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240 Resilient cities in practice

Krisztina Anna Fekete[1], Dr. Ágnes Zsóka[2]

[1]PhD student, Corvinus University of Budapest, krisztina.fekete@uni-corvinus.hu

[2]Professor, Corvinus University of Budapest, agnes.zsoka@uni-corvinus.hu

Abstract

In the focus of sustainable development, resilience is one of the main characteristics that modern and liveable city should have in the 21st century. Currently, we are facing serious global problems, including climate change, social inequalities, resource scarcity, pandemics and related healthcare system challenges, cyber insecurity, etc. All those problems are representing complex risks and require complex system solution approach. Even if Europe is not the most vulnerable region in the globe, consequences of our changing climate are significant and new challenges emerge constantly. As core components of the current system, cities represent major contribution to greenhouse gas emissions and they serve as centres of population, decision-making and institutional power. For these factors, cities have a special role in sustainable development processes. Despite a wide range of sustainability approaches and solutions, there are still plenty of obstacles that slow down the process of development. These obstacles are especially peculiar in cities, as a consequence of high population density, limited space and limited availability of affordable housing, dependency on external food supply and water supply etc. The aim of the paper is to highlight the differences between the theoretical and the practical approach in the case of closing the gap between expectations and achievable development. It follows a practice-oriented approach to examine whether a locally, well-planned complex development chain could achieve a significant improvement in the inhabitants' life, according to social, economic and environmental indicators. The purpose of the study is to provide potential good practice examples to the recent field of smart solutions, related to climate change mitigation and adaptation. Trough specific small-scale solutions the involved fields and the smart, complex system-oriented modifications and their effects will be presented. The applied methodology is case study analysis, which aims to assess the resilience of an 8000 inhabitants' settlement in Europe. Results of the paper show that with a determined, multidisciplinary, complex, solution-oriented approach an appreciably higher resilience can be achieved, by affecting different fields of challenge (such as energy sector, heating, social awareness) and simultaneously target climate adaptation and mitigation. Contribution of the paper to its field, is the approach that the analysed case represents and the evidence that even a small city'

effort can be resilient and contributes to tackling climate change and sustainability challenges.

Keywords: Climate Change, Resilience, Complexity, Small Scale Solutions, Smart Solutions

Introduction

The potential limits of both uncontrolled and sustainable growth and development have been in the focus of scientific research for decades. The potential stocks of available natural resources, the consequences of demanding human activities and, last but not least, the intensifying overpopulation put significantly huge pressure on the Earth' ecosystem and our institutions alike. Currently we are facing seventeen identified and monetarized global challenges, defined by the United Nations (United Nations, 2021), such as poverty, famine, deterioration of health and well-being, different quality of education, gender inequality, sanitation difficulties, access to affordable energy, not inclusive economic growth, inequality, vulnerability and unsustainable cities, irresponsible consumption and production, climate change, vulnerability of life below water and on land. All these problems are representing interrelated challenges. However, one of them, Climate Change, is outstanding as it has strong relationship with all the other sixteen and its impacts affect all of them. This is one of the most complex risks, that is globally observable and the perceived consequences are often independent from the origin of the emission.

According to the WEF's Global Risks Report 2020 (WEF, 2020), the Top 5 global risks in terms of likelihood in 2020 were extreme weather, climate action failure, natural disasters, biodiversity loss, and human made environmental disasters. All of these climate change related environmental risks have strong connections with social risks (such as food and water crisis, infection diseases), geopolitical risks (such as interstate conflict, state collapse), economic risks (such as growing unemployment rate, fiscal crisis, energy price shock), and technological risk, (namely IT infrastructure breakdown) (WEF, 2020). The forecast of WEF for the year of 2021 is more dispiriting, while the indirect consequences of uncontrolled climate change became even closer. However, still climate action failure is seen as the driving force of the other potential global risks, the respondents of the WEF survey noticed infection disease and livelihood crisis (probably related to the COVID-19 pandemic) as the most critical threats in a short run (0-2 years), beside extreme weather events, cybersecurity failure and digital inequality. In medium term (3-5 years), the negative economic consequences are expected such as asset bubble burst, price instability, commodity

shocks and debt crisis, combined with IT infrastructural difficulties and breakdowns. Finally, in a long run (5-10 years) serious geopolitical consequences are prognosed such as weapons of mass destructions and state collapse (WEF, 2021).

The role of climate change in shaping our future is undeniable. For appropriate mitigation and adaptation measures and actions to avoid reaching the tipping point of irreversibility, the biggest emitters are identified, their monthly/yearly CO_2 equivalent emissions are monetarised, and environmentally friendly innovations are internationally promoted. The focus from an only top-down approach has been shifted to a broader point of view, where the local, small scale innovations (bottom-up) are valued and lifted up as best practice in the international level. The need of well-designed local actions and the use of the two approaches on parallel to reach global sustainable development became globally accepted (Bulkeley and Betsill, 2003).

Although cities are representing just 2% of the Earth's surface (United Nations, 2020), they contribute to 80% to the global GDP (United Nations, 2018) and they are major contributors to climate change by consuming 70-78 % of the world's energy and produce more than 60% of the global greenhouse gas emissions, according to optimistic estimation (United Nations, 2020) which mainly stems from energy generation, transportation and emissions related to buildings (UNEP, 2021). Less optimistic estimations calculate with 75% (UNEP, 2021) or even 80% (Hoornweg, et al., 2020). Furthermore, cities, in developed and in developing countries, megacities and small cities, rich and poor ones, with high or low population density, represent more than 55% of the world population in total, which number is estimated to increase up to ~ 60% for 2030 (UN-Habitat, 2020). These facts put cities into a central position, how they could increase resilience and tackle climate change during urban development. In this paper, resilience is analysed along sustainable climate change mitigation and adaptation potential, from the perspective of a smaller Central-European city and examines how smart solutions connect and contribute to the urban development.

Our paper includes a literature review, where the role of cities and the importance and literature of urban resilience are interpreted, and the most important definitions are stated. The literature review is followed by a case study. In the chapter of Methods, the applied qualitative methodology is presented, the case study of the development projects and the investigated fields of the settlement, Tamási in Hungary. In the chapter of Results and Discussion, the accomplished developments of Tamási and the achieved improvements are presented and evaluated, from the point of view of sustainability. Finally, a summary and conclusions are given.

Literature Review – Urban Resilience

Cities are the centre of services, development, institutions and industrial activities by the potential to control resources such as natural resources, financial and human capital and act as a platform for insure flow of capital, people and information. With all of the advantages that cities could provide their inhabitants, there are significantly high risks which concentrates in these locations. Cities should enhance their resilience not just but mainly the consequences of climate change, and urbanisation, land consumption, dependence of hinterland, pollution, heat islands effect, waste and water management, housing and infrastructure capacities (Meadows, et al., 1972), (United Nations, 1987), (United Nations, 2012) , (OECD, 2010), (UN-Habitat, 2011), (Revi, et al., 2014), (Kocsis, et al., 2016), (Kovács, et al., 2017). Although, cities represent significant share in consumption of energy and production of waste, they have the local authorities, which can also control these segments (energy use, waste generations, transportation, etc.) by keeping in focus of sustainability and climate mitigation or adaptation (Angel, et al., 1998), (Collier, 1997), (Collier and Löfstedt, 1997), (DeAngelo and Harvey, 1998), (Feldman and Wilt, 1993), (Harvey, 1993), (Lambright, et al., 1996), (McEvoy, et al., 1999), (Wilbanks and Kates, 1999).

The appearance and the spread of the phenomenon of 'Urban Resilience' (UR) started in 1973 (Holling, 1973), which highlight the need of persistence in the case of human and ecology relation. The number of articles and research which was published in the last, less than 50 year in this topic was significantly lower than the parallelly developed usually gradated phenomenon 'Urban Sustainability' (US). The significant increase in the publications of UR has been started in the 2000s (Zhanga and Li, 2018). According to Zhanga and Li (2018), Table 1., the research priorities across global, regional, city, community and facilities levels of 'Urban Resilience' are different. While in the global level UR puts more focus on the self-protection and the after-crisis restoration, until then at a regional level the diversified, stable urban economic structure is the target. On the city level, policy management and institutions get larger consideration, until in the facilities level the reliability and the fast and efficient applicability of the built infrastructure are the priorities.

Table 1. Research scale of Urban Resilience.

Scale	Items	Scale	Items
Global	Ecological environment protection	Urban/city	Urban governance
	Resource protection and utilization		Urban system
	Population and health		Urban Security

Regional	Regional economic structure	Community	Residents' demand
	Regional resource flow		Neighbourhood
	Regional resource carrying capacity		Community management
Facilities		Infrastructure management	
		Transportation	
		Building	

Source: own edition based on (Zhanga and Li, 2018, p.143).

'Urban Resilience' or 'Resilience' have not had one globally accepted definition, but this phenomenon is over-weaved by disciplines and scientific fields. Two waves of the approaches could be identified. In the first one, one thing is common, the flexibility, which is needed to cope with the unexpected, the emergency recovery capabilities. In the field of **psychology**, 'resilience' is seen once as the ability to effectively cope with inner (development imbalance) and external (major losses) stresses (Werner, 1982), or "reflect the capacity for recovery and maintained adaptive behaviour that may follow initial retreat or incapacity upon initiating a stressful event" (Garmezy, 1991) or as a concept of a "combination of serious risk experiences and a relatively positive psychological outcome despite those experiences" (Rutter, 2006), (Shean, 2015).In the field of **engineering science**, 'resilience' is implemented to the system to reduce once potential failure, secondly consequences of faults and finally, the recovery time (Bruneau and Reinhorn, 2006, p. 1), (Bahadur, et al., 2013). In the field of **economics**, 'resilience' has been applied in micro, meso and macro level to internalised the motivation of private and public sector policies to contribute to the system recovery from a shock (Rose, 2004), or as a business management approach as a strategy to handle difficulties in the business flow or disaster impacts (Webb, et al., 2000) (Bahadur, et al., 2013). According to **social scientists**, 'resilience' is rooted in ecological theories, while cross- and multi- disciplinary methods are needed to adapt. This approach generated the socio-ecological system (SES), which involves both fields equally during the analysis (Folke, 2006). "Urban Resilience is the passive process of monitoring, facilitating, maintaining and recovering a virtual cycle between ecosystem services and human wellbeing through concerted effort under external influencing factors" (Zhanga and Li, 2018, p. 145). Finally, in the field of **ecological science**, 'resilience' is measured by the persistence and the ability of systems to absorb fluctuation and maintain previous status (Holling, 1973), (Hassler and Kohler, 2014).

In the second wave of the definition's development, parallel interpretations exist, which are in common by highlighting the role of uncertainty. According to (Martin and Sunley, 2015) there are three different approaches of 'resilience', which differ from each other

in reactivity and resistance (Prisi, 2019): technological, ecological and adaptive resilience. ‘Resilience’ according to the technological approach is the return to the stabile status of a system between the timeframe of the external impact and the recovery. According to the ecological approach, ‘resilience’ describes the highest possible external shock that the system can resist without any consequence or any permanent damage. The followers of the adaptive approach see ‘resilience’ as an ability to adapt to the new circumstances that occurred due to the external change. This is a shift in the past system and is hardly measurable.

Despite of the different definitions and approaches, the most common, main characteristics of the phenomenon of resilience are the following (Bahadur, et al., 2013):

- High diversity;
- Effective governance and institutions;
- Acceptance of uncertainty and change;
- Non-equilibrium system dynamics;
- Community involvement and inclusion of local knowledge;
- Preparedness and planning;
- High degree of equity;
- Social capital, values and structures;
- Learning;
- Adoption of a cross-scalar perspective.

In this article, the adaptive approach and the **IPCC** definition are followed, while they are found to include all the relevant prospects from the different fields. According to the IPCC (2014), ‘resilience’ is “the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation” (IPCC, 2014, p. 5).

Methods

The classification of a country-, region-, city- or even household-level of resilience can be calculated according to several different indices (quantitative method), such as the examination of the labour market, population density, literacy rate, education level of the dwellers, added value of the private sector and so on. In case of the quantitative analysis, the number of the applied indices are varied from one (Drobniak, 2017), or 52 (CRI, 2018) up to even 139 (Wang, et al., 2018), (Nagy, et al., 2020).

However, the adaptive resilience can be hardly measured by indices because it represents a shift in a complex system (Prisi, 2019). For that reason, a qualitative research, the case study method is applied to present the importance of resilient thinking even in a small-scale city development.

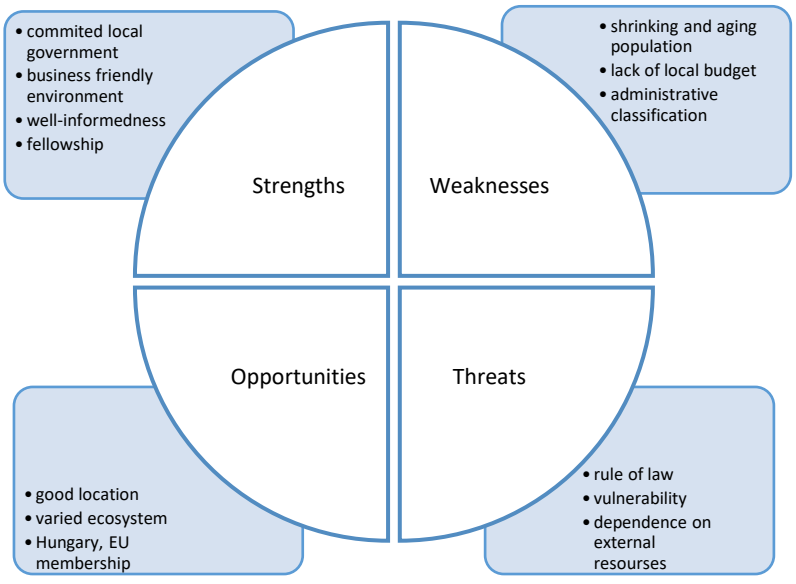
Tamási, a city in Tolna county and the centre of Tamási district in Hungary, was selected to the analysis of resilient thinking, as consequently determined city management goals and significant bottom-up developments have been set, followed and achieved in this city in the last 15 years. The local government is committed to build up a complex, interconnected city management system, which makes Tamási capable to cope with significant challenges as a consequence of social and /or environmental and economic changes.

During the analysis, the complexity and the involved fields of the adapted projects are examined. The aim of the research is to present the potential development that have been achieved through complex and resilient thinking, and to assess its features in the light of sustainability.

Results and Discussion

As a basis for the evaluation of resilient thinking, a SWOT analysis was made for Tamási.

Figure 1. SWOT analysis of Tamási.



Source: own edition

Tamási's environment has varied terrain and provides thermal spa facility, which is the base of the region tourism. It is located near to Lake Balaton and it is just one hour away from Paks, which city currently has one of the biggest investments and developments in Hungary. The local government of the city is determined to the

sustainable, climate resilient development which consider nature and social well-being beside economic efficiency, as well. The development projects usually mixed financed from either or both local, national budget and from EU funds. While, the city has shrinking and aging population, in January 2020, 7.852 dwellers in 11.195 hectares (KSH, 2020), which data determines its administrative classifications and the available resources and the projects.

Tamási as regional best practice

In Tamási, the local government sets its development projects' planning and their implementations according to three leading factors to create an integrated city management system. These factors are environmental, economic and social factors, where environmental and economic factors are inseparable from each other, and their sustainability is key during the decision-making process. The environmental awareness comes from once the local heritage and the small city status dependence, while the economic cost-efficiency, sustainability connected to the limited available resources and the common sense. In Tamási, during the last decade, an integrated city management system has been built up through relevant development projects and conscious new project implementations with the use and integration of smart technology. The projects and the management system increase the resilience and sustainability of the city (Hallegatte et al., 2020):

- by identifying medium and long-term purposes according to local abilities and needs, concluded in Tamási City Development Strategy (Dulicz, 2016) and in Tamási's Climate Strategy (Tamási Municipality, 2020);
- following their strategy, the main goals were broken down into manageable targets, development projects;
- the development projects were prioritised according to local needs (current, medium, long-term);
- during the development, the inclusivity of local dwellers has been increased;
- the "plan – implement – monetarize – intervene" steps were followed;
- the capability of immediate modification has enhanced by the integrated systems to prevent or lighten external shocks,
- efficient natural resources utilization has been adapted;
- the environmental footprint of the city has shrunk;
- the city infrastructure has been improved;
- the efficiency of the public services has been developed
- the engagement between citizens and local government improved;
- and finally the city never stops developing.

Those, previously mentioned projects, which helped to increase the resilience of the city are the following (Széles, 2017), (Széles, 2018):

The first significant project in this development was the **geothermic heating system**, which is based on the main natural, tourist attraction of the location, the use of the 47 Celsius hot, thermal and curative water. Based on this natural opportunity a heating system was established provide heating service for 17 service points in 4,7 km long. Through the integrated smart operational system the whole process is adjustable, a necessary intervention can be made in any point and during the whole operation data is collected that provide information for intermediate interventions or future optimalization. While this system used in public facilities, such as dormitories, government offices, police station etc., different heating curves are set, which fits to the need of the service points. By using the natural heat of the thermal water 70 percent expenditure saving could be achieved. The remaining 30 percent of cost, which comes from the use of gas-based heating was replaced, through another project, by using **biomass-based heating** from the locally collected green waste. Currently this heating system is only using renewable energy. Through this project, the city could increase its energy efficiency, by separating from an unsustainable energy resources and utilize its natural resource in a sustainable way by not causing any harm in it. This intervention decreased the emitted greenhouse gases, the amount of the used energy and changed the resource of it. Beside the economic advantages of the project, such as reduction in the system's maintaining and heating expenses and the reduction in green waste handling fee, the project increased the self-sufficient ability of the city by using renewable energy, which is generated by locally and by distributing the natural resource more consciously the gas consumption has dropped.

Since 2018, the locally abundant **green waste** is collected separately and its pass at the collection point is free of charge to ensure the needed biomass and the fundamental treatment of the green waste. Those who contribute to the biomass with green waste, receives extra point in the city card system, which could be transfer for discount in the local shops or for services. With this movement, the local government tried to approximate to circular economy and increase the citizens environmental awareness and engagement to the development. By the use of green waste, the number of households burning dropped, which caused better air quality and smaller air pollution, including GHG emission as well.

The next project is the improvement of the **public lighting system**, 1.445 pieces of old public lightnings were replaced by new LED streetlights, which includes SIM cards, operates online with Citytouch management system and communicates on LORA. Through this solution, each and every lamp in the grid could be controlled separately from the others, through the remote control the luminous intensity could be set, and the streetlamps could be switch on or off according to the need of different residential areas. Additionally, the system could send instant feedback about possible breakdown with the details of the failure, the location and number of the lamps. According to this push notification, the reparation can accelerate, which can increase the satisfaction of

the inhabitants with the public service. As the benefits of this project the nominal energy use dropped by 40 percent, and 20 percent drop could be achieved by the control over the luminous intensity. With this more energy efficient solution the city greenhouse gas (GHG) emission, energy usage and energy expenses decrease, the traffic-safety increases, and new administrative divisions, peripheries, received infrastructural development by installing the old lamps, which generated higher social inclusivity. This LED public lighting system provide further development potential such as installing cameras for security reason, traffic counting, traffic lights control, traffic control system to optimise public transportation, parking systems, air pollution measurement etc., but its main advantage is the network that can connect tools, collect and analyse data and become main part of the city management system. Through this, the decision-making of the location can become more valid and grounded.

Based on this project in 2017, 20 **thermometer sensors** were installed in 20 elderly dwellers' home, who were the most vulnerable for the winter stress. These sensors monitor the daily temperature in the houses and send alert if the temperature drop under a critical value. This simple service can increase the inclusion of the marginalised people, social responsibility, through the collected data the provided social services during wintertime could be optimized.

Considering the challenges of the local dwellers, an **intelligent wastewater pump** system was built, which in case of a blockage, cleans itself without any stoppage in the service. This system has been integrated and in the first year prevented almost 150 cases and up to now almost 400 cases. That is resulted a significant expenditure saving (wages, stop in the operation during fieldwork, disinfection, lower maintaining expenses, etc.) Connected to this topic, Tamási has a **smart rest room** at its main bus station, which is 100 percent accountable, sends push notifications when the fundamental tools are out of stock or immediate intervention is needed. These developments are economically sustainable, decrease health risks and related expenses. These projects serve as a good example for considering the essential need of the inhabitants and find smart sustainable solutions for them.

To further increase the energy efficiency of the city, they use **solar cells** in office – school - police buildings as part of the 'smart building' development and **sensors** for monetarize water usage and identify water leakage. During the COVID-19 pandemic, the establishment and the use of **e-administration** options have been improved and increased to ensure safety during administration.

Conclusions

The local government of Tamási sees the city as an excellent testing platform for experiments with new technologies to eliminate the early defects of the innovations and through this living lab form, the innovations and the best practices, that are

technologically developed in place, can increase the sustainability and resilience not just locally, but could be adapted by bigger and more complex cities, regions. Tamási has the essential motivation, sustainability centred attitude and the capability to take this stakeholder position.

As it is showed through the diverse development projects in Tamási, the resilience of a city can be increased by deliberate city management, complex interconnected network-based approach, involvement of the community to identify the areas of improvements, considerations of the local capacity and challenges and finally openness to learning.

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