Sustainable Construction in the Era of the Fourth Industrial Revolution, Vol. 107, 2023, 35–44
https://doi.org/10.54941/ahfe1003090

A Smart Sustainable City Tailored to Changing Needs

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ABSTRACT

Methodology: The idea of a smart sustainable city has been developed for years. It encompasses such aspects of the functioning of a city as its user-friendliness, which particularly refers to its inhabitants, and, at the same time, efficiency as regards the use and distribution of resources and eco-friendliness, both for current consumers and future generations. Despite the increasingly common understanding of such a direction of urban development, there is an ongoing intensive search of the tools which would make it possible to collect, analyse and evaluate the solutions of creating and perfecting a smart sustainable city. The primary aim is to gather information about the expectations of city residents and the assessment of the possibility of implementing them. The basis for the considerations were literature research and an analysis of management methods and tools used in enterprises. On this basis, it was assumed that it is possible to implement these methods and tools for the management of cities and urban agglomerations.
Conclusions: As a consequence, the focus was on two tools supporting management and the concept of their use in city management was presented. It is possible to collect the proposals of implemented solutions from the users by way of systematic improvement. On the other hand, if any of them does not fulfil its role in the expected scope, the application of the Failure Mode and Effect Analysis (FMEA) may be helpful. Both methods have basically the same goal – to promote the constant development of the adopted mode of operation by introducing improvements or adjustments. The very knowledge of them is not sufficient to make decisions on the introduction of changes, though. It is necessary to analyse the causes for which the current arrangement must be modified.
Recommendations: It is postulated to implement these methods after their preparation in an IT form, so that they are available on various mobile devices. This will allow for broad access to obtaining information from users of the agglomeration, i.e., people who are interested in improving urban spaces.

Keywords: Smart sustainable city, Continuous improvement, FMEA

INTRODUCTION

We live in dynamic times, marked by the high turbulence of the environment, which affects the kind and level of our needs. These changes concern not only the economic life, but also the environment we function in day by day. Most of us – people – live in cities (UN World Urbanization Prospects., 2011). This is where we work, learn and often live on the permanent basis. That is

why this environment should be friendly to us. Now and in the future. It is thus justified to systematically monitor the needs of city users and take into consideration their observations concerning the ways of shaping these places.

THE CITY AS USER-FRIENDLY SPACE

Depending on the point of view, the city can be defined in a variety of ways. The concept is understood differently by urbanists, economists and social scientists. From the perspective of managing the city and the goal we set in this context, we can to a large degree agree with the definition formulated by the European Charter for the Safeguarding of Human Rights in the City. As the fundamental right, it indicates the possibility of satisfying users' needs in the social, political and economic aspect because cities belong to their residents.[1] It seems, however, that limiting ourselves to people who inhabit these spaces is too narrow an approach to its users. Every day they are visited by people who stay there during the day, taking advantage of their services and facilities, but who are not their dwellers. These groups include broad masses of students attending urban schools and people who work in the city but live in its outskirts. On the one hand, they expect the conditions that will allow them to ensure individual success; on the other hand, it is them that contribute to the city's success.

The perception of the city through the rights of these citizens is consistent with the definition of the European city concept (Siebel, 2000). It focuses on the political-social-economic community, based on numerous interactions among urban dwellers. What is particularly important is the fact that the economic criterion is not the only one considered in the context of city management. It is emphasized that the norms and principles of European culture must be maintained and followed. This especially refers to the rules of action consistent with the assumptions of sustainable development (Macełko, Urbisch, 2015). However, it requires the active involvement of the users of urban space (Billert, 2012).

According to one of the approaches found in the existing body of literature, the city is seen as smart, when formal leadership and grassroot initiatives can be integrated and synchronized in a single urban organism with the application of state-of-the-art technological solutions (Ben Letaifa, 2015). The development of such cities is aimed at increasing the quality of life of their users, also in the context of the natural environment, the security of functioning in urban spaces and the sustainability of this development. All these elements should be based on the centrally controlled and monitored technological infrastructure (Kumar et al., 2020), also in the aspect of data collection and the analysis of information obtained from the residents.

The idea of a smart sustainable city has been developed for years (Colldahl et al., 2013; Al-Nasrawi et al., 2015; Bibri, Krogstie 2017 b, c; Höjer, Wangel, 2015; Rivera et al., 2015; Kramers et al., 2016). It is usually used to

[1] Cities belong to all their residents. Everyone must be able to find the conditions for achieving fulfilment from a social, political and ecological point of view, while assuming solidarity duties. Local authorities foster respect for the dignity and quality of life of their residents. [https://uclg-cisdp.org/en/news/european-charter-safeguarding-human-rights-city]

describe a city which functions with the support of advanced information-communication technologies, which cooperate with urban systems, and relations between them, aiming to ensure the high quality of life to citizens, at the same time taking care of sustainable development for future (Bibri, Krogstie, 2017a).

The concept of a smart sustainable city involves aspects such as user-friendliness, which especially concerns residents, and efficiency as regards the use and distribution of resources and environmental performance, both for current consumers and future generations. Despite the growing understanding of the significance of such a development of cities, tools for collecting, analysing and evaluating smart sustainable city solutions are still being sought intensively. One of them could be Quality Function Deployment (QFD) (Motała, 2021). It is especially aimed at gathering information about city users' expectations and assessing the possibility of implementing them. There should be constant improvement and overcoming difficulties that occur on the way in a smart sustainable city. In obtaining information and analysing it in this respect, other methods and tools usually used in organization management may appear helpful.

IDEAS FOR ENHANCEMENTS AND IMPROVEMENTS IN THE FUNCTIONING OF CITIES

Information that helps to improve the functioning of a smart sustainable city can be gathered with the application of tools which are usually used for such tasks in the process of organization management. As regards ensuring the increase of the user-friendliness of cities, Constant Improvement (CI) and Failure Mode and Effect Analysis (FMEA), tailored to the specific requirements of urban space users, are proposed.

Systematic improvement is a process aimed at constantly increasing the quality of offer for city users. It means continuous work on improving solutions that serve this purpose. The outcomes do not have to be significant; instead, in the case of CI, we expect slight, but constant changes, implemented on the basis OF the suggestions of people at whom they are aimed (Singh, Singh, 2015). It is necessary to get in touch with them and gather detailed information about their expectations.

There are three kinds of space within urban areas – private (flats, gardens), social (places belonging to specific small groups) and public (available to all users). The improvement of cities, based on the cooperation of urban administrative bodies and city users, takes place in social and public spaces. The former have a certain degree of autonomy and not all solutions that are introduced there have to be subject to broad consultation and require the consent of management entities. What is the exception are the improvements affecting the users from outside a given social space. Changes in public spheres should be supported by a wide group of users. It is obvious that not all of them will always agree to implement proposals, for example, due to diverse local or individual interests.

The number of areas subject to potential improvement is basically unlimited. However, they can be categorized to a certain degree if they are analysed

with respect to the use of tools normally applied for seeking potential spheres for improvement. Constant improvement is usually focused on perfecting processes (Bhuiyan, Baghel, 2005). The city, as a place where large numbers of people stay every day, pursuing their objectives with the use of various resources, is the venue of numerous processes. They can be grouped and discussed from the perspective of two criteria – the kind of process and its user. Processes undertaken in the city, as a public place, concern satisfying basic social needs (Gaweł, Szafranek, 2018) – a safe place to live, convenient transportation, access to everyday items, as well as leisure and entertainment. Such a division may serve as the criterion for grouping processes implemented in urban spaces, at the same time indicating the directions of possible perfections in the context of constant improvement.

The users are the second proposed criterion. Depending on the adopted level of detail, it is possible to carry out often very precise divisions. It does not seem justified, though. With reference to gathering information, we should focus on the groups of people using the same areas. They can be understood strictly spatially, as parts of the city, housing estates, parks, etc., or they can be seen as a type of the area used – schools, kindergartens, car parks, shopping malls, etc. The local rather than process-based approach tends to use a failure mode and effect analysis. It is assumed that we will identify and eliminate faults and deficiencies, both those that have already occurred and the potential ones (Stamatis, 2003). If the same spaces are repeatedly used, it is easier to recognize emerging errors and suggest the ways of removing them or minimizing their consequences. The goal of FMEA is the achieve the maximum satisfaction of city users, which usually means the high quality of offer, by way of the reduction of recognized and anticipated problems and through lowering the risk of failure of undertaken actions (Subriadi, Najwa, 2020).

OBTAINING INFORMATION

A large number of product or process users see their faults or are able to indicate the ways of improving them. It is absolutely understandable as it is those who have contact with these products or processes on a daily basis who know the specific nature of products and processes best. While obtaining information in small spaces, such as organizations, it is possible to gather a large amount of it in a relatively short time and in a systematic manner. It is a lot more complicated to do it in the area of a city. Specifically, when the initiative from city users rather than getting answers to questions is expected.

What is an effective way of gathering data is the establishment of contact by the managers of metropolitan areas with the representatives of different social groups, acting as organized smaller communities in districts or housing estates. One of the methods to obtain information from a wide group of city users is the implementation of various tools used in social participation in urban management (Foster-Fishman et al., 2009). Broadly defined participation involves the activation of city users both in an organized and unorganized way. Each person has the right to and possibility to submit comments and participate in the discussion on potential changes. Consequently,

the directions and ways of changes are proposed by citizens, while the role of the authorities is to regulate the scope and manner of their implementation and the organization of the process of introducing modifications itself. Owing to such an approach, people get freedom to participate in the decision-making process and the creative ideas and knowledge of interested people can be utilized (Castelnovo et al., 2016).

The use of continuous improvement (CI) and failure mode and effect analysis (FMEA) requires a specific way of collecting data. It means not only indicating the idea for improvement or the emerging failure, but also the specification of the place it concerns and the stakeholders connected with this activity. In the case of CI, it is necessary to prepare the concept of modification, covering the scope of changes, the proposal of the manner of implementation and, first of all, potential beneficiaries and the benefits they get. The accuracy of the use of FMEA consists in the identification of the fault or imperfection, indicating its location and its implications, both in the context of utility and social scope, i.e., the number of people that may suffer. It is necessary to gather data from city users and transform them into comparable data, although it does not constitute the end of analysis. A decision to implement changes and use resources to remove deficiencies requires examining the justifiability of their introduction and the causes of their appearance.

THE IDENTIFICATION OF CAUSES AND EFFECTS

In order to identify the causes of deficiencies or come up with the proposals for improvements, we should not only prepare their catalogue, but also reflect on their origin. What is a tool that enables even an extensive and in-depth analysis is Ishikawa diagram (Prayudha, Harsanto, 2020). The diagram is a quantitative tool which can be used in a variety of fields. Factors are grouped into a few categories; most often, it is assumed that they are divided into people, methods, machines, materials, measurements and the surroundings, although this distinction may differ in the literature, depending on the subject of analysis (Luca, 2016; Rodgers, Oppenheim, 2019; Botezatu et al., 2019). If we adopt the classical division, the following categories should be identified:

- People – all city users,
- Methods – the way of the process implementation or the manner of execution of an element (procedures, principles, regulations, etc.),
- Machines – what equipment is needed to introduce improvements or eliminate imperfections,
- Materials – what materials are needed to introduce improvements or eliminate imperfections,
- Measurements – how to measure the quality of the process or of the examined element,
- Surroundings – the conditions in which the process is implemented or the element is used.

For the complete identification of a proposal or problem, it is also justified to include such categories as:

- Implementation capacity – how complicated the application of the proposed solution will be (it will be necessary to take into consideration the inconvenience to city users caused by its implementation and comparing it with potential benefits),
- Environment – will the proposed solution be in line with taking care of the sustainability of the natural environment.

The analysis with the use of Ishikawa diagram does not only help to prepare a detailed list of causes of imperfections or identify the origin of improvement proposals. It enables seeking solutions also at the level of distinguished elements rather than limiting oneself to the scale of the whole examined issue. As a result, they will be able to be used for the selected groups of users, processes or analysed elements. This will significantly facilitate the implementation of improvements or adjustments because they concern a narrower group of issues under consideration, which makes them easier to accept. What is more, a consent to implement them is easier to reach and the cost is lower. It also enables a group of interested parties to spread the implementation of changes over time. If we avoid revolutionary changes, they will be easier to accept and finance. At the same time, city users will be given more time to adapt to changing conditions.

Owing to the preparation of a detailed list of changes in various fields, we will be able to accurately identify people, devices and materials needed to implement them. Consequently, it will be possible to calculate the costs of implementation, which, in turn, is one of the areas of estimating the level of significance of implemented modifications.

THE IDENTIFICATION OF SIGNIFICANCE OF MODIFICATIONS

Financial calculation is the most common measure of the significance of innovation or adjustments. On the hand, it may be seen as the estimation of benefits that could be obtained by city users thanks to the improvement of the analysed solution. On the other hand, losses arising from the functioning of imperfect solutions are estimated in comparison with the cost of eliminating them. In each of these situations, the lowest possible cost matters. It is a rational approach, which, however, is not always the right one.

The city, as a community used by a large number of people with highly diverse needs, should meet the expectations of the broadest possible group of users. It is obviously impossible to satisfy them all. However, the implementation of minor changes, resulting from the analysis based on Ishikawa diagram and the information obtained owing to social participation, allows us – having in mind the limitations always present - to tailor them to the current needs in the optimal manner.

In order to check whether a given solution is worth consideration, ABC analysis, based on the Pareto principle, can be applied. It assumes that the improvements or adjustments classified in group A are worth attention because they will bring the best effects. What should be discussed here are the evaluation criteria. The classical approach can be used, i.e., if the modification generates relatively big benefits (perfections) or significantly reduces

costs (imperfections) as compared to the other considered ones, it should be taken into account. However, in the case of an analysis referring to the city, which is a place under a number of different influences, such an approach will be insufficient.

ABC analysis has a quantitative character, so it can use categories that enable us to identify variables in an evaluative/numerical manner. The factor worth consideration is the number of users who will take advantage of the solution in question. In this case, percentage rather than numerical criteria should be applied because this will allow us to establish the actual number of people who will use the solution.

Another significant category in a sustainable city is the long-term effect on the environment. We may thus consider the level of a positive environmental impact, e.g., in the context of air pollution or water conservation. In the former case, there may be ideas connected with planting, using alternative sources of warmth and energy, or the reduction of exhaust gas emissions. The latter involves aiming to create small water reservoirs in urban areas, eliminating hard surfaces in favour of permeable ones, taking care of maintaining wetland, or planting again, thanks to which vegetation collects excess water. The above solutions should be analysed by checking the relation of the cost of implementation to their direct effect, calculating the cost per time unit. The lower it is, the more effective the solution will be.

IMPROVEMENT IN THE SMART FORM

By perceiving the city as a form of community of its users, we assume that they have an influence on its development. In our pursuit to shape cities as sustainable entities, we should take into account benefits both to their current and future residents. If we consult the users about solutions of this type, we will probably obtain very precise proposals that can be applied at a small scale because in such a situation most of us – people – look at the area in which we function on a daily basis. At the same time, there is a growing awareness of the influence of city users' activity, which stimulates a search for solutions which are in line with environmental protection. Along with being sustainable, cities should also be smart. This means that they should use available technologies in the best possible way.

Table 1. A list of data collected online with regard to improvement proposals (Author's own work).

Improvement proposal	Where it would be implemented	Proposed details of implementation	Who will benefit from it	Comments

As regards obtaining ideas for perfecting already existing urban concepts and gathering data about their imperfections, smart solutions should also be used. The abovementioned process, which involves collecting, analysing and selecting information, can be carried out with the use of remote tools. With reference to gathering improvement proposals, we suggest a list that is

Table 2. A list of data collected online with regard to information about imperfections (Author's own work).

Error / failure / imperfection	Where it occurs	Proposed way of elimination	Who suffers consequences	Who will benefit from rectification	Comments

commonly available online, presented in Table 1, while information about imperfections can be gathered on the basis of data shown in Table 2.

Some data compared in the forms could be automatically transferred to analysis in the form of Ishikawa diagram. The users who would benefit from the solutions and those who would suffer some losses due to imperfections can be treated as factors in the category of "people". Proposals concerning the details of improvement implementations or error elimination can be put under the category of "method". Places of potential implementation or occurring failures are the "surroundings", which are taken into consideration in Ishikawa diagram. Comments written by city users who fill in the forms can also include information which can be potentially placed in the diagram.

CONCLUSION

Apart from the above, however, there are a number of data which have to be filled in from the level of the city administrators, who have a comprehensive picture of them and can access information which is not commonly available. Gathering information from city users, letting them participate in the discussion and listening to them talking about their needs can considerably raise the quality of functioning of metropolitan areas. It is the people who are directly involved in using cities that have the best knowledge of them and can indicate the most troublesome faults and the expected development directions. That is why for the city to be sustainable, its users must be heard. And if the city is to be smart and technologically efficient, we need to obtain and compare information from them.

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