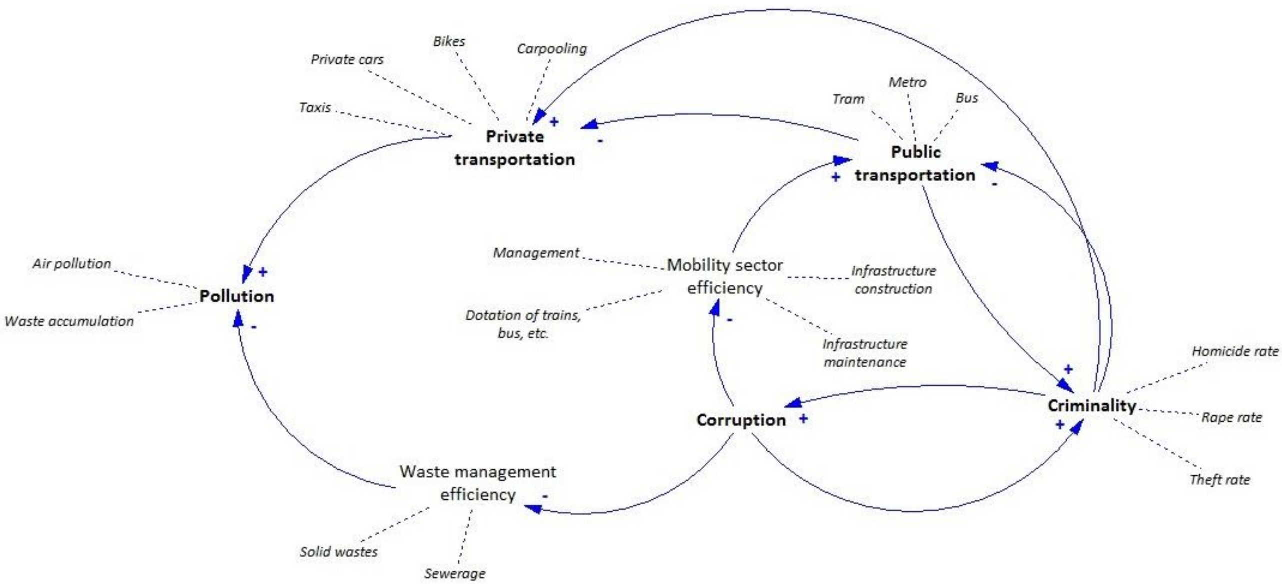

Figure 2. System model (produced by the authors, 2017)

The results from the survey with participants from São Paulo and Rome shows that for more than 82% transportation is the main issue, the mobility efficiency can positively impact the usage of public transportation as shown by the system analysis (figure 2), but it is impacted by corruption, as for example the yellow line of São Paulo subway had a cost per kilometer of USD 145.454.545,49 (Lepeska, 2011), the extension of the green line had a cost of more than USD 570 million per kilometer (Dias, 2012), while in other cities, for example in Madrid the subway had a cost of USD 58 million per kilometer (Lepeska, 2011).

The discrepancy of values on the green line, might be due to the fact of the corruption scandals involving this line (e.g. Bedinelli, 2017, Pires, 2017) where just for two parts of the expansion project were discovered around USD 45 and 37 million in kickback schemes. The corruption made not only the expansion costly, but to increase in time, since the contract started in 1995 and to date the work has not been finished. Considering cities limited budget, an increase in costs means less free budget for other projects. In some cases, investment projects on sustainability can even reduce costs to the point where it pays the investment (Pohlmann-Gonzaga & Akdidach, 2022).

For the system analysis (figure 2), with the increase in corruption a city suffers an increase in criminality. According to Soares (2004), corruption has a negative correlation with crime reporting rates,

and crime reporting is one of the necessary ways to minimize criminal activity. This brings people to feel unsafe, and therefore to avoid public transportation, as Patterson (1985) points out is the case for the elderlies; or Freedman (2004), on security tips when travelling says that public transportation must be avoided late night. Also, public transportation growth can also generate an increase in criminality (e.g. Smith & Clarke, 2000).

With the human need to move, the shift from public transportation naturally brings to a growth in the private transportation usage, which in turns increases pollution. In addition, as Wilson (2007) points out, corruption is one of the issues in the waste management sector, which if poorly managed can increase pollution.

2. Methodology

A bottom-up approach was used for the development of the metrics and for the validation of the indicators, with an online survey and two focus groups respectively, done with inhabitants of Rome and São Paulo.

2.1 Metrics Development

The online survey contained 11 questions divided in three categories:

a) demographics: nationality, age, profession, city lived (São Paulo or Rome) and for how long (years);

b) categorization of S.A.: main issues of the city and Likert scale for core main issues;

c) proposition: any other idea proposed by the interviewed.

The full survey is available on table 8, it was sent to Brazilian and Italian residents who lived in São Paulo and/or Rome. The people were selected by convenience and the inhabitant's proportion of both cities has been respected (4 times more people living in São Paulo than in Rome according to the UN Database (2015)).

The core issues were three topics chosen by the authors as the most relevant in terms of societal impact on environment, that could approach the indirect pressure socio-environmental metrics of Holmberg and Karlsson (1992).

The main issues were a broad spectrum of the core issues, being:

a) unemployment.

b) difficulty of movements within the city (transportation);

c) criminality;

d) corruption;

e) dirtiness;

f) food quality;

g) pollution.

2.2 Indicators Validation

The main metrics, represented on the figure 1, are the result of the survey analysis. For each one of those metrics some indicators were developed, based on literature review and/or authors understanding of the pertinence of each data point needed.

For validating the effectiveness of those indicators two focus groups were conducted (semi-structured, where only the first question was given and the role of the moderator was to develop the discussions), one with four Rome citizens and other with four São Paulo citizens. Each focus group was conducted in the national language using the online tool Google Hangouts, where it was possible not only to conduct a group discussion remotely, but also sharing the indicators table (table 4) with the group. To start the discussion, the table was shown, and two questions were asked: if they thought those indicators were pertinent for assessing sustainability in the city and if they saw any relationships between them.

After the focus group, the point of view for each indicator and propositions of the participants was summarized, followed by a content analysis to allow the creation of the indicators framework (table 1).

2.3 Analysis

In this study two different analytical tools have been applied, firstly the Sustainability Solution Space to understand the interaction and the behavior of the indicators, then the multi-criteria analysis to make a comparison between the current state of the two cities of interest.

2.3.1 Sustainability Solution Space (SSP)

The SSP assessment method started with first a weighting of the indicators from 0-2, regarding the direct influence of one indicator on the other, being 0 no influence and 2 strong influence. For the influence measurement was first used the author's knowledge of whether the indicator should be awarded zero, than a literature review was made for each of the indicators that were scored 1 or 2.

After this mapping, following the procedure presented by Wiek and Binder (2005), it was summed the influence exercised to and from other indicators, and then those totals were added to the graph (figure 3), to visualize the activity or passivity level of each indicator. Active indicator means it has a high influence on the other indicators, when passive are influenced. Active indicators are the first targets for systemic change (together with ambivalent indicators) and passive indicators represent a way to measure the system improvement.

With the same indicators, a lower and an upper boundary were defined. Considering that a main function of a city is to provide a habitable place for citizens, there were chosen as boundaries the first and 50th best city to live (Mercer, 2017), respectively as upper boundary and lower boundary, being the first Vienna (Austria) and the 50th Kobe (Japan). As shown on table 6, for each indicator were found the respective data for the upper and lower boundaries, together with the data from São Paulo and Rome.

Those are regional data, mostly found in the local language, therefore, even if an effort was made to have all the indicators completed, some of them were not found or did not exist, thus marked as "N/A". Important indicators for the sustainability assessment (active, ambivalent and neutral), when found "N/A" for Vienna and Kobe were thus retrieved for the next city in the classification (second or 49th, for example), until found. In cases where no data were found for a group of the population (e.g. per 100.000 inhabitants), the value was calculated by the authors from the total population value.

2.3.2 Multi-criteria Analysis (MCA)

MCA is a tool which allows decision-makers to overcome the difficulties that raise when dealing with large amounts of complex information, making them able to choose among different possible scenario in a convenient way (Dodgson, 2009).

Multi-criteria analysis cannot solve all conflicts within a decision-making process but is useful to reach a compromise in case of divergent preferences as well to guarantee the transparency of the process.

MCA techniques can be used to identify a single most preferred option, to establish a ranking among them or to shortlist a limited number of options for subsequent detailed appraisal, or finally to simply distinguish acceptable from unacceptable possibilities (Dodgson, 2009).

3. Results

3.1 Online Survey Results

Figure 4 shows the distribution of the participants in the two cities; it is correspondent to the actual difference in population between them. Although the rough number of participants tried to represent the actual size, the sample is not representative of the population of both cities. In terms of age participants range was from 17 to 74 with a median of 24, mode of 21 and an average of 29,89. When considering the profession range, it consisted by 52,2% of students followed by 13,4% of engineers. Most of the participants (64,2%) lived in São Paulo for more than 5 years, followed by participants living in Rome for more than five years (14,9%).

The figure 5 shows which were the main issues of the city in the participants' opinion, it is important to note the difference between them and the core issues chosen by the authors, which considered food (supply chain, access and quality) one of the main issues in the modern urban environment of São Paulo and Rome. The most chosen issue, transportation, was also pointed by 82,1% of the participants as the sector who needs more improvement. With participants on the comment section also referring to it, as the following examples:

"A good public transportation system I believe is key to a better quality of life (…)"

"We need to create a balance between investments and infrastructure improvements"

"(…) A research with students from São Paulo State University (USP) shows that the majority spent between 3-4 hours a day in urban transports" (translated by the authors from Portuguese).

With the data collected for the metrics, it was developed a framework with some indicators for each

metric, as seen on table 4. This original set of indicators was then discussed in a focus group (specifically for each city) in order to assure its validation in the local context.

3.2 Focus Groups

To have further, local insights about the indicators for each metric, two focus groups were conducted, with four Rome citizens (from age 24 to 27, living in Rome all their lives) and four from São Paulo (aging from 21 to 54, being one student and the other professionals in different industries, all of whom lived in São Paulo all their lives).

With the table 4 shared on their screens (on the Google Hangouts tool) it started the discussion that gave the foundation for the creation of table 1. Below are reported some direct quotes from the recording that instigated discussion, about whom all participants within the focus group agreed (they are translated from Italian and Portuguese to English by the authors).

One of the Rome citizens argued: "You should include an indicator about tap water quality; this is a good measurement for pollution. If the tap water is not drinkable, there can be serious consequences". The same person when regarding pollution said that both indicators Ambient Concentration of Air Pollutants in Urban Areas* [µg / m3] and PM10 daily average concentration [µg / m3], were out of the scope for the project for being too specific and not context oriented, also considering that most indicators are "per year, or per thousand" and those two were moment oriented.

Another Rome focus group participant argued about the necessity of integrating data on kilometers of public transportation line and cycles paths, because this, as she argued, can bring faster public transportation and/or alternative to private car mobility, a topic that was also discussed and agreed by all participants of the São Paulo focus group (without interference of the researchers, both groups discussed the importance of exclusive paths to make transportation faster and/or safer).

A topic that generated a lot of discussion and misunderstanding on the table 4 was the indicator about cellphone and internet lines. Even when explained the context of this indicator (that was developed by the United Nations), of remote work possibility due to IT infrastructure and thus being less dependable on the transportation network, all participants thought remote work is still utopic. One from São Paulo mentioned Yahoo - the American internet company - who tried remote work, but it has not worked out well. About pollution this same person argued that there were too specific indicators and none of them was about waste management and the measurements of São Paulo's landfills capacity and recycling rates.

Table 1. Indicators framework (produced by the authors, 2017)

Indicators				
Corruption	**Transportation**		**Pollution**	**Criminality**
	Public	**Private**		
Corruption perception score (country) [0 - 100]	Average commuting time [min / (person*day)]		CO2 emissions [kg / (person*year)]	Number of recorded crimes per 100.000 inhabitants [-]
Number of legal actions (regional level) [(year*100.000 person)^-1]	Usage by mode [%]		Air Quality (O3, PM10 and NO2) [µg/m3 - annual average]	Number of recorded homicides per 100.000 inhabitants [-]
	Representation of monthly commute cost as % of avg income [%]	Average price of gas [$]	Waste production [kg / (person*year)]	Number of rapes per 100.000 inhabitants [-]
	Number of bus stops [km^-2] and buses [-]	Number of cars per 1.000 inhabitants [-]	Recycling rate [%]	Number of thefts per 100.000 inhabitants [-]
	Exclusive bus and rail paths [km]	Cycle paths density [km/ 100 km^2]	Connection to the sewerage system [% of the total residents]	Number of stolen vehicles per year [-]

3.2 Sustainability Assessment Results

The assessment was done with the data collected for each indicator in table 1. Where the indicator was not found the cell is marked "N/A" and the full data is available at tables 7.2 and 7.3 in the annexes for São Paulo and Rome respectively.

3.2.1 Sustainability Solution Space (SSP)

A system grid with the interaction among indicators is represented on the figure 3, with usage by mode of transportation being considered an ambivalent indicator, because it has high impact on commuting time and CO2 emissions for example, CO2 emissions is instead an highly passive indicator, due to the fact that CO2 emissions are connected with O3 concentration (one of the indicators about air pollution).

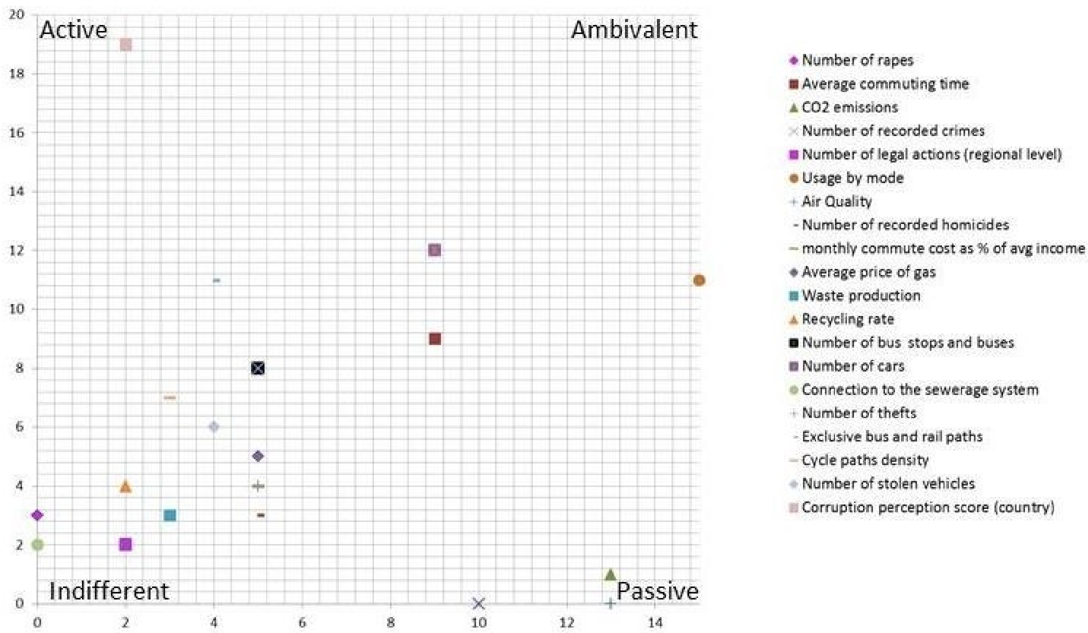

Figure 3. Indicators interaction system grid (produced by the authors, 2017)

Each indicator had it score based on a literature review, listed below are the indicators with their overall score in brackets, with the results for activity and passivity respectively, accompanied of the literature review for each activity scoring. The foundation of the indicators grading is the following:

a) Corruption perception score (19,2): corruption has a high impact on criminality (e.g. LaPorta et al., 1999 and Uslaner, 2005), since corruption it is seen as a broad spectrum inside many hierarchical levels of public entities it was scored two for: theft rate, cars stolen, homicides, number of recorded crimes and to the number of legal proceedings regarding corruption (more corruption, more likely to have legal cases against corruption opened). For public infrastructure related problems it was given one as score, because mobility, sewerage and recycling can be affected by public policies (not measured here) and corruption impacts public policies at a certain degree (e.g. Hafi et al., 2012).

b) Average commuting time (9,9): investments in new transportation systems (or improving current ones) can reduce average commuting times (e.g. Barbour, 2006), so the value two was attributed to all the indicators regarding transportation system choice and infrastructure, and also to air pollutants, because commuting time, distance and mode can impact air pollution (e.g. Good et al., 2015 and Johansson et al., 2017).

c) CO2 emissions (1,13): the value one was given, due to the chemical reaction of CO_2 and O_3 in the atmosphere.

d) Number of recorded crimes (0,10): the number of recorded crimes in a city is the sum of different practiced crimes that were reported to the police, meaning no activity towards other indicators.

e) Number of legal actions (regional level) related to corruption (2,2): the corruption perception index is composed by expert analysis and opinion surveys (T.I., 2017). Since legal actions on corruption can generate media coverage, increasing awareness, this would impact both analysis methods results, thus implicating in a 2 level of impact only on corruption perception index.

f) Usage by mode of transportation (11,15): it has a high impact on the average commuting time (e.g. Lisco, 1968 and Chen et al., 2008), also in CO2 emissions, because there are modes of transportation that emit less CO2 and air pollutants (e.g. Nocera & Cavallaro, 2011, Gulliver & Briggs, 2004, Tzeng et al., 2005). The number of cars also has a direct high effect on the transportation usage. Since infrastructure can impact the mode of transportation choice (Scwhanen & Mokhtarian, 2005, see Hess (2014) for example of car related infrastructure) it was attributed a value of 1 for all infrastructure related indicators (e.g. number of bus stops).

g) Air Quality (0,13): air quality indicators are a consequence of other actions and do not impact any other indicators.

h) Number of recorded homicides (3,5): it has a high impact on the number of recorded crimes, since the latter is a sum of all crimes committed. It was also considered having a small influence on thefts, because of larcenies, many homicides can increase the theft followed by homicide (or attempt).

i) Monthly commute cost as % of average income (4,5): the price of the public transportation can directly impact commuters' choice (e.g. Fujii & Kitamura, 2003, Oum et al., 1992). The indicator has low impact on the number of cars per 1.000 inhabitants and number of bus stops and exclusive bus lines, because for the first indicator more cars can mean more car users, and the reduction in passenger flow can impact public transportation price, while for the second indicator, since it is mostly related to public infrastructure, it tends not to be directly reflected on the price, although its maintenance is included in the price taxation.

j) Average price of gas (5,5): the price of gas is mainly determined by the oil prices and public policies relating to gas pricing (for inflation control, e.g. Springer 2013), which explains the low passivity score; for activity it is scored two only on mode of transportation choice, due to gasoline price elasticity and private transportation usage (e.g. Sterner, 2007, Sterner et al., 1992). Because of price elasticity a change on the average price of gas has low impact on CO2 and air pollution, and also it sightly impacts cars sales.

h) Waste Production (3,3): it has no strong impact on other indicators.

l) Number of rapes (3,0): other criminality indicators have no relation with rapes, but rape strongly impacts the number of recorded crimes, due to the way the indicator is built. It has a low impact on homicide and theft rates, because a rape is sometimes followed by a homicide or a theft.

m) Recycling rate (4,2): it has a high impact on waste production, if considering that waste production is counted as what arrive at landfills. Recycling is considered a form of waste reduction (e.g. Subramanian, 2000), and it also reduces CO2 equivalents and air pollutants derived from landfill management, but these interactions were considered as low score interactions.

n) Number of bus stops and buses: there is a high impact on the mode of transportation choice (e.g. Currie & Wallis, 2008, Mohring, 1972), and a low impact on air pollution and CO2 emissions, since more direct routes tend to have lower emissions and low impact on car ownership and transport infrastructure.

o) Number of cars (12,9): it has a high correlation with air pollution and CO2 emissions (e.g. Small & Kazimi, 1995), commuting time (e.g. Gardner & Abraham, 2007, Gatersleben & Uzzell, 2007 and usage by mode since it is one of the components for the sum. For lower impacts, it has some on other mobility types infrastructure (e.g. Dill & Carr (2014) for bicycles) and on stolen vehicles.

p) Connection to the sewerage system (2,0): it has a low impact on CO2 emissions due to the calculation of CO2 equivalent emitted and waste production.

q) Number of thefts (4,5): it has a strong impact on total crimes, and a low impact on homicides and car stolen.

r) Exclusive bus and rail paths (11,4): strong impact on the average commuting time, since those lines tend to decrease the transportation time, also on the usage by mode of transportation (Murray et al., 1998, Beirao & Cabral, 2007), number of bus stops and buses.

s) Cycle paths density (7,3): the increase in cycle paths density tends to attract commuters from other types of transportation (e.g. Pucher et al., 2010, Nelson & Allen, 2014, Schwanen et al., 2004, Plaut, 2005), causing changes on the average commuting time, as an high impact. Moreover, since public policies towards mobility infrastructure are interlinked, the implementation of cycle paths can impact infrastructure related indicators, with a low score, that was also reflected in CO2 equivalents and air pollutants, since they have other sources than transportation and the shift may not cause a high impact.

t) Number of stolen vehicles (6,4): it has a high impact on the number of recorded crimes and thefts due to the way indicators are built, and a low impact on mode of transportation (a stolen car from a commuter would, in the short term, take out a car from the streets) and in homicides, since car robbery can lead to larceny.

The 34 indicators represented by those macro-indicators described above are shown on table 7 with their value for the upper and lower boundaries, together with São Paulo and Rome data.

The results from the SSP indicators impact matrix suggests that both São Paulo and Rome, to improve sustainability should focus their efforts on ameliorating ambivalent and active indicators as: usage by mode of transportation, number of legal actions, average commuting time, exclusive bus and rail paths, and corruption perception index. Passive indicators should be kept monitored for measuring efficacy.

The table 2 shows the selected target indicators, with the upper and lower boundary (Vienna and Kobe), together with the data from São Paulo and Rome. One column is dedicated to the desired outcome since some indicators might be the best to increase (for example the usage of public transportation) and others to decrease (CO2 emissions).

Table 2. Upper and lower boundary for target indicators (produced by the authors, 2017)

No.	Name	Unit	Upper Boundary	Lower Boundary	Current value Rome	Current value São Paulo	Resulting lower boundary	Resulting upper boundary	Desired Outcome
1	Corruption perception score (country)	Score	75	72	47	40	40	75	+
2	Average commuting time	Minutes	N/A	80 (Ministry of Public Management, 2001, apud. Hyogo-Kobe, 2017)	42	111	42	111	-
3	Number of legal actions (regional level)	(year*100.00 person)^-1	N/A	N/A	0,98	N/A	N/A	N/A	-
4	Usage by mode: Public Transportation	% of total population	39% (Wien, 2017)	33% (Kobe, 2017)	27,5%	47,58%	27,5%	39%	+
5	Usage by mode: Private Transportation	% of total population	27% (Wien, 2017)	29% (Kobe, 2017)	55.00%	53,2%	27%	55%	-
6	Usage by mode: Bycicle+On foot	% of total population	34% (Wien, 2017)	37% (Kobe, 2017)	17,5%	0,2%	0,2%	37%	+
7	Exclusive bus path	km	846,6 (Wien, 2017)	N/A	112	519	112	846,6	+
8	Exclusive rail paths	km	301,2 (Wien, 2017)	N/A	59	342,7	59	342,7	+

As it is possible to observe above, the indicator 3 has only the data from Rome and will be excluded from the analysis. The other indicators where N/A is contained for the upper or lower boundary will be

selected looking to the following city from the Mercer (2017) ranking (2nd for Vienna, and 49nd for Kobe, or until found).

For average commuting time data from Zürich (Switzerland) were used (Winkelmann & Bachmann, 2004), being 31,6 minutes. For exclusive bus and rail paths were used data from Washington, DC (USA), with zero (e.g. CNN Library, 2017, NACTO, 2011, Lazo, 2016) and 118 miles (CNN Library, 2017), or 189,90 kilometers, respectively.

For the target indicators, attaining sustainability is approaching the upper boundary for those with positive expected outcome, and approaching lower boundary for those with negative expected outcome. The ideal city would have the corruption perception index approaching Austria (high), Zurich's commuting time (low), both high public transportation and by bicycle and/or foot media of transportation as Vienna and Kobe respectively. This would decrease even further the private transportation (motorized) indicator, together with the increase in public transportation infrastructure (bus and rail paths).

3.2.2 Multi-Criteria Analysis (MCA)

The main goal of the MCA carried out was to understand which of the two cities has currently the highest degree of performance considering the five-core metrics of our comparative analysis in this way: transportation (public and private), pollution, corruption, and criminality (analyzed together).

The MCA started with merging in one table the indicators' values for both cities and then splitting it in the three sections mentioned above. For each section the indicators represent the criteria of the analysis, with some indicators that have not been used because of their non-pure numeric values, namely "*Usage by mode*", "*Number of bus stops and buses*" in the transportation section and "*Annual daily average of air pollutants*" in the pollution section. All the criteria included have been ranked, and then by using the "rank sum" (RS) weight method (Kenyon, 2017) their respective weights were calculated.

As usual in the MCAs, each column represents a criteria and each row a different scenario. In our case the scenarios are only two: the current conditions of São Paulo and Rome.

According to the nature of most of the indicators we chose, in the entire analysis the higher is the value of the criterion, the worse is the condition (e.g. higher number of recorded crimes means higher degree of criminality, higher number of cars per habitant means more pollution and traffic). The few indicators whose increasing value relates to a positive trend: "*Exclusive bus and rail paths*", "*Cycle paths density*", "*Recycling rate*" and "*Connection to the sewerage system*" have been modified consequently to have criteria which represent a worsening situation when increasing in value, then respecting the monotonicity condition. Thus, the arbitrary values 1 and 2 have been attributed to the two first indicators mentioned, "*Exclusive bus and rail paths*" and "*Cycle paths density"*; then, the latter two have been replaced by: "*Non-Recycled waste rate*" and "*Rate of no connection to the sewerage system*", obviously adapting the respective values.

First operational step of the MCA was constructing the three tables with the possible scenarios in the rows -*a*- (Rome and São Paulo), and the criteria (indicators) -*g*- in the columns. Then for each value $g_j(a_i)$, where g_j is the j-criteria and a_i is the i-scenario, the reciprocal number was calculated. Next step has then been normalizing the obtained values by dividing them by the highest value each criterion assumes in the same column.

Finally, the overall score for each scenario in every sector is obtained by multiplying the value of every criterion for its respective weight.

Results:

Table 3. MCA results (produced by the authors, 2017)

	Corruption and criminality	**Transportation**	**Pollution**	**Overall score**
São Paulo	0,82	0,54	0,88	2,24
Rome	0,64	0,61	0,74	1,99

From the table above it is possible to see that Rome is in a global perspective more performant than São Paulo. Indeed, the corruption, criminality and pollution metrics got a lower mark for the Italian city, while São Paulo has shown to be more efficient in terms of transportation.

4. Discussion

4.1 SSP

The SSP allowed for a comparative assessment regarding also other cities in terms of quality of living. The authors suggest that instead of focusing on quality of living, a next research focus should be on best practices for each individual indicator, because even though both Vienna and Kobe have good practices in sustainable city management, some indicators indicate very high emission when comparing to other cities. Also, the reference cities are in different economic stages, which might imply different points in a Kuznets curve, for example. An example of generic target for upper and lower boundaries would be basing the CO2 emissions on Chakravarty et al. (2009), who allocates carbon target between nations, and could be used to develop city targets.

For the target indicators the main limitation was language and/or data availability, since local city data is usually available only in the local language - as the research so far has proven - and the authors did not speak nor write in German and Japanese, it was difficult to find the data and use the right expressions. Some e-mails were sent to the city departments responsible for the missing indicators, but until the publishing date there were no response.

The SSP shows the systemic impact of the indicators and how to target the system to achieve better results, it goes beyond Rome and São Paulo indicators, bringing best practices and the sustainable space the cities should target to be into.

4.2 MCA

Among the various possibilities discussed in the methodology section for applying an MCA, in this work the tool has been used only to compare two existing scenarios, that are the current condition of Rome and São Paulo.

The application of the MCA was not immediate, since some indicators had to be adapted or inverted in meaning (e.g. "*Connection to the sewerage system*" to "*Rate of no connection to the sewerage system*") in order to respect the monotonicity condition, and some other indicators ("*Exclusive bus and rail paths*" and "*Cycle paths density")* had to be graded with arbitrary values for the same reason.

As explained in the previous section, the MCA allowed us to establish a ranking between the two cities for every metric that has been considered, thus coming to the result that the Italian city is in a global perspective currently more sustainable than the Brazilian one.

4.3 Proposals

From the outcome of the SSP analysis some ambivalent and active indicators have been identified: usage by mode of transportation, number of legal actions, average commuting time, exclusive bus and rail paths, and corruption perception index.

Those indicators perfectly reflect the perception of the main issues of the cities portrayed by the dwellers who gave their opinion in the initial survey, as well as the outcomes of the discussions had with the two focus groups in the phase of validating the indicators. Therefore, is possible to identify the direction in which proposals for raising the overall sustainability degree of the cities should go: transportation, corruption and criminality are the most sensitive aspects. Addressing those aspects would not only decrease the MCA scores, but also bring both Rome and São Paulo closer to the upper and lower boundaries identified in the SSP.

Considering the analyses carried out in this study, the authors promote some proposals to increase the sustainability in São Paulo and Rome:

● introducing a municipal counter-corruption authority to monitor all the public investments;

● Strengthening the police control;

● Introducing civic educational campaigns in schools;

● Improving the public transportation sector, especially focusing on exclusive paths for bus, and on metro lines, which could greatly reduce the average commuting time;

● Extending the bicycle paths.

5. Conclusion

The project focused on creating a sustainability assessment, with local participation, for the cities of São Paulo, Brazil and Rome, Italy. It used both MCA and SSP methodologies to analyze the indicators and data available, which was shown to be effective in bringing insights for the proposals. In fact, the MCA brought an intra-group, comparative, assessment and the SSP an overview of the indicator's ecosystem and its impacts, identifying which indicators to target in order to achieve better scores. Those better scores were also brought to light by the SSP with the comparison with the best cities to live in.

The project concludes that Rome is currently a more sustainable city, overall, than São Paulo, but both should address first the corruption problems to improve their sustainable positioning according to both MCA and SSP methodologies.

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Annexes

Table 4. Indicators before focus group (produced by the authors, 2017)

Indicators				
Corruption	**Transportation**		**Pollution**	**Criminality**
	Public	**Private**		
Corruption perception index (country)	Average commuting time per person per day [h / (person*day)]		CO2 emission per capita per year [kg / (person*year)]	Number of recorded crime per 100.000 Population
	Distance Traveled per Capita per day by Mode of Transport [km / (person*day)]		Ambient Concentration of Air Pollutants in Urban Areas* [µg /m3]	Number of recorded homicide per 100.000 Population
	Internet and Cellphone lines per 100.000		PM10 daily average concentration [µg /m3]	Number of rapes per 100.000 inhabitants
	Transport price representation of minimum wage	Average price of gas	Waste production per capita per year [kg / (person*year)]	Number of thefts per 100.000 inhabitants
		Number of cars per 1.000 inhabitants		Number of stolen vehicles per month

Table 5. Indicators data for São Paulo city (produced by the authors, 2017)

São Paulo data				
Corruption	**Transportation**		**Pollution**	**Criminality**
	Public	**Private**		
40 (Transparency International, Brasil, 2017)	118 (FecomercioSP, 2015)	104 (FecomercioSP, 2015)	1.500 Kg COeq per capita (Rede Social Brasileira por Cidades Justas e Sustentáveis (RSBCJS), 2015)	4.009,21 (data for calculation obtained from SSP, 2016)
N/A	Metro 10,8% Train 3,8% Bus 31,6% Chartered Bus 1,3% School transportation 6,8% Car 41,6% Taxi 0,5% Motorcycle 3,5% Others 0,2% (Metro, 2013)		CO: 3.170 NO2: 199 O3: 182 PM10: 29 (µg/m3) (ibidem)	7,25 (SSP, 2016)
	Average wage: BRL 1.416,13(Minist ério da Saúde, 2010) Ticket price BRL 7,6 10,73%	Gasoline BRL 3,38 (1,09$)[1] Alcohol BRL 2,39 (1,09$) Diesel S10 BRL 3,16 (1,09$) (ANP, 2017)	337,749 (2011) (ibidem)	19,09 (SSP, 2016)
	18.800 bus stops and 15.000 buses (SPTRANS, 2017)	212 (Metro, 2012)	1,46% (2011) (ibidem)	1.473,14 (SSP, 2016)
	342,7 km of rail (ANTP, 2014), 519 km exclusive bus paths (CET, 2017)	32,76 (CET, 2017)	91,89% (RSBCJS, 2015)	82.830

[1] Conversion made by the authors

Table 6. Indicators data for Rome (produced by the authors, 2017)

Rome data				
Indicators				
Corruption	Transportation		Pollution	Criminality
	Public	Private		
47 (Transparency International, 2016)	42 (TomTom Traffic Index, 2016)		2.406 kg (Rapporto Cittalia 2010)	7.558,4 (Criminality in Rome, 2014)
0,98 (Italian counter-corruption authority, 2011)	Private transportation 55% Public transportation 27,5% On foot 16,5% Bicycle 1% (Annual report on quality of public services - Rome, 2014)		CO: N/A NO2: 42,8 O3: N/A PM10: 29,3 (Air quality Rome, 2015)	4,2 (Criminality in Rome, 2014)
	Average wage: 28.423,78 $, ticket price 1,66 $ (single ticket 100 min) 2,8% (Monthly commute cost, 2014)	1,71 (gasoline) 1,51 (diesel) (Fuel prices, 17/05/2017)	592,94 (Waste production Rome, 2015)	10,1 (Criminality in Rome, 2014)
	2.227 buses and trams number of stops (all media included): 8.352 (Number of buses and bus stops, 2015)	816,2 (Sustainable mobility Rome, 2014)	41,20% (Waste production Rome, 2015)	5.192,7 (Criminality in Rome, 2014)
	59 km metro rail paths, 112 km exclusive bus paths (Exclusive bus and railway paths, 2015)	20 (Cycle paths density, 2013)	89% (Connection to sewerage, 2014)	N/A

Table 7. SSP Results with upper and lower boundaries (produced by the authors, 2017)

No.	Name	Unit	Upper Boundary (Vienna)	Lower Boundary (Kobe)	Current value Rome	Current value São Paulo	Resulting lower boundary	Resulting upper boundary	Desired Outcome
1	Corruption perception score (country)	Score	75	72	47	40	40	75	+
2	Average commuting time	Minutes	N/A	80 (Ministry of Public Management, 2001, apud. Hyogo-Kobe, 2017)	42	111	42	111	-
3	CO2 emissions	kg	5500 (Wien, 2017)	2180 (Japan Center for Climate Change Actions, 2016)	2406	1500	1500	5500	-
4	Number of recorded crimes per 100'000 inhabitants [-]	Unit	12027,3 (Vienna Online, 2017)	1663 (Kobe, 2017)	7558,4	4009,21	4009,21	12027,3	-
5	Number of legal actions (regional level)	(year*100.000 person)^-1	N/A	N/A	0,98	N/A	N/A	N/A	-
6	Usage by mode: Public Transportation	% of total population	39% (Wien, 2017)	33% (Kobe, 2017)	27,5%	47,58%	27,5%	39%	+
7	Usage by mode: Private Transportation	% of total population	27% (Wien, 2017)	29% (Kobe, 2017)	55%	53,2%	27%	55%	-
14	Usage by mode: Bycicle+On foot	% of total population	34% (Wien, 2017)	37% (Kobe, 2017)	17,5%	0,2%	0,2%	37%	+
15	Air Pollution (O3)	µg/m3	57 (Augustyn et al., 2016)	N/A	N/A	182	57	182	-
16	Air Pollution (PM10)	µg/m3	21 (Augustyn et al., 2016)	7,6 (Tsunetomo, et al., 2017)	29,3	29	7,6	29	-
17	Air Pollution (NO2)	µg/m5	45 (Augustyn et al., 2016)	12 (兵庫県農政環境部環境管理局, 2016)	42,8	199	12	199	-
18	Number of recorded homicides per 100'000 inhabitants [-]	Unit	3,17 (Vienna Online, 2017)	3,6 (Kobe, 2017)	4,2	7,25	3,17	7,25	-
19	Representation of monthly commute cost as % of avg income [%]	%	3,39% (Univie, 2017; Wien, 2017)	0,44% (Shinkansen, 2017)	2,8%	10,73%	0,44%	10,73%	-
20	Average price of gasoline	Local currency per liter	1,1 (OEAMTC, 2017)	124,5 (Global Petrol Prices, 2017)	1,71	3,38	-	-	+
21	Average price of diesel	Local currency per liter	1,008 (OEAMTC, 2017)	107,9 (Global Petrol Prices, 2017)	1,51	3,16	-	-	+
22	Average price of alcohol	Local currency per liter	N/A	N/A	N/A	2,39	-	-	+
23	Waste production	Kg/Person*year	3729,32 (Wien, 2017)	332 (Kobe, 2017)	592,94	337,749	332	3729,32	-
24	Number of rapes per 100'000 inhabitants [-]	Unit	19,1 (Vienna Online, 2017)	7,23 (Osaka, 2017)	10,1	19,09	7,23	19,1	-
25	Recycling rate [%]	%	6,75% (Wien, 2017)	2,8% (Kobe, 2014)	41,2%	1,46%	1,46%	41,2%	+
26	Number of bus stops	Unit	4132 (Wiener Linien, 2014)	740 (Kobe, 2017)	8352	18800.00	740	18800	+
27	Number buses [-]	Unit	3664 (Wien, 2016)	N/A	2063	15 000	2063	15000	+
28	Number of cars per 1000 inhabitants [-]	Unit	372,5 (Wien, 2017)	412 (UUB, 2017)	816,2	212	816,2	212	-

29	Connection to the sewerage system	% of the total residents	99,7% (Wien, 2017)	98,7% (Kobe, 2017)	89%	91,89%	89%	99,7%	+
30	Number of thefts per 100'000 inhabitants [-]	Unit	341,67 (Vienna Online, 2017)	N/A	5192,7	1473,14	341,67	5192,7	-
31	Exclusive bus path	km	846,6 (Wien, 2017)	N/A	112	519	112	846,6	+
32	Exclusive rail paths	km	301,2 (Wien, 20171)	N/A	59	342,7	59	342,7	+
33	Cycle paths	km	1298 (Wien, 2017)	N/A	258	498,3	258	1298	+
34	Number of stolen vehicles per year [-]	unit	1418 (Vienna Online, 2017)	N/A	N/A	82830	1418	82830	-

Table 8. Questions of the online survey (produced by the authors, 2017)

Questions of the online survey	
Category	**Question**
Demographics	What is your nationality? Age Profession In which of those cities do you live or have lived? (More than one answer possible) For how many years? (More than one answer possible)
Categorization of S.A.	Which are the main issues of the city in which you live or you used to live? (More than one answer possible) Please, rank in a 0-5 scale the importance of each one of the following criterias for their importance on the urban sphere when analyzing life quality In which sector do you think the city where you live or you used to live needs the more improvements?
Proposition	Would you like to share with us any suggestions and/or comments?

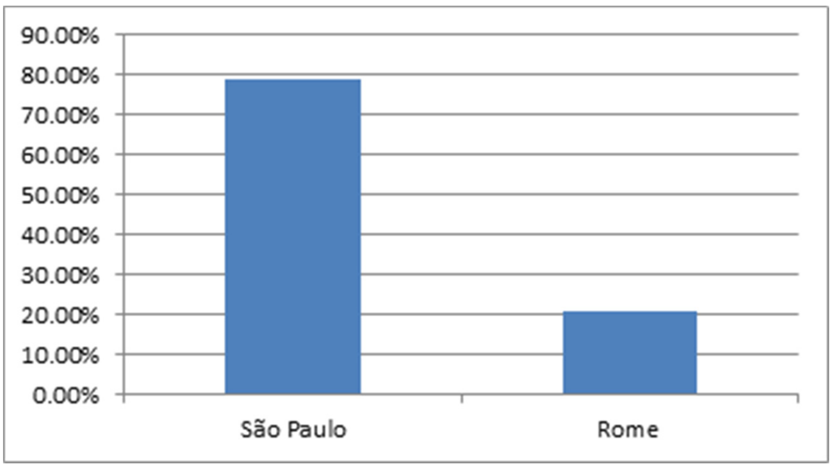

Figure 4. Survey: Cities where participants lived (produced by the authors, 2017)

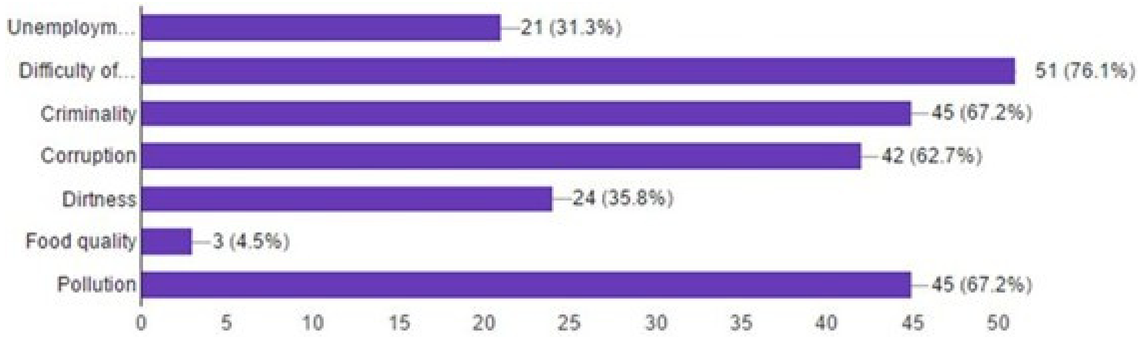

Figure 5. Survey: Main issues (produced by the authors, 2017)