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## 15min City Score Toolkit – Urban Walkability Analytics

# 15min City Score Toolkit – Urban Walkability Analytics

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## Abstract

The 15min City Score is an urban metric that gives a comprehensive overview of a city's walkability and can be used to assess the accessibility of cities, neighborhoods and specific places based on the availability of essential services. Nevertheless, the estimation of this metric for a city can be an intense and complex analytical process. In this article, we present the design and development architecture of the 15min City Score Toolkit, a Python-based tool for automating the metric estimation. The tool streamlines the analysis by using Open Street Map and custom data as input, allowing for flexibility and for the testing of custom-built scenarios. The toolkit has been implemented as QGIS plugin and has been tested on over 112 cities to show its effectiveness and computational efficacy, as well as its potential in supporting and analyzing the 15-minute city concept.

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## Keywords

15min City, Service Accessibility, Urban Planning, Walkability, Toolkit.

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## 1. Introduction

This article presents the 15min City Score Toolkit, an open source Python tool to assess the urban metric aimed at measuring service accessibility by walk. The tool is packaged both as standalone notebook (Albashir et al., 2024a) and as integrated with the QGIS environment (Albashir et al., 2024b).

Walkability in terms of neighborhood services proximity had been assessed in many cities by examining the distribution of the accessibility to essential services (Hall & Ram, 2018). One of the most known applications was conducted in New York City, which was later generalized to around 130 North America cities and it is now available online for most US cities (Walk Score, N.D.). This version of the metric (Walk Score ©) is well recognized in different fields spanning from real estate, where its used a metric to estimate property values, to public health (Duncan et al. 2011, Hirsch et al. 2013). Also, it includes a wider range of indicators, namely the access to amenities, the population density, the block length and the intersection density (Walkscore, N.D.).

A slightly different version of this metric includes crime statistics (Lucas et al., 2010), both these tools have the underlying goal of providing an holistic assessment of walkability, providing an effective and scalable descriptive method, but falling short in respect to the complexity of the General Theory of Walkability (Speck, 2013). Moreover, two major gaps were identified: first, the absence of standardization in data sources and methods to calculate the Walk Score, including the amenity selection criteria; second, the time-consuming process of estimating the score for a city at a granular level.

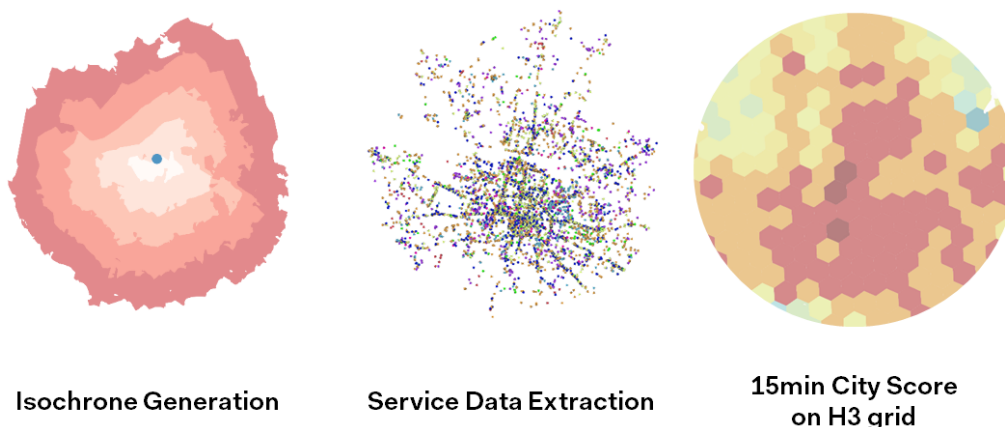
The toolkit introduced in this article is based on the conceptualization outlined in Abdelfattah et al. (2022), which builds on the popular concept of 15-minute city (Moreno et al., 2021), and on the overarching framework of general accessibility (Geurs & van Wee, 2004; Hansen, 1959). The concept of the 15-minute city became popular in the post COVID-19 pandemic world and is getting increasing attention from the international urban planning community and major cities are shaping their plans on this approach. The attention on accessibility and service availability was also present before the popularization of the concept, with the 20-minute neighborhood strategy implemented in Portland in 2010 (City of Portland, 2012). In this case, including additional factors related to access and pedestrian conditions. namely grocery stores, commercial stores (divided into two types), parks, public elementary schools, sidewalks, and frequent service transit stops.

The common approach between these application is the definition of a timeframe (15 minutes, 20 minutes, or  $n$  minutes) of walking or cycling to access the essential services. Consequently, part of the research efforts focused on assessing the compatibility of existing cities and urban areas with this concept by evaluating analytically how service accessibility is distributed. This tool aims to join the efforts of using quantitative evidence to support livable cities planning, by recognizing that the overarching concept behind the 15-minute cities is the sustainable and equitable opportunity to access essential facilities.

The process of estimating the 15min City Score includes various steps, including (i) the definition of the proximity service categories, (ii) the collection and mapping of amenities, (iii) the walking catchment analysis, (iv) the proximity accessibility estimation, and (v) the final computation of the score. In this process the needs of standardizing some of the assumptions required to perform this analysis, and the opportunity to streamline and automate an otherwise time-consuming process, appears evident and were considered as starting point of the development process. This article discusses the design parameters of the tool, the detailed structure and role of each of the main functions in the implementation of the tool. Finally, the application on several case studies is included, showing the results of the toolkit to test the scalability and flexibility of the tool in assessing case studies of different size, geographical location and data availability.

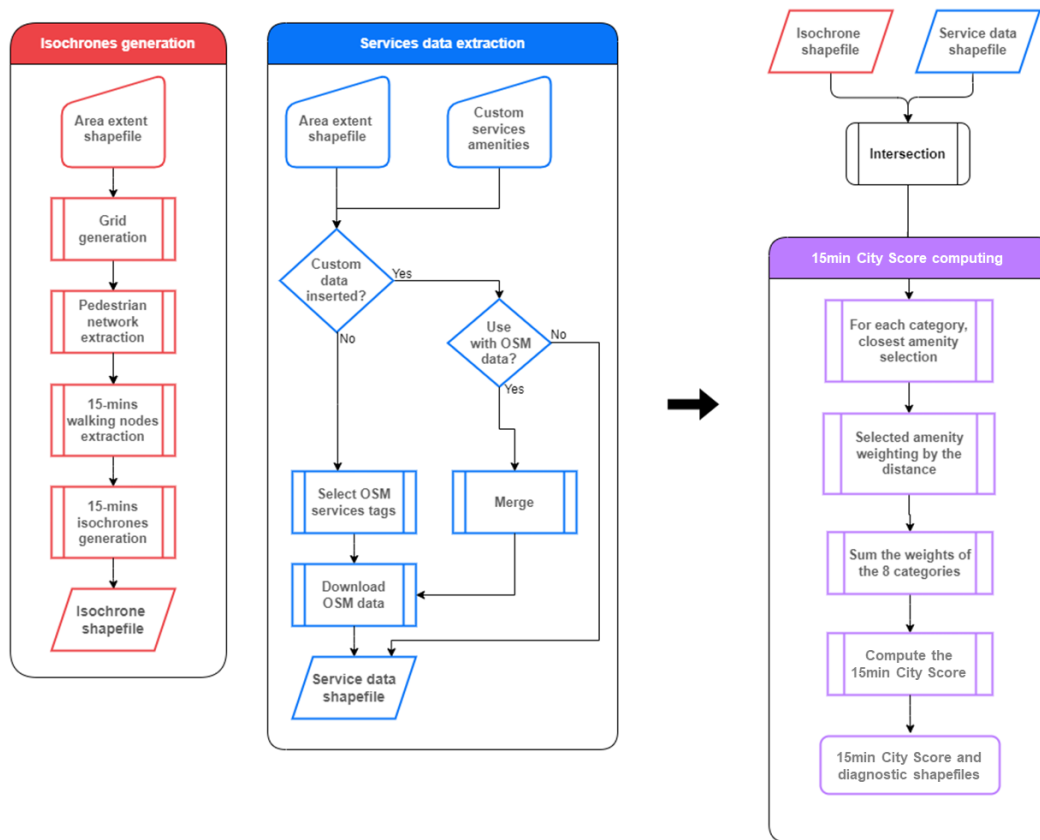
## 2. Tool Design

The 15min City Score Toolkit is an end-to-end tool that enables the user to automatically estimate a service accessibility metric over a custom urban region. The design of the tool was meant to be straightforward and efficient for the extensive spatial computation required in the intermediate steps of evaluating the score. The tool is developed using Python due to its fast and powerful capabilities and ease of use, and for its integration with the QGIS environment. Moreover, several network and geospatial analysis libraries were used in the development, such as GeoPandas, PySal, OSMnx and networkx.



**Figure 1** – Tool design schematization

The design architecture is illustrated in *Figure 1* and *Figure 2*. Briefly, the tool was built on top of three main functions, namely isochrone generation, service data extraction, and the 15min City Score computing, described in detail in the next section.



*Figure 2* – Design architecture of the 15min City Score Toolkit.

The conceptual framework for designing and implementing the toolkit started with the definition of proximity services; thus, the first step of the project was to identify the essential services and categorize them into eight main categories, modeled on previous work of the authors (Abdelfattah et al., 2021). Hereby, the following classification is proposed and used in the tool: neighborhood services, healthcare, neighborhood shops, education, sports, cultural entertainment, open leisure and mobility. The corresponding amenities belonging to each of the main categories were defined taking into account the commonly used amenities in literature and practice, as the tool is designed to be suited to different regions with different proximity services and community needs around the world. Below, we are listing the detailed amenities within each of the main categories:

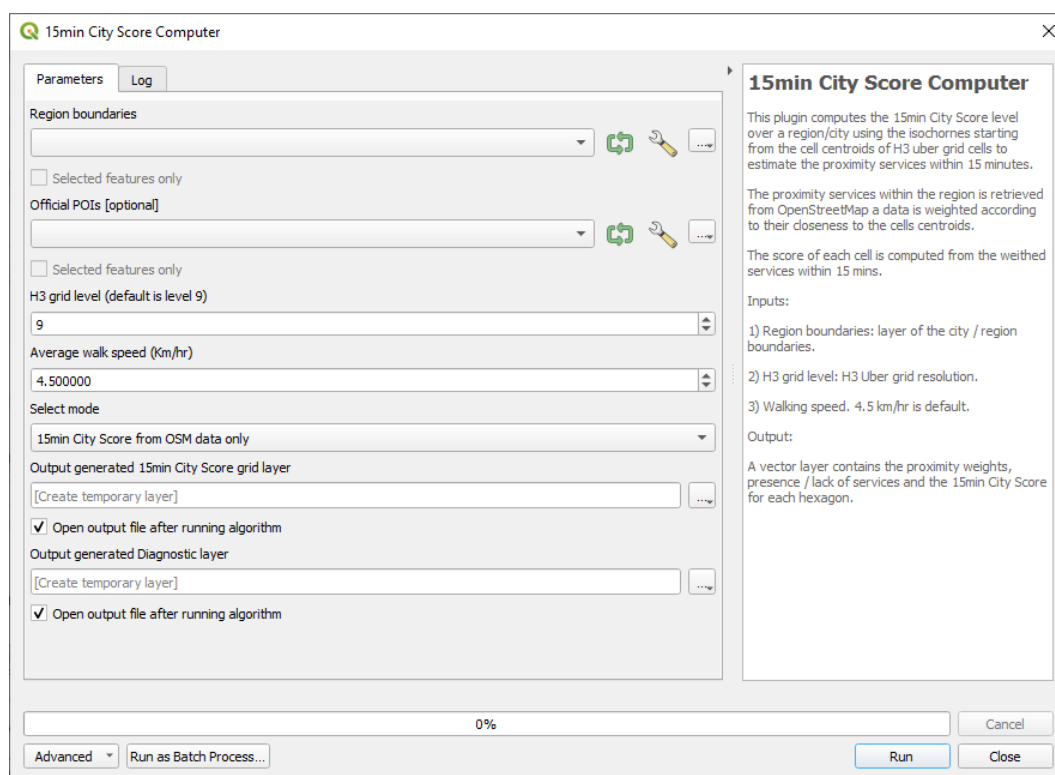
- **Neighborhood services:** post offices, banks, civic and community centers, police services, filling water points, local administration offices, bars, cafes, tobacconists and newsagents;
- **Healthcare:** hospitals, pharmacies, first aid, clinics, and local health services;
- **Neighborhood shops:** grocery, retail, bookshops, local markets, restaurants, supermarkets, and the local non-food shops;
- **Education:** kindergartens, schools, colleges and universities, professional schools, and libraries;
- **Sports:** gym and sports facilities;
- **Cultural entertainment:** cinemas, theaters, art centers, and museums;
- **Open leisure:** parks, playgrounds, and gardens;
- **Mobility:** surface public transportation stops, bike parking facilities, bike sharing and car sharing facilities, underground metro stations, and railway stations).

In order to fulfill this design goal, OpenStreetMap (OSM) was defined as the primary source of proximity services. It was decided to use data from OSM because it is considered the biggest openly licensed collection of geospatial data and the largest Volunteered Geographic Information (VGI) source (Brovell et al., 2016), moreover OSM constitutes a worldwide available open data source, which is an essential requirement to ensure the scalability of the tool. While the categories remain fixed, the toolkit has the additional option of bypassing the data collection process from OSM, and of using custom user-defined amenities data. This is particularly relevant when testing development scenarios or when local geospatial data repository have more reliable data than OSM.

Once the main categories were defined, it was needed to identify the correct space discretization to implement. In this case, it was deemed coherent to adhere to another industry standard, which is the Uber's Hexagonal Hierarchical Spatial Index (Uber, 2018). The selection of this gridding schema was driven by two main reasons: firstly, the worldwide consistency and availability, and secondly, the hierarchical structure, which allows the users to select the appropriate detail level according to their analysis needs. Moreover, the H3 hexagon scheme enables the integration of results with different spatial data. The design of the tool, however, allows the user to pick the zoom level of the score estimation by choosing the H3 hexagon level resolution.

### 3. Functionalities and Processes

As outlined above, the 15min City Score toolkit has three main functions, in this section the specifics of each of the three functions is presented. *Figure 3* shows the interface of the toolkit in QGIS.



*Figure 3* – Interface of the 15min City Score Toolkit in QGIS.

#### 3.1 Isochrone generation

As the 15min City Score is based on the accessibility to the essential services through the pedestrian network, an extraction is performed from OSM Highway data, including exclusively segments suitable for walking. Once the walkable network is extracted, the H3 hexagons' centroids are assigned to the nearest nodes in the network. This step is aimed at linking each centroid of the cells to the network, enabling the calculation of the walking accessibility within the network.

Furthermore, accessibility to services is calculated in terms of walking minutes to reach the service, starting from the centroid of each hexagon. In order to correctly estimate the walking time, 15 isochrones, one for each minute interval, are generated over the network. This step is critical as it needs to be consistent among networks of different size, granularity and structure, moreover it can become resource intensive in case of large analysis extents. This process was optimized through OSMnx (Boeing, 2017) and networkx Python libraries and the generation of convex-hull vector-based polygons.

### 3.2 Services data extraction

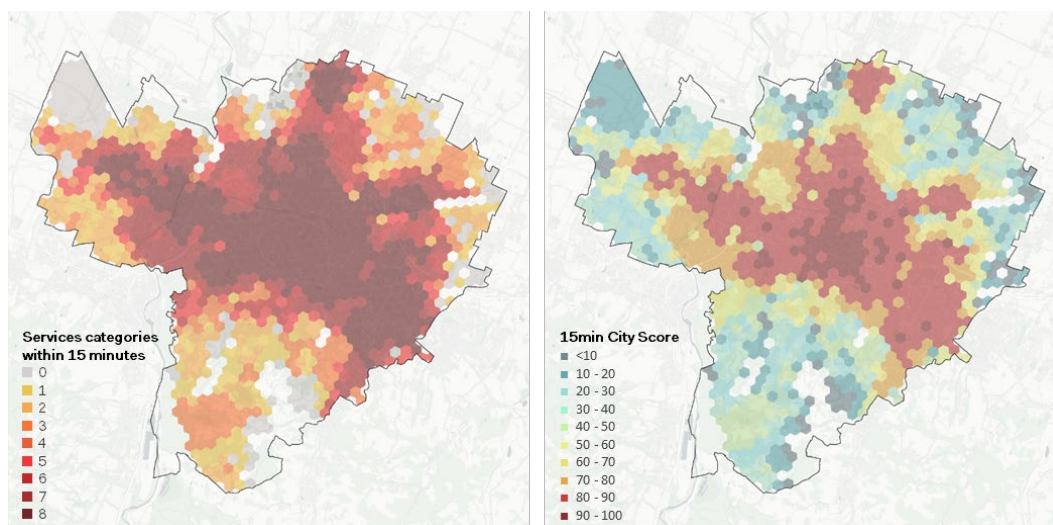
After the travel time analysis, the tool filters and downloads the amenities data for each of the predefined categories within the study area, by querying the OpenStreetMap database. In addition to this, in this version of the tool, an alternative function is implemented, enabling the user to either add custom POI data to the original OSM data, or to input a complete set of custom POIs.

### 3.3 15min City Score computing

This function performs an intersection between the proximity services data with the generated isochrones. In this tool, each amenity is weighted based on its proximity to the cell centroid (i.e., the needed time to reach the amenity from the starting point). This is done by implementing an exponential distance decay function due to its ability to reflect actual pedestrian walking behavior. This approach is different from the traditional Walk Score (Walk Score, n.d.), which by design assigns different weights for different categories. For the scope of this tool, the score of grid cell considers the nearest amenity from each category without implementing additional weighting schemes keeping a consistent importance among all the amenity types.

The process makes the weighting values of each category range from 0 to 1 based on its closeness to the centroid and consequently, the 15min City Score is initially calculated as a sum of the weighted categories. This step keeps the initial values of the score in a range between 0 (reflects no essential service within 15-minutes) and 8 (fully served zone). An additional process is performed to scale the values of the score to be between 0 and 100, which is the preferred visualization scale.

Along with the 15min City Score layer, additional diagnostic features were implemented in the tool to be able to dissect the results and identify specific service deficiencies. The diagnostic report (i.e., a layer that provides information about the density of each of the category services throughout the city) enables a quick overview of the density of the mapped services within the city. *Figure 4* shows an example of the outputs of the toolkit.



**Figure 4**– Examples of the toolkit outputs for the City of Bologna: accessible service categories within 15 minutes (left); 15min City Score values (right).

## 4. Conclusions and future works

In this article, it is presented the 15min City Score Toolkit, a Python tool integrated with QGIS user-friendly environment to assess an urban metric of service accessibility. Moreover, the focus is given to the design choices, the technologies and the libraries used, and the design architecture to develop the tool, as well as a detailed description of the main functionalities of the tool.

As part of the evaluation process of the tool, the 112 cities selected to join the EU Mission: 100 Climate-neutral and smart cities by 2030 (European Commission: Directorate-General for Research and Innovation, 2024) were used as case study. The results can be accessed through an interactive map (Transform Transport, N.D.), and show the advantages of the tool in the optimization of proximity services analysis for walkability planning and in support of the 15-minute city concept.

The future versions of the tool are intended to extend the functionalities with the idea of building a more scalable and versatile toolkit. In particular, the development will focus on the utilization of custom pedestrian networks as alternative data input and add functionalities to highlight zones covered by the different proximity services in the model of the 15-minute city.

The current distributions of the 15min City Score Toolkit are available on Zenodo (Albashir et al., 2024a; Albashir et al., 2024b) and are shared with the license CC BY-NC-SA 4.0 (Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International) (Creative Commons, N.D).

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### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Credit authorship contribution statement

**Abubakr Albashir:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Visualization.

**Federico Messa:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – original draft, Writing – review & editing.

**Dante Presicce:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – original draft, Writing – review & editing.

**Alessandro Pedrazzoli:** Methodology, Validation, Formal analysis, Investigation, Resources, Data curation.

**Andrea Gorrini:** Conceptualization, Methodology, Validation, Investigation, Writing – review & editing.

**All authors have read and agreed to the published version of the manuscript.**

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