# GIS-based Livability Assessment: A Practical Tool, a Promising Solution?

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Abstract: Livability is a complex phenomenon, describing urban quality in the light of dwellers' needs and expectations towards the urban environment. Accordingly, the conceptualization and assessment of livability have various challenges, ranging from the subjectivity of the dwellers' needs to the dynamics of urban life. The first part of the paper briefly introduces these challenges and the key elements in the concept of urban livability. As a follow-up, the rest of the paper provides potential approaches to grasp the complexity of urban quality and to handle the challenges of livability assessment. GIS has a significant role in each of these approaches, thereby the paper concludes with an evaluation of the advantages and relevance of GIS-based livability assessment. Overall, the current summary supports the hypothesis that GIS-based livability assessment implies more than a practical tool, by providing a general approach to understand and assess livability in a transferable way. Thereby livability assessment is appropriate to support urban planners in the improvement of urban quality, as well.

## 1 INTRODUCTION

Livability is a much-discussed concept in scientific research for investigating city quality (Kamp et al., 2003; Kashef, 2016; Ley and Newton, 2010; Pacione 2003; Ruth and Franklin, 2014; Veenhoven, 2000). However, measuring livability is a challenging task due to the complexity of urban environments and the subjectivity of the human perception along with the lack of a consensual definition of livability or its factors.

The notion of livability has become quite popular in the past few years, supposedly due to the so-called "livability rankings" performed by various companies and researchers (Giap et al., 2014; Kashef, 2016; Okulicz-Kozaryn, 2013). This rising interest shows the relevance of the investigation of urban quality, however, these lists are usually used rather for city-marketing purposes than the actual representative assessment of livability. The most significant limitation of livability rankings is the lack of intra-urban scale in their results and the underrepresented importance of residents' (often subjective) needs. Overall, livability rankings tend to represent the standard of living instead of actual livability (Conger, 2015; IMCL, 2011; Kashef, 2016).

On the other hand, livability as a scientific concept has much more to offer, not just by representing differences between various socio-economic groups and intra-urban scales but by providing a transferable conceptual framework also for planners aiming to improve urban quality (Brown, 2003; Conteh and Oktay, 2016; Kovács-Győri and Reinel, 2017). This means that through livability assessment, a city – or a given area within the city – can be "diagnosed" before actual planning actions take place, by providing an overview on the existing challenges and insufficiencies of various urban elements such as transportation or urban parks (Kolcsár and Szilassi, 2018; Szell, 2018; Žlender and Ward Thompson, 2017). However, because each city and its urban system is unique, the assessment should be robust and transferable to reflect the characteristics of different places adequately (Albeverio et al., 2008; Miller et al., 2013).

The improvement of urban quality – as a way to respond to various urban issues with local or global origin – is often a goal in international initiatives as well such as the Sustainable Development Goals (SDG) and the New Urban Agenda (NUA) (Caprotti et al., 2017; Costanza et al., 2016; United Nations General Assembly, 2015, 2016). However, it is often



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challenging to assess the current conditions regarding the affected population and the localization of the problems within the city. Especially, because cities as complex systems are hard to be evaluated in details (Batty, 2013). As a conceptual framework, livability can also support these endeavors of SDG and NUA by depicting the complex urban system and its components through the lens of the "person-environment" relationship (Kamp et al., 2003; Pacione, 2003). Based on Van Kamp et al. (2003) the quality of this relationship is considered as a basic definition of livability.

While livability can provide a conceptual framework for urban quality assessment, GIS makes the practical analysis possible and valuable (Onnom et al., 2018; Pacione, 2003; Yin et al., 2018). First, by using GIS, data can be collected, stored and analyzed according to thematic groups representing various elements of the urban system (e.g., transportation, public spaces, urban green). Second, the consideration of spatial and temporal aspects is crucial in urban analysis, which is, of course, another advantage of using GIS for livability assessment. Last, the visualization of the results in the form of maps can support planners and decision makers in the further steps of urban quality improvement.

To utilize the advantages of GIS in livability assessment, the concept of livability – by highlighting its key elements and potential assessment factors – should be investigated in a systematic way (Section 2). As a follow-up, Section 3 summarizes different approaches to assess and evaluate a selection of these factors, as well as their robustness and application in urban planning. Finally, Section 4 gives a synopsis of the possible data sources along with the advantages and limitations of GIS-based livability assessment.

# 2 THE CONCEPT OF LIVABILITY

This section provides an overview of the conceptualization of livability and its assessment describing the definition of livability and its key elements in the form of a conceptual framework. This framework corresponds to the first step in the complex task of assessing the livability of cities, by also considering the subjective perception of their dwellers.

## 2.1 Definition

There is no general consensus on the definition of livability. However, the various existing definitions often share some of the important characteristics, such as the quality of the urban environment in the light of the perception and expectation of the dwellers (Kamp et al., 2003; Pacione, 2003; Ruth and Franklin, 2014).

Based on Pacione (2003), Van Kamp et al. (2003) and Ruth and Franklin (2014) I interpret livability as the quality of the person-environment relationship in the urban context, concerning the needs and expectations of the residents towards the urban environment. The perception of the people profoundly influences these needs and expectations, and their personal values, thereby making the livability assessment highly challenging (Brown, 1975; Pacione, 1990; Veenhoven, 2000).

Although this general definition serves as a good starting point for any further step in assessing livability, a framework on the potential factors and their systematic assessment is still lacking.

## 2.2 Key Elements

As mentioned in Section 2.1, I consider livability as the quality of the person-environment relationship, based on what this "environment" provides and how it fulfills the needs and expectation of the residents.

In the proposed livability assessment framework, I identified the key elements of this person-environment relationship, to represent urban life (Figure 1).

The upper part of the figure describes the individual aspects regarding the dwellers' needs and values. These values usually depend on many individual factors, e.g., the length of residency, sense of place, or the degree of integration into society (Bonaiuto et al., 1999; Fried and Gleicher, 1961; Merton, 1968; Taube and Levin, 1971). Furthermore, the needs and expectations themselves can vary according to the level of development in an area. The lower part of the figure depicts the urban environment, consisting of the built and natural environment along with the infrastructure as *urban form*, whereas *urban functions* represent what this environment can provide for the citizens.

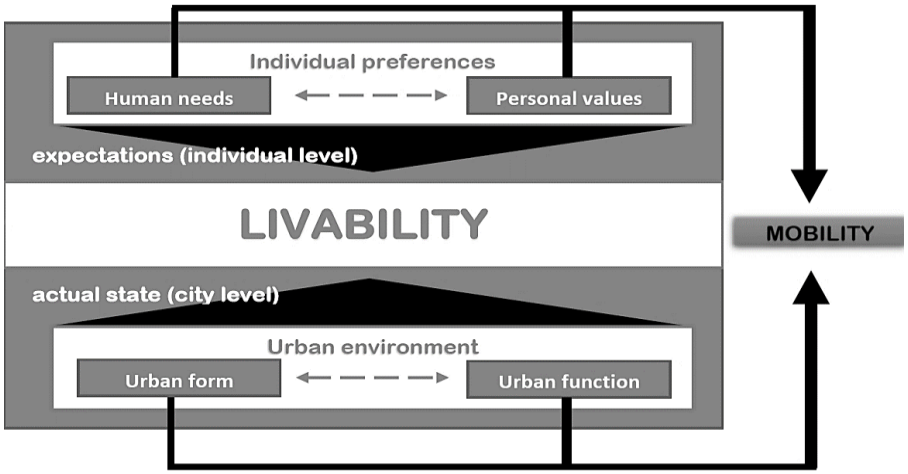


Figure 1: Key elements in livability.

## 2.3 Properties of Livability

Based on the person-environment relationship and the key elements introduced in 2.2 (personal aspects, urban form, urban functions) I identify three major characteristics of these elements – and thereby the properties of livability.

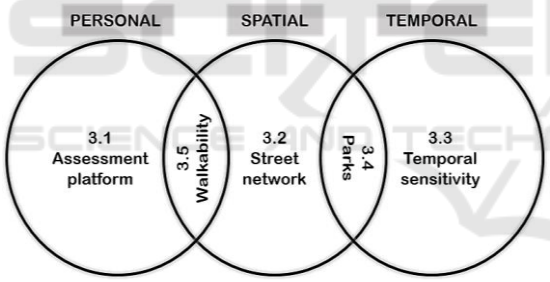


Figure 2: Use cases representing the properties of livability.

As Figure 2 illustrates, the use cases described in Section 3 reflect given livability properties to grasp the complexity of livability assessment. Thereby it is possible to focus on the important characteristics of livability in a systematic way. Similar to urban form and urban functions, these properties are mostly only separable on a conceptual level, whereas in the real urban system, they are concurrent. Accordingly, all use cases have a potential connection to all of these properties, however in each case, one or two characteristics are emphasized and the research questions along with the analysis address the given property.

- *Spatial aspects*: All livability factors and elements have spatial characteristics, either in absolute sense (e.g., location) or in a relative way (accessibility). The ubiquity of spatial aspects in the urban system is the reason why applying GIS-based methods is appropriate and beneficial in livability assessment. In 3.1 the different spatial scales are further detailed, whereas 3.2 elaborates on the details of mobility and its role in livability assessment also emphasizing the relevance of spatial accessibility.
- *Temporal aspects:* The factors and elements of livability will vary over time so it is important to consider temporal sensitivity of livability assessment (3.3). It can be done either by identifying more dynamic factors (mostly in the case of mobility and urban functions) or emphasize the temporal aspects of the residents' needs and preferences. Similar to spatial scales, we can also identify temporal scales for the factors and the analyses, which are significant for urban planning, and are discussed further in 3.4.
- *Personal aspects:* Either in the form of preference and need or perception and cognition, livability will always be a concept with high level of subjectivity, which should not be neglected in any of the analyses, but the degree to what these aspects are emphasized can vary. Therefore, personal aspects do not necessarily equal to individual preferences or perception, but depending on the type and goal of the analysis, individual aspects can be more crucial. "Personal" in this sense means that it is able to reflect the person-environment relationship to some degree. The assesment platform (3.1) and the concept of walkability (3.5) strongly considers personal aspects next to spatial ones.

# 3 GIS-BASED LIVABILITY ASSESSMENT APPROACHES

This section provides an overview of different approaches aiming to assess livability. This includes different contexts, such as online platforms, planned events or social media data, to evaluate various elements and properties contributing to livability (Figure 1 and 2).

## 3.1 Livability Assessment Platform

Existing assessment approaches often focus either on a city or a region (Antognelli and Vizzari, 2018; Conteh and Oktay, 2016; Saitluanga, 2014) or provide frameworks for ranking cities through complex indices (Giap et al., 2014; Okulicz-Kozaryn, 2013). The former group is usually quite detailed and applies GIS methods, but they often lack transferability or holistic view, thereby they cannot be directly adapted to other cities. Whereas the indices developed by the latter group often neglect spatial aspects, especially considering intra-urban differences. More importantly, most of the existing assessment platforms or rankings lack subjective aspects, or as an alternative, factors that represent the person-environment relationship, instead of merely statistical, quantitative factors, such as number of shops or crime occurrence. Using statistical factors – depending of the purpose of the assessment – is not necessarily a disadvantage, however if we consider the basic concept of livability we can see that these assessments would then reflect standard of living instead of livability (IMCL, 2011). This is a common challenge of livability assessment platforms: to represent the expectations and preferences of the dwellers' and at the same time consider spatial aspects of the measured factors.

An assessment platform developed by Kovács-Győri and Reinel (2017) attempts to overcome these challenges by providing a framework that integrates spatial and individual aspects of livability into the evaluation process. The work also summarizes a set of possible livability factors along with their assessment and possible data sources to extract them. The result is a platform where residents can be asked about their preferences regarding the livability of the environment; thereby it also supports participatory planning and research on the human perception of livability. Due to the emphasis on spatial aspects, it is important to define spatial scales for the provided factors, not just regarding data availability but also to investigate the effect of each factor on the perception of livability. There are three main spatial scales according to Kovács-Győri and Reinel (2017):

- *Fine spatial scale*: factors in this category affect people's perception only within the sight distance. Therefore, these factors also require input data with rather high spatial resolution. Factors of urban form assessment belong to this category, such as building height, shop windows, or urban green.
- *Neighborhood scale*: this category consists of urban function factors. In theory, a livable neighborhood provides all necessary functions in a relatively short distance (such as grocery shops, recreation or meeting facilities).
- *City scale*: only a few facilities are relevant on this scale, mainly those of having a higher importance in a comparison between cities (i. e. livability ranking) such as hospitals, airports and cultural facilities (theaters, museums). Also, because in the case of these facilities the functionality overrides the accessibility, mainly due to the lower frequency or higher relevance of the visit.

## 3.2 The Role of Mobility and Street Network

On Figure 1, mobility is highlighted, as an element of the livability concept that suggests higher relevance. The figure also represents that mobility has a connection with each livability element. For example, human needs and urban functions have a strong influence on the destination what one might visit, whereas personal values determine transportation mode by affecting residents' preferences. Lastly, urban form will influence the route taken by a person, due to the characteristics of the infrastructure or even aesthetics.

Another way to support the importance of mobility is to investigate livability-related planning actions performed by practitioners. The findings of NARC (Young and Hermanson, 2012) confirms that transportation-related goals and actions are more common in planning practice than in the case of any other fields ranging from policy to environment. Changes in the transportation system usually have an immediate effect on dwellers. Furthermore, they are often easier to perform (less time or resource consuming) than changes of other urban characteristics such as perceived safety or access to healthcare.

Regarding the assessment of livability, the analysis of mobility provides a way also to analyze qualitative urban characteristics quantitatively by

using data that are more "tangible" on characteristics such as accessibility. However, it does not mean that mobility should only describe quantitative features (e.g., proportion of sidewalks), because mobility analysis can reveal important aspects of perceived safety, health or even economic conditions in a city (Frank and Engelke, 2001; Gehl, 2010; Saelens et al., 2003). As an example, the quality of the environment can be assessed based on the time spent there, or the preferences of the people (e.g., the route they take, transportation mode) (Gehl, 2010; Gehl and Svarre, 2013).

Another demonstration of the role of mobility is the following example: there are two areas with a similar number (and quality) of functions, such as grocery shops. In one of these areas the accessibility of the shops is considered better, for example, they are in a 10-minute walking distance, or they are not merely accessible by car. This area with better accessibility will be considered more livable, as better functionality alone could not compensate the lower accessibility. Thereby, although mobility has a clear connection to every livability property (spatial, temporal, personal), when it comes to general livability assessment, the focus slightly shifts toward the spatial aspects, by assessing the available infrastructure and considering the accessibility of specific functions as a first step.

## 3.3 Introducing Temporal Sensitivity

Livability assessment also has temporal characteristics, as cities are dynamic systems. While an area can be considered livable among given circumstances, it is interesting to investigate how the perception of the people might change if these circumstances change temporarily. Although disasters and other unplanned events can be highly influential and usually induce a significant decrease in livability, even for a longer period, the situation might be different in the case of planned large events, such as the Olympic Games (Kovács-Győri et al., 2018). Another aspect of investigating the temporal properties of livability is illustrated in 3.4, where different temporal patterns of an urban function is analyzed.

To trace this temporal sensitivity for example in the case of planned events, the required data sources should be able to reflect fine spatial and temporal scales along with the perception of the people. Although there are limitations regarding data representativeness, social media data (particularly from Twitter) can provide information in a larger amount about the preferences and emotions of the people, with sufficient spatial and temporal resolution.

The results of the spatiotemporal analysis of the tweets during the Olympic Games in London has shown that Twitter data can represent differences in the emotions and topics of residents and tourists while tweeting. Furthermore, the sentiment of the tweets before and after the event will be different from the patterns during the Olympics. The analysis included sentiment extraction and the visualization of the results in the form of hot spot density maps to represent intra-urban differences. The workflow and the methods applied can also be used for planning purposes, by extracting information about the spatiotemporal behavior and sentiment of the visitors and residents during large planned events. Moreover, the extraction of topics from tweets was also part of the workflow, which can also be utilized by further investigation for planning purposes, such as the observation of topics reporting problems (e.g., traffic jam, service delays).

## 3.4 The Spatiotemporal Patterns of Urban Park Visits

Urban parks have a prominent role in the urban system not just by providing a place for social contact or recreation but they are also beneficial for the environment and the physical and mental health of visitors (Bertram and Rehdanz, 2015; Chiesura, 2004; Hartig and Kahn, 2016; Picavet et al., 2016). However, due to this complex role, it is often time- and resource consuming to provide a general overview of the perception of park visitors and their spatiotemporal behavior all over the city. Like the case of planned large events, Twitter data can offer meaningful insights also for this instance. It is possible to extract spatial and temporal patterns of park visits, while also considering the sentiments of the tweets, which is useful to represent the perception of the visitors for planning purposes (Kovacs-Györi, et al. 2018).

In their study, Kovacs-Györi (2018) used over 11 million tweets along with polygons representing urban green extracted from OpenStreetMap, to analyze the spatiotemporal patterns of park-related posts and the users who posted them. Based on the temporal frequency of a user's tweets, the authors identified potential residents. After the preprocessing steps, the spatial analysis involved the measurement of the average distance between a Twitter user's main activity center and a tweet posted from one of the identified urban green areas. Then content analysis was performed by using a dictionary and assigning

sentiment scores to each word in a tweet. Furthermore, using a similar method, an emotion was also assigned to each tweet, where the algorithm made it possible. As a last step, temporal analysis was performed to identify the daily, weekly, and seasonal patterns of park visits.

Based on the analysis of these spatiotemporal and affective patterns, the classification of park users became possible. The study found that many visitors tweet from a park located 3-4 km away from their main activity center (derived from tweeting activity). Twitter users were also more likely to be more positive while tweeting from a park compared to other areas in the city, which supports the significant role of parks in urban livability. However, there might be slight differences between parks in terms of temporal and intensity patterns of the positive sentiments. Regarding the temporal characteristics of tweeting in parks, the authors concluded that afternoons, weekends, and the summer are particularly popular for park visits. Interestingly, in some cases, a given park was more popular during the winter than in fall, which might also be significant information for urban planners.

### 3.5 Walkability

Just like parks, walking also has its priority when it comes to good urban quality and livability. Walkability has a special role even within mobility, as it is considered "human-scaled" and brings a different perception of the surrounding urban environment than other transportation modes (Gehl, 2010). However, to utilize the role of walking in improving urban quality, walkability should be adequately represented in the transport system, both in terms of infrastructure and statistics, which is often not the case. The integration of walkability assessment into planning routines can provide a valuable addition to urban quality improvement by demonstrating the effect of walking both quantitatively and qualitatively (Dörrzapf et al., n.d.).

Just as in the case of livability, walkability also lacks a clear definition, including key factors and their assessment. Dörrzapf et al. provided a framework to define and evaluate walkability from the perspective of pedestrians' perception. The integrated approach combines GIS methods and biosensor technologies to represent how pedestrians feel and perceive the environment when walking. By utilizing biosensors and GPS receivers, researchers are able to connect physiological body responses (e.g., stress moments) to given locations while walking. If this measurement procedure is repeated with many participants in the same area, it is possible to identify hot spots with similar physiological responses. Thereby, walkability has high relevance for planning by grasping qualitative aspects of walking in a systematic and measurable way.

## 4 DISCUSSION

Beyond the traditional role of GIS in collecting, storing and visualizing data and results of the spatial and temporal analysis, the current position paper introduced the further potential of GIS-based livability assessment. On a conceptual level, it was shown that spatial and temporal aspects are essential to adequately represent the person-environment relationship because the complexity and dynamics of urban systems require it. Concerning the practical side of livability assessment, the paper highlighted some use cases where GIS analysis using various data sources were used. All the examples were constructed in a way to represent either a specific segment (e.g., temporal sensitivity, urban parks) or the whole assessment process by focusing on the person-environment relationship, and the perception of people, instead of merely statistical factors such as the number of grocery shops or average income levels.

However, as it is often the case, livability assessments have also some limitations. These limitations can be inherent, such as the subjectivity of human needs and perception, which raises the most challenges in livability assessment, but at the same time, can be considered essential in the process. Whereas other issues are more related to the input data, whether they are available at the right scale and for the right temporal extent, or they are representing the phenomena examined. These are just some general limitations; however, it can vary from case to case depending on the circumstances and goal of the project.

Section 3 provided an overview, among others, on a set of GIS-based analysis techniques and data sources for assessing various aspects of livability. Questionnaires in the form of an assessment platform, social media data by analyzing the spatiotemporal and affective content of tweets, and biosensors to quantify human perception are all promising ways to assess elements of the person-environment relationship by extracting relevant information from data, also for planning purposes. By considering the spatial and temporal characteristics of the data using GIS, researchers, decision-makers, urban planners and other stakeholders can gain valuable insights on urban livability, also by identifying less well-performing

areas and elements. The "diagnosis" of the city in this regard, along with various visualization techniques, and the support of participatory planning all raise awareness about the situation of the residents and their needs and expectations, thereby supporting transparency. Hopefully, these evaluations are also able to make urban quality improvement actions more effective through detailed assessment and planning, followed by systematic monitoring of the progress and results.

# 5 CONCLUSION

Livability assessment due to its complexity requires a holistic approach by considering both its key elements and different properties. As a first step, I identified these elements and properties, and then provided use cases to illustrate the relevance and potential analysis methods for each of them. The dominance of the spatial properties in livability assessment indicates the potential of applying GIS methods. The identified livability properties also define the required characteristics of the datasets used for livability assessment. Beyond spatial and temporal information, any potential dataset should provide personal aspects, at least by representing any aspect of the person-environment relationship. Thereby, the application of GIS methods are especially helpful for social media data or sensor measurements, in livability assessment. Although this approach also has its limitations, it can still be useful in urban planning to "diagnose" a city before and after performing actual planning actions in the process of urban quality improvement.

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