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The Influence of Social Infrastructure Accessibility on Liveability in Urban Neighbourhoods

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1 ABSTRACT

The liveability in urban neighborhoods partially depends on the living conditions in the residential environment (Die Bundesregierung 2016: 3). These include the supply of goods and services as well as their quality and accessibility. The infrastructures that influence the liveability in urban neighborhoods vary depending on the age, social status and life stage of the residents. These include educational, administrative, health, cultural and recreational facilities. Reasonable accessibility may also be perceived very differently by young adults without children, families, baby boomers or the elderly. According to Prof. Carlos Moreno's model of the "15-minute city", each trip should have a maximum walking or biking distance of 15 minutes (Moreno 2021). However, the model of the 15-minute city does not specify speeds, i.e. what distance is achievable within the travel time. This can differ depending on the target group.

The focus of this paper is on the spatial analysis of factors that determine the quality of life of baby boomers (birth cohorts 1955-1969)[1] in urban neighborhoods in terms of infrastructure provision. It is likely that some existing infrastructural facilities will necessarily have to be maintained at the location, e.g. some educational institutions or large recreational, cultural and sport facilities. Others, however, could function in the future via delivery systems. Particulary in view of digital developments, some systems and offerings are outdated in their current form or need to be restructured and adapted. The question also arises as to what need there is for new infrastructure offerings.

In this context, this subproject of the research project "Ageing Smart – Intelligent development of spaces", which is funded by the Carl Zeiss Foundation, examines the following research question using the city Jena as an example: Which infrastructures condition a high liveability in urban neighborhoods and how must they be accessible? The results of the accessibility analysis can be overlaid with the population data of the city of Jena on the basis of selected infrastructures. In the next step, it is examined how many of these infrastructures can be reached by baby boomers within a reasonable distance in 15 minutes by foot and by bike. Based on this analysis, it will be discussed where infrastructures need to be supplemented or digitally substituted in order to promote a high quality of life for Jenas population – especially for baby boomers – or where accessibility on foot and by bike needs to be increased.

Keywords: livability index, accessibility, social infrastructure, 15minute city, walkability

2 THE CONCEPT OF THE "15 MINUTE CITY" AS A BASIS FOR ACCESSIBILITY ANALYSIS

A variety of uses can be found in urban neighborhoods. In addition to residential use, these include especially services, stores, businesses as well as social and technical infrastructures. The scope of the facilities is primarily determined by demand. This varies depending on the resident structure. The goal is to reach all necessary facilities through active mobility. This reduces motorized individual traffic so that air quality improves, noise is reduced and space is created.

The concept of the 15 minute city, first mentioned by Prof. Carlos Moreno, concretises the guiding principle of the city of short distances. In the "city of short distances", the aim is to reduce motorized private transport and increase the proportion of distances covered on foot, by bicycle or by public transport. It is backed up by the Leipzig Charta, a guiding document of national urban development policy, that also calls for "[...] compact, socially and economically mixed cities with well-developed infrastructures [...]" (BMI 2020: 3).

The goal of the 15 minute city was formulated as follows: "[...] all residents are able to access their daily needs (work, housing, food, health, education, and culture and leisure) within the distance of a 15-minute walk or bike ride." (Moreno 2021) Short distances covered through active mobility contribute to climate protection as well as to improving air quality in cities. In addition, city inhabitants save time and are

[1] As defined in the research project "Ageing Smart – Designing Spaces Intelligently", funded by the Carl Zeiss Foundation.

physically active, which can have a health-promoting effect. Neighborhoods can be strengthened and space in public areas can be saved and reallocated by reducing stationary traffic.

The concept reduces the guiding principle of the city of short distances by public transport and specifies a specific time in which the infrastructures are to be achieved. Regardless of Moreno's definition, many accessibility studies based on that concept also consider accessibility by public transit. It only describes a tangible idea of how cities should be equipped. It is not universal and does not take into account that the walking distance is significantly less than bicycle distance. In addition, it does not take into account walking and cycling speeds. Different population groups move at different speeds. As a rule, the average walking speed is between three and six km/h. The average cycling speed is usually 15 to 20 km/h. Furthermore, not all urban inhabitants are able to get around by bicycle.

Accessibility models based on the 15 minute city concept only take into account whether there is a corresponding infrastructure within the radius. The different lifestyles of city inhabitants are not taken into account. Accordingly, it is quite possible that a resident can already find very good infrastructure facilities in their neighbourhood according to the analysis, but does not use them for various reasons. The concept of the 15 minute city can therefore be seen as merely a basic idea, which is further substantiated by the Liveability Index.

3 CONCEPTUAL MODEL: CONCEPTION OF A “LIVEABILITY INDEX” BASED ON THE ACCESSIBILITY OF SOCIAL INFRASTRUCTURES IN URBAN NEIGHBOURHOODS

In order to concretize the idea of the 15 minute city and to investigate the accessibility of infrastructures as part of the liveability in urban neighbourhoods, an index has to be formed. This index consists of different variables – in this case different infrastructure facilities. It forms a theoretical construct to measure the accessibility of infrastructures as a precondition for liveability of the inhabitants of urban areas.

The different variables can be weighted or combined according to their target group-specific importance. This procedure creates additional scope for decision-making for municipalities, as they can individually adapt each variable and their weighting to the demands of the resident structures in different urban neighbourhoods. By combining the variables, it is possible to examine how well the residents are equipped with infrastructures of general interest. In addition, two further options for action can be explored. On the one hand, the accessibility analysis based on the index shows deficits in infrastructure provision. On this basis, location decisions can be made regarding supplementary infrastructures in order to improve the liveability at the target groups' residential locations. On the other hand, this method can be used to identify residential locations that have a high liveability according to the variables examined. This can potentially trigger relocation chains that can counteract a housing shortage.

Public infrastructures as well as privately provided ones in urban areas that are periodically visited (see Table 1) and can only be provided digitally or as a delivery service in part or at considerable expense are examined. The distinction between public and private providers is important because the municipal options for action are very limited in the case of private infrastructures.

Approximation of a Liveability Index based on the accessibility of infrastructures

The social infrastructure in municipalities forms the basis of services of general interest. This includes "retail and everyday supply/local supply, education, social services, health and medical care, emergency services, disaster control and fire protection, leisure facilities, community facilities".“ (Beirat fuer Raumentwicklung 2011: 4). These services are supplemented by "public and private local and long-distance transport" (ibid.). Specifically, according to the Academy of Spatial Development (ARL), the public social infrastructure essentially includes primary and secondary schools, universities, the library system, childcare, youth care and youth psychological services, care for the elderly, health care, sports and disaster control (Winkel 2018).

Local supply as well as restaurants, pharmacies and general practitioners are provided by private parties and can hardly be controlled by municipalities, they are part of the private infrastructure. The Land Use Ordinance does allow areas to be designated for these purposes. However, occupancy depends on private individuals, so these facilities are usually only available if they are economically viable. Vacancies can‘t be completely avoided by the municipality.

Areas for local recreation, sports facilities and public transport stops are usually provided by municipalities. The possibilities for planning and implementation are limited on the one hand by the availability of land. On the other hand, these usually are non-economic infrastructures whose operation and maintenance must be ensured by the municipalities. Thus, the financial resources of the municipalities are also decisive for their quality and quantity.

Local infrastructures whose daily or at least regular accessibility can significantly influence the liveability are selected here as examples for further investigation. Infrastructures that are visited only rarely or only by small parts of the population on a regular basis, such as universities, museums and churches, are excluded, as are the emergency services and services that are nowadays regularly perceived digitally, such as banking and postal services.

Public Infrastructure	*Private Infrastructure*
Public transport - Bus stops - Tram stops - Underground stops	Local supply (goods for daily needs): - Discounters/Supermarkets - bakery, butcher, drugstore (in close proximity) - Shopping centres with appropriate assortment
Environment and local recreation - Green spaces - Parks - Local recreation areas	Medical care - General practitioners - Pharmacies
Sports facilities - Sports halls - Sports fields - Other sports facilities	Gastronomy - Restaurants - Cafés - Bars
Child and youth care, schools - Day nurseries/kindergardens - Primary schools - Secondary schools - Playgrounds - Youth centres	

Table 1: Examples of local infrastructures whose accessibility can significantly influence liveability

To make the indicators measurable, the accessibility must be quantified. There are several ways to do this. Based on the concept of the 15 minute city, the assumption can be made that all variables are equally weighted and fulfilled if they are reached within 15 minutes on foot or by bicycle. However, due to the points listed in chapter 2, this approach is not meaningful. Based on this, further concretisations are made.

Therefore accessibility is classified in a three-stage evaluation scheme (very good, good and acceptable). For this study, an acceptable walking distance is assumed to be 15 minutes at an average walking speed of 5 km/h. Accordingly, a distance of five minutes is considered very good and a distance of 10 minutes is considered good.

Furthermore, the individual elements of the infrastructure are weighted, whereby the weightings can vary greatly depending on the cohort considered. As an example, a weighted scheme could be structured as below (table 2).

4 CALCULATION IN GEOSTATISTICAL GRIDS

To apply this research approach methodologically and to make the site assessment manageable, the results are aggregated in grid squares. The weighted accessibility values of the individual infrastructures are then summed up into an index value for each grid square. In the case study the 1 ha INSPIRE grid (100m x 100m grid cell) by the European Commission is used. This format was established by the Statistical Office of the European Union (eurostat) with the goal to provide comparable statistics at the EU level (Eurostat/European Union, n.d.). The datasets are based on surveys, the current one is from 2011. In 2022 the census was surveyed again, the data is expected to be available from March 2024 (Statistische Aemter des Bundes und

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der Laender 2023). Usually the survey interval is every ten years, in this case eleven. The processing of the results takes an additional one to two years.

The advantage of this approach is to obtain a uniform and sufficiently accurate spatial comparison framework for the calculation of the index without having to take individual local conditions into account. It is also advantageous that data is increasingly being collected and evaluated in geostatistical raster form in order to have a neutral, comparable spatial basis on the one hand and to ensure data protection on the other.

	very good / x3	*good / x2*	*acceptable / x1*
Public Infrastructures			
Public transport - Bus stops - Tram stops - Underground stops	3	2	1
Environment and local recreation - Green spaces - Parks - Local recreation areas	 3 6 6	 2 4 4	 1 2 2
Sports facilities - Sports halls - Sports fields - Other sports facilities	 3 3 3	 2 2 2	 1 1 1
Child and youth care, schools - Day nurseries / kindergardens - Primary schools - Secondary schools - Playgrounds - Youth centres	 6 6 3 3 3	 4 4 2 2 2	 2 2 1 1 1
Private Infrastructures			
Local supply (goods for daily needs): - Discounters / Supermarkets - bakery, butcher, drugstore (in close proximity) - shopping centres with appropriate assortment	 9 3-9 9	 6 2-6 6	 3 1-3 3
Medical care - General practitioners - Pharmacies	 6 3	 4 2	 2 1
Gastronomy - Restaurants - Cafés - Bars	 3 3 3	 2 2 2	 1 1 1

Table 2: Example of a weighted scheme to to make the influence of various indicators measurable

5 CASE STUDY: LIVEABILITY FOR BABY BOOMERS IN THE CITY OF JENA

As an example, the conception of an area-wide Liveability Index for the population group of baby boomers in Jena is presented. The city of Jena is located in the federal state of Thuringia. The population includes 110,502 people (31.12.2021, Thueringer Landesamt fuer Statistik 2022a) on an area of 11.477 ha (31.12.2022, Thueringer Landesamt fuer Statistik 2022b).

The data basis for the example of Jena was partly provided by the city of Jena within the framework of the above-mentioned research project. The points of interest (POI's) were taken from Open Street Maps (OSM), the accessibility analyses were carried out with ArcGIS Pro.

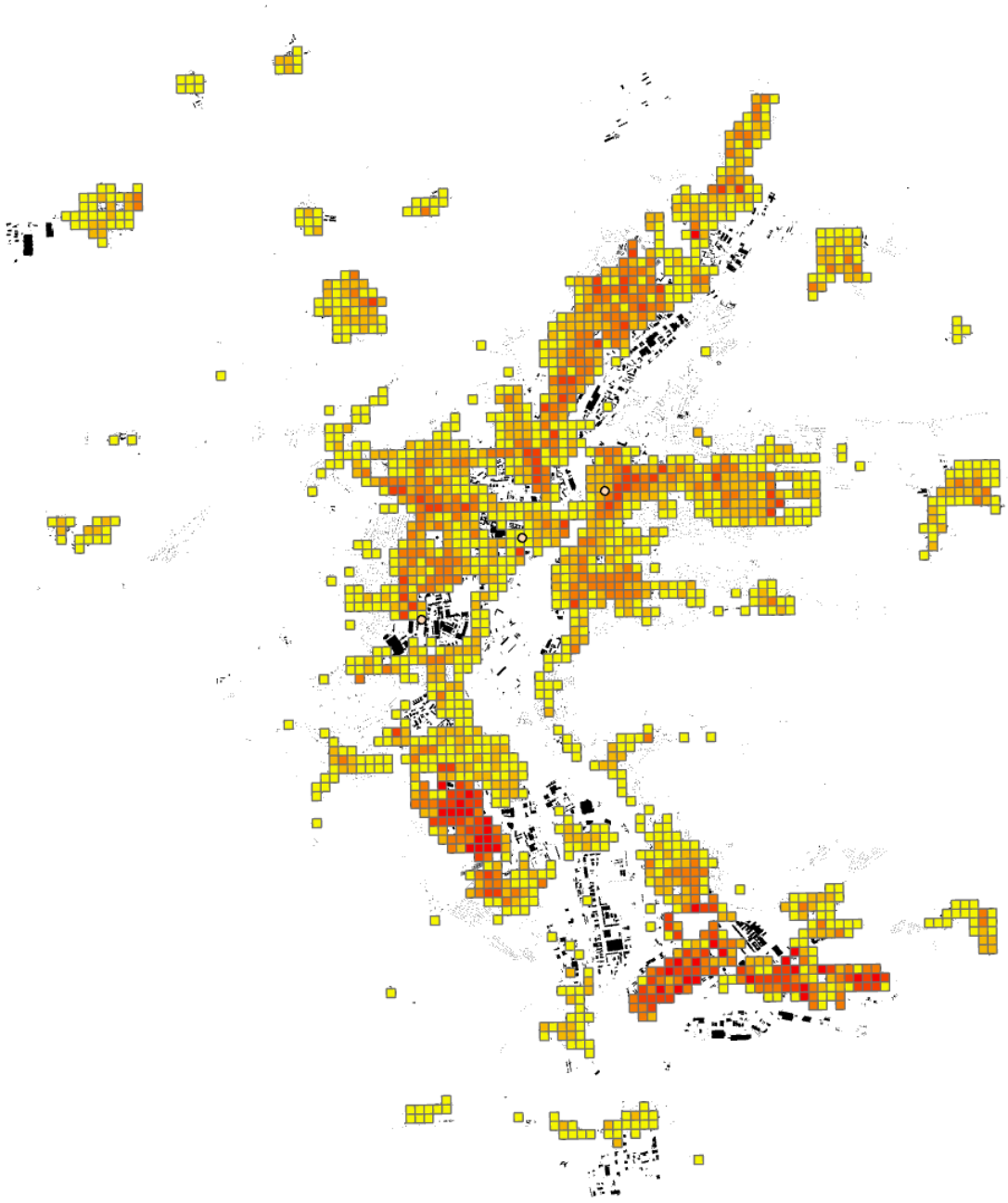

Fig. 1: Distribution of the total population in Jena (red many, yellow few)

The population density is particularly high in the large structures in Jena-Lobeda in the south (average age: 44.9 years) and in Jena-Winzerla in the southwest (average age: 46.8 years) (see Fig. 1). In addition, it is higher in the terraced housing west of the Saale. The population density is correspondingly lower in the districts with more dispersed building structures around Jena.

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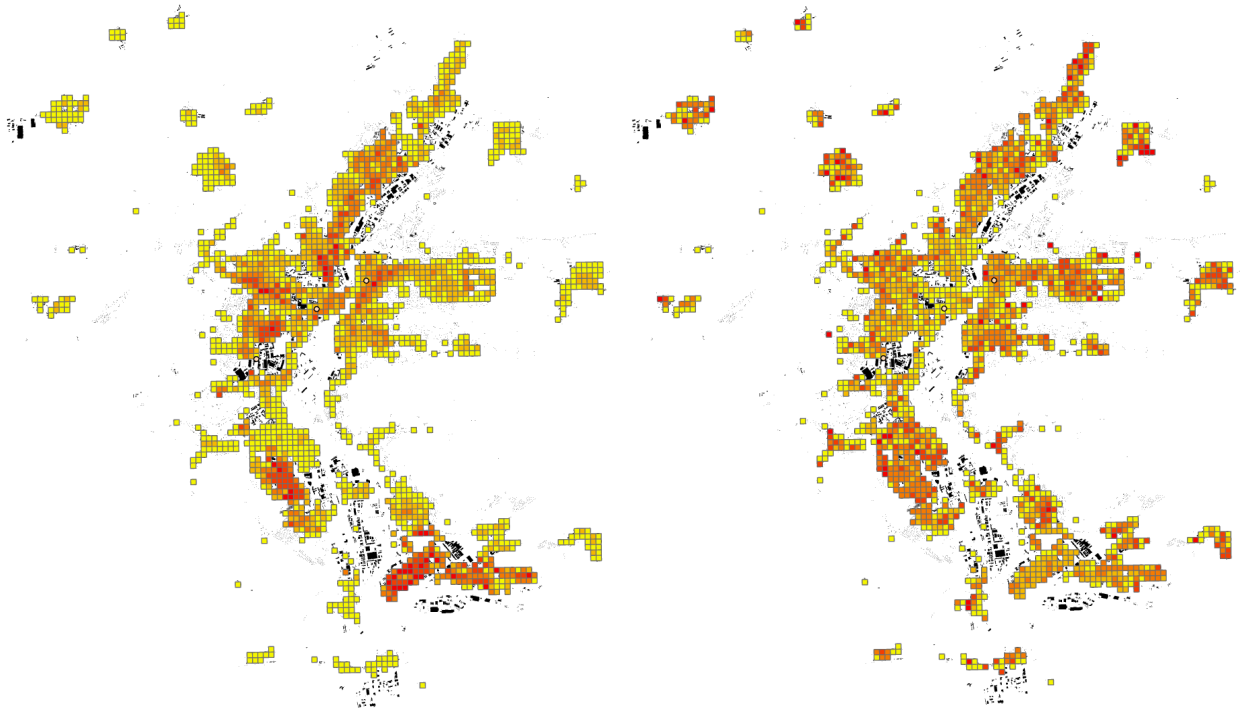

Fig. 2: Distribution of Baby Boomers in Jena – Absolute (red many, yellow few). Fig. 3: Distribution of baby boomers in Jena – Proportion of total population (red many, yellow few)

In absolute numbers, the baby boomers are distributed largely in line with the total population (Fig. 2). When looking at the distribution of the baby boomers as a proportion of the total population, it can be seen that the baby boomers make up a moderate to high proportion of the total population and are relatively evenly distributed in the urban area (Fig. 3).

The list of indicators presented above needs to be adapted for the specific study group. For example, childcare facilities and schools are rather irrelevant for the cohort of baby boomers.

The accessibility model is also specified. For this, a walking speed of 5 km/h is assumed, and accessibility by bicycle is not included because it is assumed that a relevant part of the group can no longer use a bicycle as they get older.

In the next step, the accessibilities for the individual infrastructure sectors are determined for the walking times 5, 10 and 15 minutes. As an example, a representation follows for the supermarkets available in Jena, which have a very different coverage of the populated urban area. While in central areas larger parts of the population live within the 5-minute range of one or more supermarkets, in decentralised parts of the city there are whole districts that lie entirely outside the 15-minute range.

In the next step, the accessibilities determined by network analysis are transferred to the inhabited grid squares of the city and the respective index value is stored.

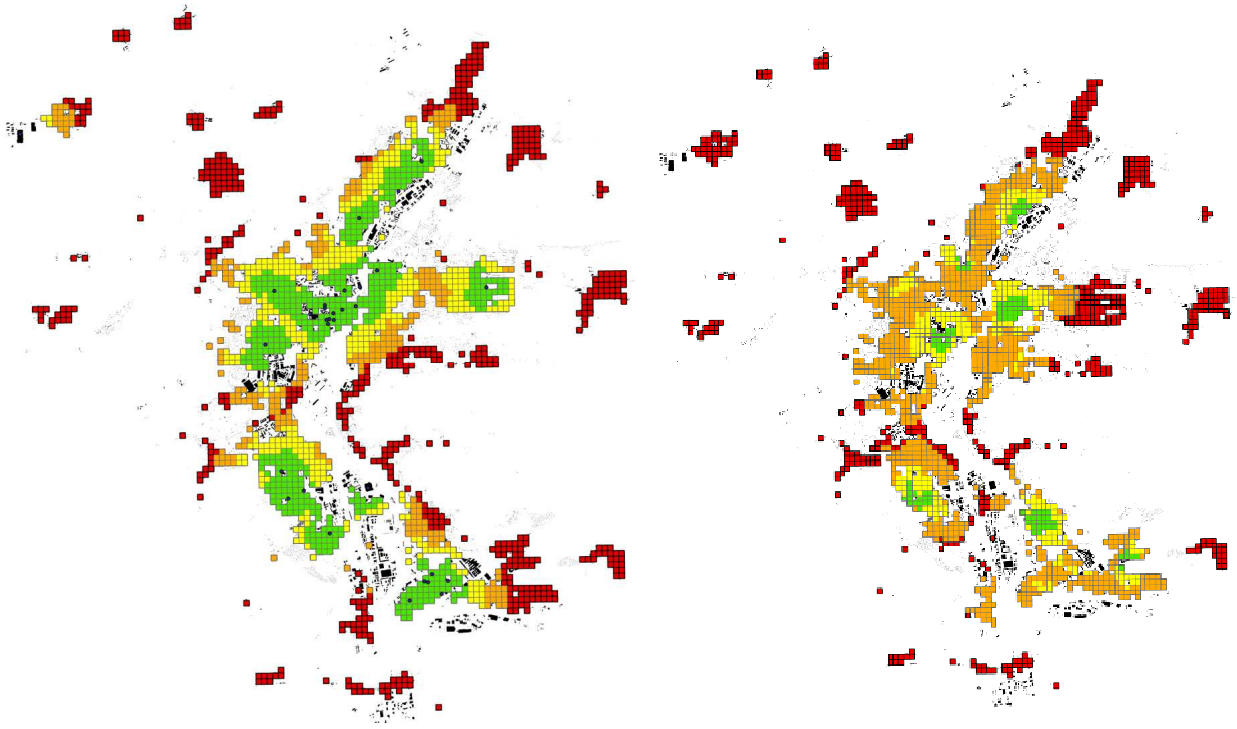

Fig. 4: Rasterized index “supermarkets” (green: <5 min, yellow: <10 min, orange: <15 min, red: >15 min). Fig. 5: Rasterized index “general practitioners” (green: <5 min, yellow: <10 min, orange: <15 min, red: >15 min)

The network analysis and transfer of the index values to the population grid is then repeated for each infrastructure sector. The accessibility of supermarkets with a full range of groceries (Fig. 4) and of general practitioners. (Fig. 5) is shown here as an example. Due to the different number of locations and differences in the choice of location, there are large variations in accessibility. In general terms, it can be said that significantly more people in Jena live in the immediate vicinity (5 min) of supermarkets than of general practitioners. The part of the city area that does not have a doctor's practice within a 15-minute walking radius is also larger.

There are smaller areas in the city centre and around district centres that have excellent accessibility in (almost) all criteria. However, this is not the rule. Urban areas dominate in which accessibility is heterogeneous across infrastructures. There are also urban areas in which the infrastructure is mostly well accessible, but in which one or a few sectors are missing. The methodological handling of such cases must be discussed. Should these areas still be considered as 15-minute cities, or should exclusion criteria be set here? These considerations are essential when it comes to quantifying the theoretical and general model of the 15 minute city.

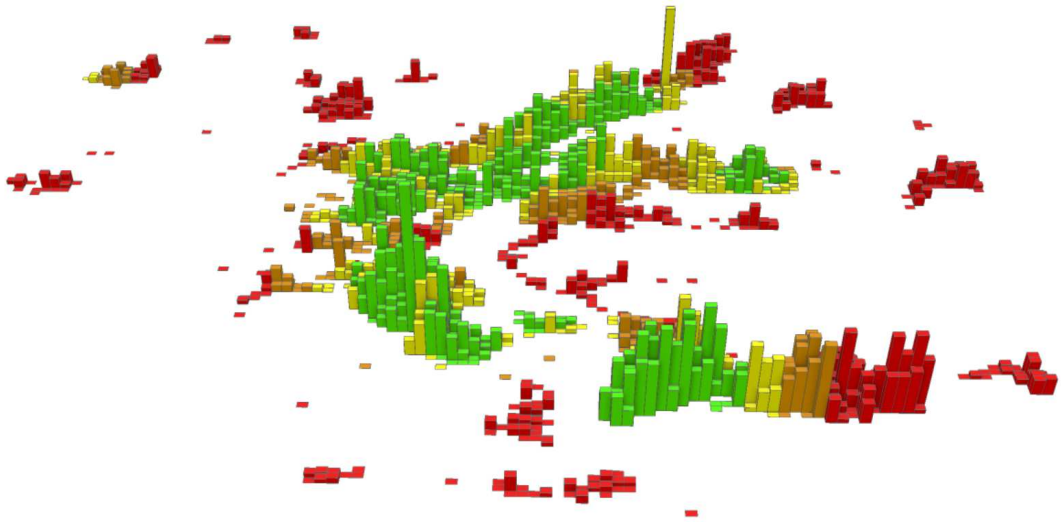

Fig. 6: population-weighted accessibility (green: <5 min, yellow: <10 min, orange: <15 min, red: >15 min)

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In a last step the results of the accessibility analysis are overlaid with the population data of the city of Jena on the basis of selected infrastructures.

Various conclusions can then be drawn from this. On the one hand, it can be determined what proportion of the population lives in a "15 minute city" tailored to the needs of its age group and where this is the case. At the same time, deficits in the municipal and private infrastructure can be identified.

6 CONCLUSION

The concept of the 15 minute city is a very interesting approach to liveability in cities, but it has some gaps. For accessibility analyses, it can only be used in a highly concretized form. Parameters such as walking and driving speeds must be differentiated and defined. By concretizing the concept, it can serve as a framework for a Liveability Index. When creating this index, it is imperative that the responsible planners and decision-makers agree on comparable criteria and quality levels. In addition, the target group must be defined.

The hectare grid represents a good reference size for accessibility analyses. The spatial reference value is sufficiently concrete to show resilient decision options. Especially since spatial planning is already imprecise to a certain degree anyway due to assumptions and scenarios. If the above points are taken into account, the Liveability Index can be a good evaluation and decision-making aid.

In the next step the index is comprehensively applied to Jena as an example. Based on the results, recommendations on potential weightings and their consequences in the location analysis can be shown.

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