Estimating the Replication Potential of Urban Solutions for Socially Integrative Cities

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1. Introduction

In the previous chapters, the topic of sustainable transition toward socially integrative and sustainable cities was widely discussed and several tools and advanced methods were introduced as useful instruments to facilitate this process. All these tools are valid aids for urban planners and decision makers in implementing specific urban solutions. Often, however, the fact that a solution is successful in a given context does not necessarily imply that it can be easily replicated in completely different ones, bringing the same benefits. Notably, successful urban solutions in Europe could face various difficulties when implemented in the Chinese context. Thus, a thorough analysis of the replication potential is required for the selection of the most appropriate solutions for any given city.

This article illustrates a new methodology for the estimation of the replication potential of urban solutions in different contexts.

In the literature, there are several tools that are commonly associated and used in support of replication,[1] e.g., technical workshops, webinars, specific knowledge transfer events, business models, cities networks and platforms for sharing knowledge. Moreover, existing methodologies for assessing the replication potential of urban solutions are based on the characterization of European Cities and their clustering into specific target areas according to a set of indicators. These methodologies are very complex, as they rely on huge amounts of data that should be made available from cities and can be excellent starting points for this type of analysis (García-Fuentesa et al. 2017). Nevertheless, what is missing is a quantitative approach able to connect the context to the specific requirements of the solution to be applied.

The novelty of this method, developed by the author and published for the first time within this book, consists in the combination of context variables of the city with features proper of the solutions that the city aims to replicate. Quantitative data and qualitative information are collected from local stakeholders and then assessed according to five specific dimensions: Socio-cultural, Institutional, Technological,

1 For example, the SmartEnCity replication toolkit, see https://smartencity.eu/news/detail/?rx_call=124 (accessed on 1 November 2020).

Environmental and Economic (SITEE replicability method). This process leads to a prioritization of solutions from the most to the least replicable based on a mathematical approach, which is a rather unusual feature among other methods.

Moreover, this multi-dimensional analysis allows the complexity of the different cities' ecosystems to be best described and understood, helping to identify the most relevant factors that may limit or facilitate replication. Cities are thus guided in the selection of those urban solutions that could be best replicated in their local context and are widely supported in the urban planning phase.

SITEE adopts a bottom-up approach, as it deals with the replication of individual measures and, therefore, does not allow the replication potential of integrated policies to be directly evaluated. However, individual measures are analysed by explicitly considering the context in which they are embedded and can thus be seen as useful building blocks towards a more systemic appraisal. Moreover, it must be pointed out that this horizontal approach can be applied to a wide range of urban solutions, from nature-based, going through technology based, including those pursuing social inclusiveness.

Furthermore, the flexibility in setting indexes and variables represents a powerful means for evaluating replicability in any local context and can produce effective results both when assessing EU measures to be potentially applied in the Chinese context, as well as the opposite case, or even when considering any other city outside Europe and China.

The first application of SITEE was carried out in the city of Wuhan, China, in Spring 2020.

From a basket of hundreds of EU eco-smart solutions, a selected group was identified matching the social integrative and inclusiveness criteria set out in one of the founding documents of TRANS-URBAN-EU-CHINA project (Müller et al. 2019), such as improving the environment and living conditions in urban areas, involving different stakeholders in collaborative and participative planning, promoting more efficient and affordable urban transport, etc.

The application of SITEE to the Chinese context might have interesting implications. China's city tier classification system can be adapted to SITEE so as to broaden and maximize the results and the impacts that can be obtained for one city, leading to the identification of a group of solutions that can be a valid option for all the cities belonging to the same tier.

A comprehensive summary of the analysis and a deep dive on conclusions and insights of the first SITEE application is provided in the final chapter of this article.

2. A New Methodology for Estimating the Replication Potential

2.1. Introducing SITEE

According to the literature, the concept of replication embodies many shades of meaning and it is arduous to find one single definition.

An extensive study published by DG ENERGY (EC DG ENERGY 2016), Directorate–General for Energy of the European Commission, connects the notion of replicability to the possibility of applying the same solution/technology implemented in a city to a different context with the aim to achieve the same objective. It states that replicability may address both:

- Scale: the extent to which a solution can adapt to the different configurations of the environment.
- Context: whether the solution can be replicated in a different environment.

More generally, replication can be defined as the application of a successful model, approach, strategy, technology, product or communication tool at the same or another location. In this regard, it is important to specify that "application" is not intended as the exact copy of the same product/solution in other contexts, but should rather be understood as an adaptation of the product/solution to a different environment or the simple inspiration in terms of ideas which lead to a different solution through the same process. Thus, it is worth identifying both the replication potential of a product/solution as such as well as those drivers of replicability that are context-dependent.

Another important point is that assessing the replication potential of urban solutions is complex, and an exclusive focus on technical aspects is not sufficient to guarantee the effectiveness of replication. It is for these reasons that, beyond the technological dimension, the socio-cultural side, as well as environmental, legal, institutional and economic aspects must be taken into account.

In other words, there is no single element that represents more than others an obstacle or an enabler to the roll-out of solutions, but it is the combined effect of all these dimensions that limits or facilitates the possibility for a project to be successfully implemented at a higher scale or in other contexts (EC DG ENERGY 2016).

In view of all this, the SITEE replicability method seeks to determine the replication potential of urban solutions in a specific context, taking into account, any local factor that could influence their applicability with the ambition to support cities in the selection of the most suitable solutions. Therefore, SITEE is based on the analysis of 5 specific dimensions:

- Socio-cultural;
- Institutional;

- Technological;
- Environmental and
- Economic.

SITEE considers the specific factors that intrinsically characterize the solution under assessment as well as the local factors relevant for the context where the solution is supposed to be replicated. Data on local context should be obtained through questionnaires addressed to institutions, stakeholders, citizens from the city targeted for replication, while specific information on the solutions should be elicited from the industrial/private entities who implemented the solutions or, alternatively, can be obtained through desk research activities and experts' estimations.

Thus, in SITEE, every dimension is associated to specific solution and context variables, listed in Table 1 below and described in-depth in the following.

Table 1. Solution and context variables in socio-cultural, institutional, technological, environmental and economic (SITEE).

SITEE Dimension	Solution Variables	Context Variables
Socio-Cultural	User interaction independence	• Population acceptance • Responsiveness to population needs
Institutional	Public–private cooperation	• Responsiveness to institutional priorities • Responsiveness to institutional needs
Technological	• TRL [1] (or SRL [2]) • Interoperability/standardization level	• Interest from research/industry/private sectors to invest • Integrability in the existing infrastructure (hardware/software)
Environmental	$CO2_{eq}$ reduction	Legal viability
Economic	• Investment costs • Operation costs • Revenues (or savings)	• Weighted average cost of capital of the city

[1] Technology readiness level. [2] Solution readiness level.

Before going through the rationale behind the method, an overview of the expected outcomes is fundamental and helpful to clearly understand the ambition and the wide application potential. The following figures (Table 2 and Figure 1) give a first comprehensive overview of how SITEE works.

Table 2. SITEE expected results—overall replicability potential. Source: Table by author.

	Socio-Cultural Replication	Institutional Replication	Technological Replication	Environmental Replication	Economic Replication	Overall Replication Potential
Solution 1	?	?	?	?	?	?
Solution 2	?	?	?	?	?	?
Solution 3	?	?	?	?	?	?
Solution 4	?	?	?	?	?	?
Solution 5	?	?	?	?	?	?
Solution 6	?	?	?	?	?	?

Given a certain number of urban solutions, the method calculates the corresponding replication potential (%) for every single dimension (Table 2). The five values obtained are then averaged[2] to get the overall replication potential of that given solution in the specific context (e.g., city, district, etc.) under assessment, leading to a ranking from the most to the least replicable solutions (Figure 1).

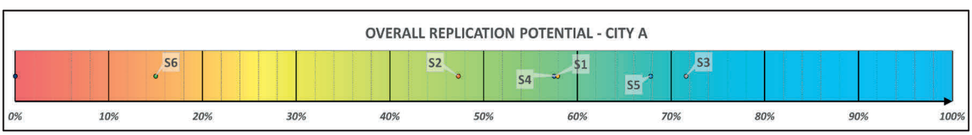


Figure 1. Solutions ranking. Source: Figure by author.

In this way, cities are supported in the selection and identification of those urban solutions that could be best replicated according to the socio-cultural, institutional, technological, environmental and economic factors proper of their local context.

2.2. The Approach

Replicability is, thus, the result of specific assumptions and intricate correlations among several dimensions and numerous variables.

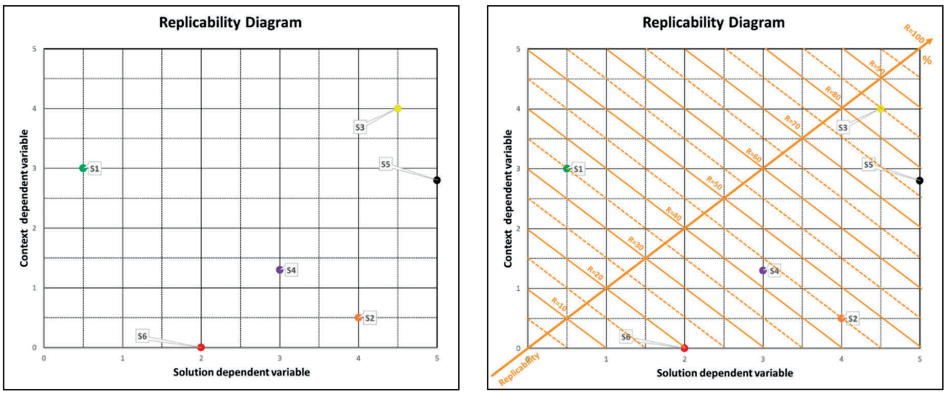
The mathematical approach adopted in SITEE makes it possible to break down this complex analysis into multiple elements that can be easily understood and graphically displayed through cartesian diagrams whose variables are dependent both on specific factors proper of the solution (horizontal axis) and on local factors

[2] Simple or weighted average.

relevant for the context (vertical axis). Accordingly, every solution can be represented as a point in the diagram (Figure 2a).

To establish a correlation between solution variables, context variables and replicability potential, a third axis is introduced (Figure 2b). The intersection between the points representing the solutions and the iso-replicability lines (diagonal lines in Figure 2b) determines their replication potential, expressed on a scale 0–100%.

This approach is likewise applied for every SITEE dimension.



(**a**) (**b**)

Figure 2. Replicability diagrams: (**a**) context–solution; (**b**) context–solution–replicability. Source: Figure by author.

2.3. The Sample

For the sake of simplification, six urban solutions have been chosen in order to conveniently illustrate the basic functioning of the method (Table 3)[3]; therefore, the quantitative figures considered in the following are just fictitious numbers used for explicative purposes.

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[3] All these urban solutions are just general examples, with no direct reference to social integration or specific relevance for the EU–China analysis that will be carried out. The only purpose is to facilitate the comprehension of the approach. In the test phase, the analysed measures have been selected according to their relevance for social integration and inclusiveness.

Table 3. Urban solutions.

Code	Solution	Notes
S1	Bike Sharing	Station based bike sharing system
S2	District Heating	Combined Heat and Power + District Heating Infrastructure
S3	Efficient Lighting	Substitution of high-pressure sodium-vapour lamps with high performance LED lamps in the public lighting system.
S4	E-Mobility Infrastructure	Electric charging stations for E-vehicles
S5	3D City Platform	3D city models are digital models representing different urban areas. They support presentation, exploration, analysis, and management tasks in a large number of different application domains. In particular, 3D city models allow "for visually integrating heterogeneous geoinformation within a single framework and, therefore, create and manage complex urban information spaces." (Döllner et al. 2006)
S6	Automated Vehicles	This solution is taken as example of innovative products not yet market-ready.

2.4. Socio-Cultural Replicability

The socio-cultural replicability is assumed to be dependent on the degree of interaction with citizens, that are intended as the final users and beneficiaries of the solution (EC DG ENERGY 2016). A solution that does not require any active role from the population is more likely not to encounter any cultural roll-out barriers. In other words, the higher the level of interaction required, the higher the chance of facing risks in the replication of the solution.

Moreover, the social acceptance of the solution as well as the extent to which it responds to the population needs represent two important factors affecting replicability.

According to these assumptions, the socio-cultural replicability diagram depends on the following variables (see Figure 3):

- *User interaction independence (horizontal axis)*: It is an intrinsic characteristic of the solution and does not vary if the context changes. This indicator can assume values from 0, active involvement of the users, to 5, passive involvement. The more the solution requires active participation of the users to work, the higher is the risk that it would not work as expected and, consequently, the lower is the replication potential.

- *Population acceptance and needs (vertical axis):* This variable takes into consideration both the degree of acceptance of the solution as well as the extent to which it is needed by the population of the specific city under assessment. The higher the "needs" and "acceptance" levels, the higher the socio-cultural replication potential is.

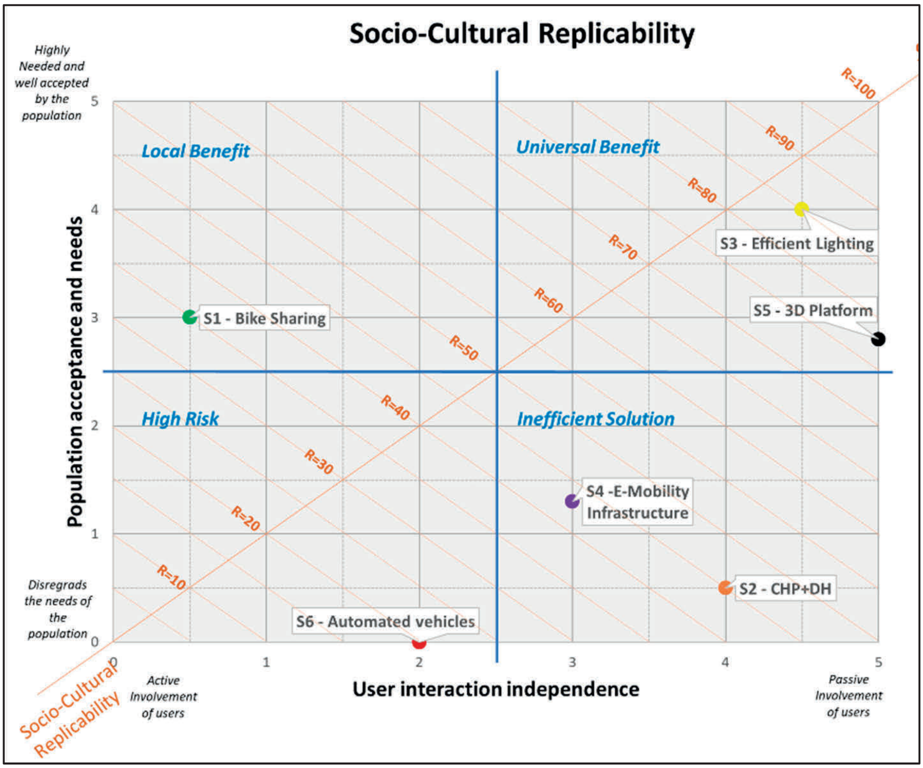

Figure 3. Socio-cultural replicability. Source: Figure by author.

The examples reported in Figure 3 clearly reflect this rationale: it is evident that bike sharing requires active involvement of citizens, notably people should use the service so that it works. For these reasons, the horizontal value is low (x = 0.5). On the other hand, efficient lighting can be considered a passive solution as it is completely independent from the interaction of citizens (x = 4.5). In this example, vertical values are randomly assigned as they may vary city by city (see Table 4—*Y*-axis).

With all these assumptions, it is thus possible to calculate the socio-cultural replicability of the solutions taken into exam (Table 4).

The results in Table 4 show how efficient lighting is the solution with the highest socio-cultural replicability potential, while automated vehicles present the lowest values since they are not needed nor well accepted by the population of the hypothetical city considered in this example (low y-values) and, as in the case of bike sharing, would require people choosing this mean of transport (low x-value).

Table 4. Socio-cultural replicability: inputs and results. Source: Author's estimations for testing the tool.

Solution	X-Axis	Y-Axis			Socio-Cultural Replicability
	Users Interaction Independence	Acceptance	Needs	Average	
Bike Sharing	0.5	*2.0*	*4.0*	3.0	**35%**
District Heating	4.0	*1.0*	*0.0*	0.5	**45%**
Efficient Lighting	4.5	*5.0*	*3.0*	4.0	**85%**
E-Mobility Infrastructure	3.0	*2.0*	*0.5*	1.3	**43%**
3D City Platform	5.0	*5.0*	*0.5*	2.8	**78%**
Automated Vehicles	2.0	*0.0*	*0.0*	0.0	**20%**

As can be seen, it is already possible to rank solutions from the most to the least replicable, but it is necessary to take into account the other four dimensions before drawing general conclusions. However, from these partial results, it is possible to get a first idea on the socio-cultural context and on the potential barriers and/or enablers to the roll-out of the solutions addressed. The same analysis can be done for each of the SITEE dimensions.

2.5. Institutional Replicability

The institutional dimension encompasses all those aspects related to the administrative and regulatory framework, also taking into account any political priority that can stem, for example, from a medium–long-term city strategy. These aspects must not be confused with financial support from public resources, which is equally important but not the objective of this specific analysis. Therefore, along with a favourable socio-cultural framework, a supportive institutional context is a crucial driver that cannot be overlooked in order to ensure the successful implementation of a solution. Additionally, the deployment of urban solutions, especially if complex, requires a firmer engagement of both public and private sectors. The more this cooperation takes place, the more replication is likely to be successful.

The assessment of the potential institutional replicability is therefore carried out according to the following variables (Figure 4):

- *Public and private cooperation (horizontal axis)*: values range from 0, public or private driven solution, to 5, public private partnership.

- *Responsiveness to institutional priorities (vertical axis)*: where high values means that the solution is highly needed by the administration and is considered among the top political priorities for the local institutions.

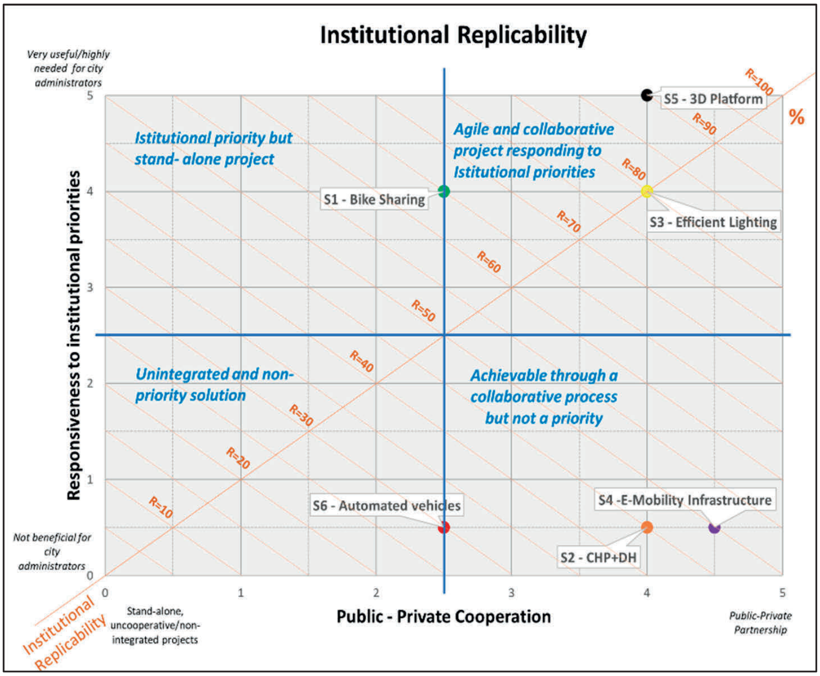

Figure 4. Institutional replicability. Source: Figure by author.

2.6. Technological Replicability

From the technical point of view, one of the limiting factors for the large-scale deployment of a device is related to interoperability issues. Interoperability is defined as "the ability of a system to work with other systems by providing services to and accepting services from other systems and to use the services so exchanged to enable them to operate effectively together" (ISO/TS 37151). This concept applies both to the technology behind the solution itself as well as to the context, which should be prepared to "receive" the solution.

However, as previously mentioned, the technological challenge is hardly ever the main barrier for the replication of an urban solution. This is even more true when the presence of a "city ecosystem" able to facilitate the deployment of projects that have been successful in another location is deeply rooted. In other terms, when industry, academia, institutional players, private businesses, etc., collaborate and act as interfaces between the projects and the social, institutional, environmental and economic contexts, they significantly contribute to the creation of the right conditions to effectively introduce, kickstart and foster the development of a specific technology.

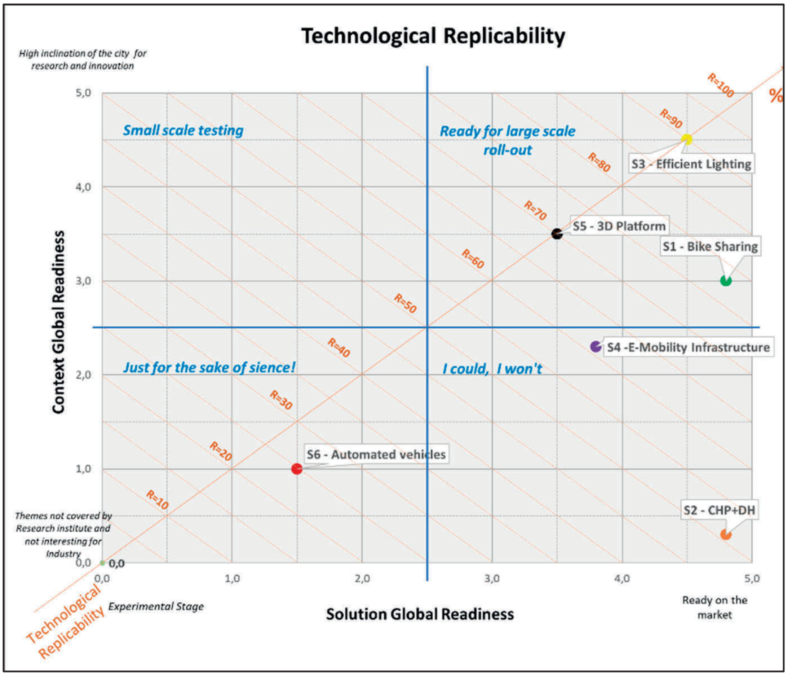

Figure 5. Technological replicability. Source: Figure by author.

Within SITEE, a broader definition of interoperability is adopted, also taking into account the research, industry and private sector communities and their interest in developing, producing and promoting a technology.

Therefore, technological replicability depends on (Figure 5):

- *Solution global readiness (horizontal axis)*: it is obtained through the combination of the TRL of the technology and an estimation of the interoperability/standardization level of the solution.
- *Context global readiness (vertical axis)*: this variable includes both the level of interests from research, industry, public and/or private sectors to invest in the technology and an estimation of the level of integrability of the solution with the existing urban infrastructure and technological background.

The higher the readiness levels of both solution and context, the higher the potential for technological replicability.

2.7. Environmental Replicability

Environmental variables often play an important role in this type of projects and constitute a crucial factor that influences decisions and might determine the choice of one solution over another. Thus, comparing the environmental impacts of several (even similar) solutions can have great leverage on potential replication and contributes to facilitate the prioritization process.

Environmental impacts aside, the legal constraints that a city is bound to respect must also be considered along with any other constraint that may hinder the implementation of a solution in a specific area of the city or limit its use cases in compliance with the local laws and regulations in force.

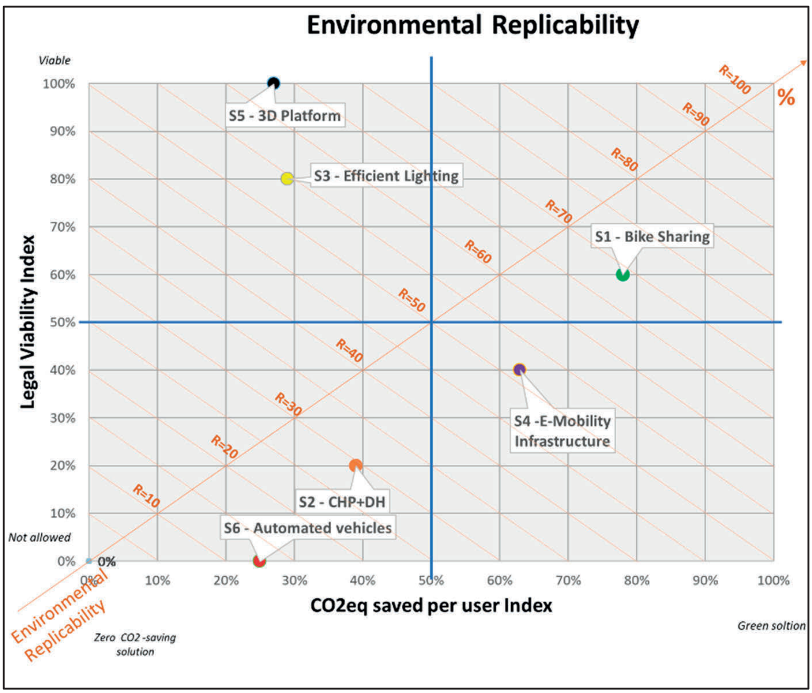

Figure 6. Environmental replicability. Source: Figure by author.

Taking both these aspects into consideration, while thinking of the potential replicability of a solution, is fundamental. It is for these reasons that the concept of environmental replicability gains an important meaning which is addressed in SITEE through the following variables (Figure 6):

- *$CO2_{eq}$ saved per user index (horizontal axis)*: absolute values are adjusted on a 0–100% scale as the calculation of replicability potential works only with ranges whose upper and lower limits are defined. Higher values correspond to greener solutions.[4]
- *Legal viability (vertical axis*): this value is the result of a qualitative estimation of the efforts required for obtaining the permit or the license for implementing a solution. This value ranges from 0, if the solution is not legally viable or can be implemented only after a very time-consuming process and big efforts so that it does not violate any legal constraint, to 5, which means that the solution is viable and minimum efforts are necessary to obtain the permits.[5]

Environmental replication is higher when emissions saved are large and legal constraints are limited.

2.8. Economic Replicability

There is no need to emphasize how economic aspects are key and decisive elements for the selection of the best solutions to replicate, especially for the city administration interests as well as from the major industry players and private investor perspectives.

A project with a positive business model that, concurrently, does not entail major obstacles from the legal and technological point of view and, in addition, brings environmental benefits while responding to the main needs of the population and institutions, is undoubtedly the perfect example of a solution to be replicated.

SITEE's economic analysis is based on the net present value (NPV) method which is a valid tool for the assessment of the profitability of projected investments. It must be made clear that SITEE is not designed to carry out a detailed cost benefit analysis, as it rather aims at providing a credible estimate of the economic worthiness of the individual solutions. A specific and targeted study is therefore necessary to evaluate the cost-effectiveness case by case.

Thus, the economic replicability diagram is built on the following parameters (Figure 7):

- *Internal rate of return* (*IRR) index (horizontal axis)*: the internal rate of return is the rate of growth a project is expected to generate.[6] A project with a substantially

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4 $CO2_{eq}$ is a valid but not exhaustive environmental indicator, so the possibility of including other environmental variables such as noise, air quality, etc., is currently in the process of assessment for the next improved version of SITEE.

5 These values are then adjusted on a scale 0–100% in order to be compliant with the requirements of the diagram.

6 Values are adjusted on a scale 0–100%, where 100% is the highest IRR calculated in the sample (rounded upward). In this way, the economic replicability potential is a relative value. This means it could change whether the package of solutions changes.

higher IRR value than other available options would provide a much better chance of strong growth. (Hayes 2020) (Ross 2020);

- *NPV/CAPEX*[7] *index (vertical axis)*: this variable takes into account the net present value of the solution in relation with the initial investment costs to be incurred. This is an expedient made to ensure comparability among solutions. The context specific dimension is provided through the calculation of the weighted average cost of capital (WACC) that is included in NPV formula and is different city by city.[8]

Economic replicability is directly proportional to IRR and NPV.[9]

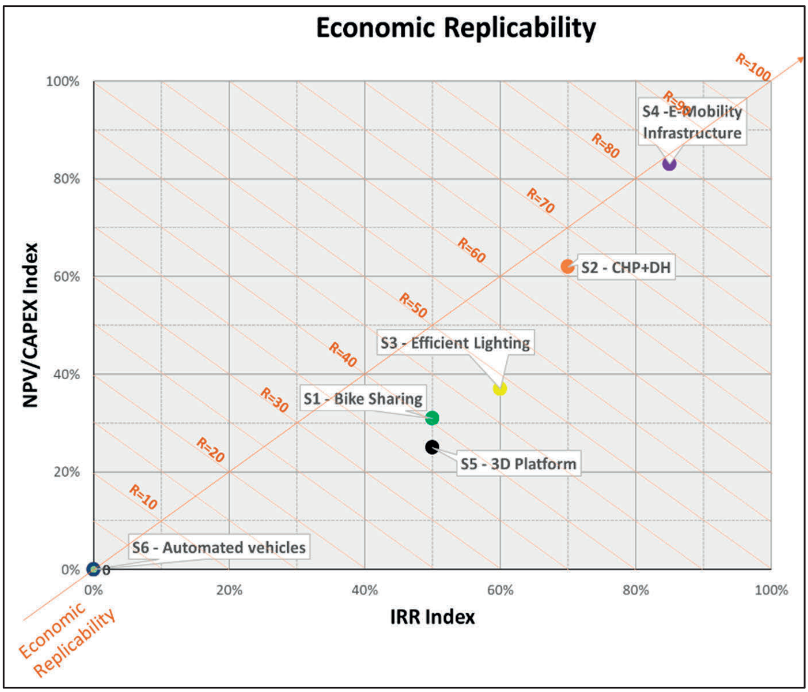

Figure 7. Economic Replicability. Source: Figure by author.

[7] Capital Expenditure.

[8] WACC is the average return rate that a company needs to earn to compensate its security holders or investors. This calculation is used to measure if a project is profitable or if it just compensates the cost of funding the project (Hargrave 2020).

[9] For equal cash flows, these two variables are not dependent on each other.

3. The Case Study in Wuhan

Within the project TRANS-URBAN-EU-CHINA, a team of experts from ISINNOVA had the opportunity to test the methodology.[10] The city of Wuhan was selected among the Urban Living Labs involved in the project and the Chinese partner Chinese Academy of Sciences (CAS) contributed as local reference and contact point of the city.[11]

The scope of the work was to estimate the replication potential of a set of European Urban Solutions in the city of Wuhan.

The results of this test have been relevant for the validation of the method and for the identification of areas for further improvement of the whole process with the ambition to build a solid and robust approach for estimating replicability that could be extended to other cities.

Testing activities carried out in this experimentation provided for:

- identification of criteria for selection of urban solutions;
- selection of urban solutions;
- calculation of the solution variables required;
- preparation and distribution of the questionnaire for collecting the context variables;
- running of the tool;
- elaboration and analysis of results with a focus on Chinese context.

3.1. Short Description of the Selected European Urban Solutions

After a dedicated selection process, which kept into account different criteria including several characteristics of social integrative cities (Müller et al. 2019) and some priority areas identified by the city of Wuhan (Aune et al. 2018)—see Figure 8—nine European eco-smart urban solutions have been selected from a rich database of more than a hundred (Table 5).

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10 ISINNOVA, is an Italian independent research institute (Website: http://www.isinnova.org/), partner of TRANS URBAN EU CHINA project.

11 CAS is the national academy for the natural sciences of the People's Republic of China, partner of TRANS URBAN EU CHINA project.

Fields of actions to promote **social integrative and inclusive cities** (D6.6):

1. Reducing urban sprawl and promoting well-balanced land conversion from 'rural' to 'urban' and appropriate access to urban land
2. Involving the different stakeholders in collaborative and participative planning and design processes on the different politico-administrative levels
3. Improving the environment and living conditions ini urban areas
4. Upgrading the physical environment in distressed areas
5. Promoting efficient and affordable urban transport
6. Assuring equal access to municipal services
7. Strengthening the local economy and labour market
8. Strengthening (technical and social) innovation in cities and neighbourhoods opening up new possibilities for the local population
9. Fostering proacitve education and training policies for children and young people in disadvantaged neighbourhoods
10. Preserving cultural heritage and fostering the identity of neighbourhoods and their inhabitants
11. Fostering social capital and engagement of local stakeholders
12. Supporting adequate institutional and financial conditions and mechanisms

Priority Areas identified for the UN-HABITAT and WLSP competition (D5.2):

A. Improving and innovating urban public spaces
B. Revitalization of waterfron spaces
C. Revalorizing industrial heritage
D. Socially inclusive and compact inner-city centres
E. Creating new tourism destinations

Figure 8. Criteria adopted for the selection. Source: Figure by author.

Table 5. Short description of the nine EU urban solutions selected.

Solution and Short Description	EU City
S1—Shared Mobility Agency [1] Set up of an Agency that provides a wide range of mobility services able to comply with the needs arising from different demand segments. Integration of **sustainable and more inclusive transport modes** with Public Transport and reduction in the use of private vehicles. Ensuring access to different mobility services to a **broader range of citizens and tourists.**	Elba (Italy)
S2—Public e-bike system [2] Introduction of innovative biking systems and green vehicles, also accessible for the physically impaired. Provision of an integrated smart card and information on service available through digital kiosks and a Mobility App. This measure ensures **equal access to e-bike services for all citizens categories**, taking into account also the needs of **physically impaired people, thereby fostering social inclusiveness.**	Las Palmas (Spain)

Table 5. *Cont.*

S3—Citizen PV Power Plant [3] A simple, profitable and secure option for interested people to participate in renewable energy development. Main concept: to sell solar panels to those citizens unable to install them due to their lack of rooftop space and let the electric company plan, build and operate the solar power facilities. Consumers operate as an energy provider, with a profitable business model, selling energy to the grid and earning revenues. Fostering **social capital investments and engagement of local stakeholders, supporting social integrative and inclusive concepts.**	Vienna (Austria)
S4—Green credits scheme [4] Encourage citizens to adopt more sustainable lifestyle patterns by providing tangible economic rewards. Public transport users will accumulate points as rewards for using sustainable modes of transport. These points can be monetized to purchase products and services in several places: shops, museums, theatres, etc. This scheme will substantially contribute to the reduction of greenhouse gas emissions while **strengthening the local economy and labour market.**	Las Palmas (Spain)
S5—BigBelly [5] Innovative approach to waste collection. It deploys smart, solar-powered, sensor-equipped waste and recycling stations that communicate real-time status to collection crews to enable efficiencies. Each unit communicates its real-time status and notifies crews when it is ready to be collected. This streamlines waste management operations, increases productivity, and keeps public areas clean and green. Improved living conditions in urban areas: this smart waste system eases logistics, declutters the streetscapes, and further **enhances the community experience with improved services.**	Dún Laoghaire County [6] (Ireland)
S6—Used Cooking Oil (UCO) in urban waste collection truck [7] Integration of the full Used Cooking Oil (UCO) to biodiesel chain. Expansion and improvement of the UCO collection system: new collection points are introduced involving smart sensors at UCO collection containers, monitored through a web-based platform. A platform allows real-time monitoring of the oil filling level, optimisation of the collector's routes, and provides alerts for unauthorized incidents (e.g., theft, vandalism, reallocation of containers). This pilot experiment represents an opportunity to strengthen technical and social innovation in the island, opening up **new possibilities for the local population (increase employment, establish a local-based fuel supply chain).**	Rethymno (Greece)

Table 5. *Cont.*

S7—Green Label Award [8] Green Label is awarded to hotels that commit to encourage the use of sustainable mobility modes by their guests, offer sustainable mobility promotional material in their lobby, provide cooking oil for recycling as bio-diesel, offer bike rentals at hotel, promote the sustainable mobility application and require their front office employees to participate in sustainable mobility training sessions. A Tourist Mobility Card is combined with this initiative to enable visitors and residents to buy one single ticket for the duration of their stay, for all their PT transfers. This measure leads to **a more inclusive, collaborative and open community of citizens and local stakeholders supporting green and cultural initiatives in the city.**	Limassol (Cyprus)
S8—Cold Ironing [9] Cold Ironing is the process of providing shoreside electrical power to a ship at berth, while its main and auxiliary engines are turned off. Thanks to this technology, significant emissions reductions have been achieved: Antwerp Port cut CO_2 emissions by more than half and NOx emissions by 97%, while CO emissions are practically eliminated. **Refurbishing of port and industrial areas is an opportunity for boosting local economy and foster sustainable transport of goods and people.**	Antwerp (Belgium)
S9—E-buses [10] The first European all-electric bus garage, hosting a fleet of fully electric buses. In comparison to the replaced diesel buses, these high capacity single decker vehicles are more efficient by 700 tonnes of CO_2 per year and have improved London's air quality since their introduction. **This solution guarantees sustainable transport modes for citizens and tourists.**	London (UK)

[1] (Ambrosino 2018); [2] (Sitycleta 2020); [3] (Energy Cities 2020); [4] (Civitas 2020a); [5] (BigBelly 2020a); [6] Case study in Ireland here: (BigBelly 2020b); [7] (Destinations Platform 2020); [8] (Civitas 2020b); [9] (AJOT 2019); [10] (Go_Ahead 2020).

3.2. Results and Analysis

Following the selection process, the work proceeded with the research and collection of the data needed to operate the tool. Therefore, desk research activities were carried out by ISINNOVA to calculate the Solution Variables. In parallel, questionnaires and detailed documentation material on the solutions were distributed to CAS in order to obtain the information necessary to quantify the Context Variables for the city of Wuhan.

This work led to the ranking shown in Table 6 below (see also details and graphical representations in Figures 9 and 10).

Table 6. Ranking of solutions. Source: Data from SITEE tool.

Rank	Code	Solution	Replication Priority Index
1	S2	Public E-bike System	93%
2	S4	Green Credits Scheme	71%
	S5	BigBelly	71%
3	S9	E-buses	37%
4	S3	Citizen PV Power Plant	26%
5	S8	Cold Ironing	17%
6	S1	Shared Mobility Agency	16%
7	S6	UCO in Urban Waste Collection Truck	7%
8	S7	Green Label Award	2%

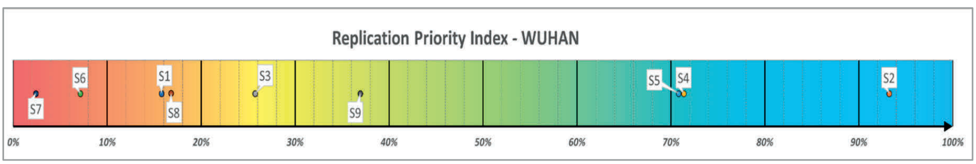

Figure 9. European Urban Solutions ranked according to their Replication Potential in Wuhan. Source: Figure by author—SITEE tool.

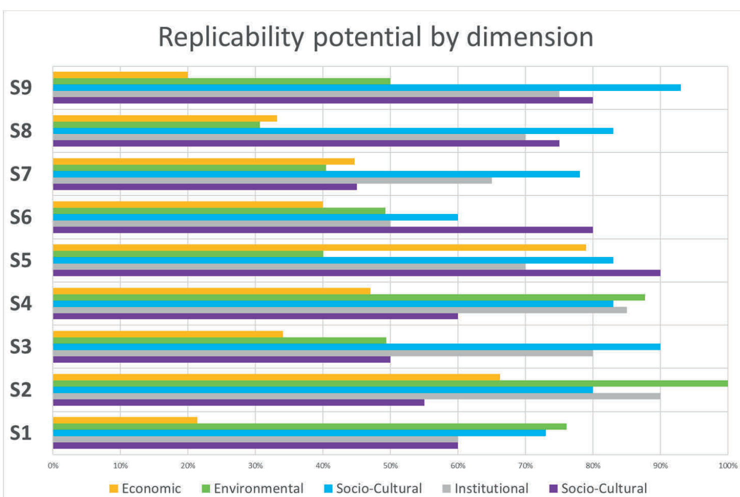

Figure 10. Replicability potential by dimension—Wuhan. Source: Figure by author—SITEE tool.

The factors behind these results are multiple and a thorough "dimensional" analysis has been carried out for each solution, with the purpose of identifying the main drivers that affect the correct and successful implementation while pinpointing the potential barriers.

A short summary of this assessment is provided hereafter for some of the solutions, while the full analysis report can be found in Deliverable 2.3 of TRANS-URBAN-EU-CHINA project (Neumann et al. 2020).

3.3. Summary of Results

In Wuhan, sustainable mobility solutions such as the Public E-bike System (S2) and the Green Credit Scheme (S4) turned out to be the most replicable as they would be grounded in a local context ready to welcome them easily both in terms of existing infrastructures, able to embed such technologies without major difficulties, and from the social acceptance point of view, as they fully meet the needs of citizens and contribute to improving the environment and the quality of their lives. In particular, according to the responses received by CAS, it was confirmed that Wuhan municipality aims to introduce eco-friendly behaviours, to raise awareness and to create affordable and sustainable incentive instruments in support of initiatives similar to the Green Credit Scheme, which could also lead to an increase in the city attractiveness for tourists.

Furthermore, making waste collection and management processes more efficient is another solution that could prove successful in Wuhan. It must be said that BigBelly system (S5) is widely spread in many cities across the world, with well-established interoperable standards that make it highly replicable regardless of the specificities of the different urban contexts. In this regard, Wuhan has already adopted a standardized system as required in other big cities in China and, recently, began to encourage collecting waste by categories in order to facilitate recycling and lower the negative impact on the environment. This solution is perfectly aligned with the current situation, because the COVID-19 residents are showing higher acceptance of measures that further improve city's environment, including innovative waste collection systems such as timely collection of medical waste from hospitals by volunteers.

It is also important to note that, although the "UCO in waste collection trucks" and the "Green Label Award" may have interesting traits that make them rather suitable for Wuhan,[12] the comparison with the other solutions makes them less adequate, albeit, with the necessary precautions, not entirely impossible to implement

[12] i.e., responsiveness to population's needs (S6 and S7), attractive technology for the industry and private sectors that would be willing to invest, etc.

nor totally to be ruled out. After all, it must be considered that the objective of this specific analysis was to identify the most replicable options starting from a portfolio of solutions that featured aspects of interest for the city of Wuhan at the outset.

Finally, it must be stressed again that the Context variables provided by the city of Wuhan were suitably combined with the intrinsic variables of the solutions analysed, therefore the final replicability value takes into account a wide variety of aspects that can strongly influence and even lead to surprising final results partially in contrast with the initial expectations of the city—as shown in Figure 11, below where, in the Context Ranking graph obtained from the questionnaire, the initial score is different from the final prioritization.

It all goes to prove how important it is that the replication analysis considers both solution- and context-specific variables in combination, making sure that the analysis is complete and reliable.

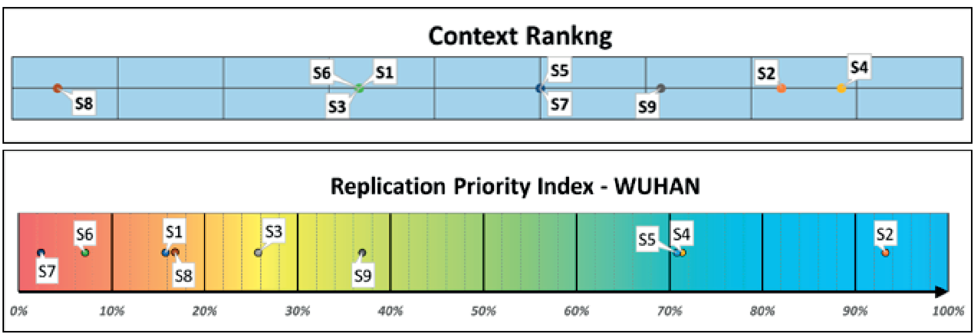

Figure 11. Context ranking and replication ranking—comparison. Source: Figure by author- SITEE tool.

4. Key Findings and Conclusions

The analysis carried out provides a good basis for drawing general conclusions both on the method itself and on potential further applications in China.

A first important conclusion is that SITEE is not only a means of prioritization of urban measures in support of decision-making process but can provide valid suggestions for improvement whenever weaknesses, that could hinder the application of potentially winning solutions, are found in the local context.

Furthermore, the application of this methodology is well suited to the comparison between cities, as crucial aspects for replication can emerge more clearly from comparative assessments.

Figure 12 shows the diverse functionalities of SITEE. As "prioritization" and "dimensional analysis" were extensively explored in the previous chapters, a relevant description is provided for the remaining functionalities in the next paragraphs.

Figure 12. SITEE functionalities. Source: Figure by author.

4.1. Gap Analysis

Beyond the dimensional analysis and its function of prioritization, SITEE is also a useful tool to detect potential gaps in the implementation of measures and could support the identification of further actions to improve and strengthen the city in areas where it is weaker so as to make it ready to take on new challenges and implement more and more innovative measures. For example, understanding the reasons for a low social acceptance of a measure could inspire the implementation of accompanying measures aimed at raising awareness, communicating and involving potential users (e.g., Green Label Awards, Public E-bike system, etc.). Or, in the case of low economic replicability, national/local financial support schemes could be envisaged for industries and companies willing to invest in research for a specific technology (e.g., UCO in urban waste trucks); or when facing bureaucracy delays in obtaining the permits, procedures could be reviewed and converted in smarter and faster processes in order to facilitate implementation as much as possible (e.g., Citizens Power Plant). Likewise, many other corrective actions could be suggested following the replicability analysis.

4.2. City Comparison

The limited scope of this test did not allow comparisons with other Chinese cities to be performed. However, it would be worthwhile and interesting to see how the assessment of the same group of solutions could lead to different results in other Chinese cities with diverse characteristics compared to Wuhan. This is possible and can be easily done in SITEE by varying the values of the context variables obtained from other Chinese cities, while keeping the solution variables unchanged.

4.3. *Potential Future Application in China*

The application of SITEE to the Chinese context might have interesting implications.

With its near-continental size, China is a country that is not easy to approach, especially because of the heterogeneity that characterizes it in many aspects, areas and sectors. Due to this complexity, Chinese cities are typically grouped into four tiers.

Traditionally, Tier 1 cities are the largest and wealthiest—often considered the megalopolis of China. As the tiers progress, the cities decrease in size, affluence, and move further away from prime locations. This means also that cities belonging to Tier 1 are directly controlled by the central government while Tier 4 cities have greater autonomy as they are county level cities.

This categorization can be adapted to SITEE so as to broaden and maximize the results and the impacts that can be obtained for one city, leading to the identification of a group of solutions that can be a valid option for all the cities belonging to the same tier.

In addition, the criteria used in the tiers classification offer an interesting starting point in the assignment of weights to the five dimensions of SITEE, not considered in this test. For example, since Tier 4 cities have a greater political autonomy, a higher weight could be assigned to the Institutional Dimension; on the other hand, the technological dimension in Tier 1 cities could be higher as they are more advanced and often host universities, important research centres and industries headquarters.

Currently another cluster classification is under development in China: the City Cluster Plan aims at creating key areas for Chinese urbanization in which cities may play different roles according to their respective positioning in the region.

In this regard, SITEE approach may help urban planners and decision makers to well identify the comparative and competitive advantages of each city in each cluster region from a multi-dimensional perspective (Wong 2019; Xing 2017).

4.4. *Connecting Cities*

Furthermore, SITEE could prove useful to connect with other European and non-Chinese cities and lead to the identification of similarities in view of possible twinning, opening a dialogue and discussing potential collaborations on issues related to sustainability and social integration. This exchange of knowledge and experiences is a fundamental step in the replication process and in the case of Wuhan, for example, the fact that two of the most replicable solutions have been implemented in the city of Las Palmas could offer ideas and inspiration on a potential twinning and lead to decisions that had never been considered before.

4.5. *Upscaling and Areas for Further Improvements*

The analysis was mainly focused on replicability. As for scalability, SITEE does not foresee a specific application but further developments are planned in that sense and could be made by adapting the multidimensional approach of SITEE to small-scale solutions to be upscaled to a wider area in the same city. Nevertheless, the high value of overall replicability along with positive scores in the economic dimension could allegedly enable the identification of highly scalable solutions.

Another potential improvement that will be implemented in SITEE relates to the Environmental dimension. Currently, only $CO2_{eq}$ emissions reduction data are processed in the tool and the possibility to integrate other relevant variables, like air-quality and noise, is under assessment.

Finally, it should be stressed that SITEE is a very versatile method which, thanks to its modular nature, allows for additional adaptations and extensions to other dimensions whenever necessary. In this regard, future investigations on how to add the health dimension will be done, and the provision of further specific metrics to better address social inclusive and integrative measures will be incorporated.

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