

Define the scope of 15-minute living circle based on big data analysis: a case of Tangshan, China

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Article

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Abstract

15-minute living circle, focusing on improving service facility accessibility and facilitating green travels, can mitigate climate crisis and improve poor life quality caused by inconvenient service facility layout. Define and delineate the 15-minute living circle is still a geospatial conundrum. Current approaches often simplify living circles into 'rectangle' blocks, or plot them by using real travel data, but ignore actual travel modes. To fill in this gap, this study explores the reachable and actual scopes of 15-minute walking living circle. Taking Tangcheng 101 Community (TC101) in Tangshan, China as a case, it takes following qualitative steps, 1) identify the exits and the farthest points of exits (FPEs) of the community and use them as origin points; 2) set up a grid of points centered on the community and use points as destination points; 3) calculate the walking time from each exit (or FPE) to each grid point through Gaode Map API and connect all the grid points being 15 minutes to create 15-minute isochrones of each exit (or FPE); 4) define two categories of living circles: General living circle and Absolute living circle. The General living circle is the union of isochrones of exits, which means the farthest scope the residents can reach; and the Absolute living circle is roughly the intersection of isochrones of FPEs, which means the largest scope accessible to all residents. The radii of the two living circles are about 1.3 km and 300 m respectively. 34014 georeferenced phone data were used to verify the scope of living circles. As the General living circle is crucial for delineating 15-minute living circle boundaries and the Absolute living circle is crucial for laying out service facilities, this study may provide insights for policies related to residential area planning and living circle planning.

Highlights

- Novel ways to delineate 15-minute living circles.
- A calculating method of the reachable range within 15 minutes from the exists of communities based on Route Planning API.
- A georeferenced phone data method to calculate and visualize the real activity range of residents on foot within 15 minutes.
- Two categories of 15-minute living circles, viz. General living circle and Absolute living circle, were proposed.
- The radii of two categories of 15-minute living circles are about 1.3 km and 300 m.

1 Introduction

1.1 Background: 15-minute living circle as a way to supply services in proximity

In recent years, with the accelerated pace of urban renewal and the continuous improvement of consumption level, the core business districts have been significantly improved, however, community facilities lag, which is incompatible with meeting the people's growing needs for a better life [1]. In

response to the poor quality of life caused by inconvenient services, and in order to allow residents to consume conveniently near their home and meet their daily needs, the community convenient living circle has emerged as a pivotal focus in urban planning [2]. The 15-minute living circle concept, emphasizing residents travel range in community planning, has gained global recognition.

In China, Shanghai city issued '*Shanghai 15-minute living circle planning guidance (abbreviated as SLCPG)*' [3] and carried out the 15-minute community living circle construction practice in 2016, inspiring other cities to adopt similar practices. In 2018, the Ministry of Housing and Urban-Rural Development issued the '*National standard for urban residential area planning and design (GB50180-2018)* (abbreviated as NSURAPD)', 15-minute living circle construction has become a pivotal tool to improve the service supply at the community level [4]. Between 2021 and 2023, the Ministry of Commerce cooperated with other ministries, piloting the 15-minute living circle construction in 100 cities, focusing on community functions enhancement [5]. By May 2023, over 80 cities have implemented the practices, resulting in the establishment of 1402 15-minute living circles, benefiting more than 32 million residents [6].

Internationally, similar policies have been adopted to supply community services and enhance community livability. In American, the '20-minute living circle' introduced by '*The Portland Plan*' in 2012, proposed a facility accessibility index of community calculated by the proportion of the population living within 20-minute walking distance to basic service facilities [7].

In Canada, the '*15-minute neighborhoods baseline report 2021*' serves as a key strategy in the Ottawa '*Five Big Moves*', focusing on transforming existing communities into walkable spaces [8]. Paris Mayor Anne Hidalgo implemented the '*15-minute city (ville du quart d'heure)*' plan in 2020 [9], aiming to improve proximity and convenience through government-led transformations and mixed-use projects [10]. In Italy, Mayors Roberto Gualtieri and Beppe Sala embraced the 15-minute city concept in their campaigns, investing 22.5 million euros and 1,351,322 euros in Roma '15 Town Halls, 15 projects for the city in 15 minutes' and Milan 'Spaces and services for Milan 15 minutes away' projects respectively to enhance public spaces, facilities, and urban connectivity [11][12].

1.2 Issue: delineating the scope of living circle

Current studies on living circle primarily focused on community governance [13], facility layout [14][15][16][17], residents' activity space distribution and scope delineation. Researchers discussed the scope of living circle from different hierarchies [18], travel modes [19][20], purposes [21], methods [22].

Although living circle is an abstract concept and a policy vision, it is necessary to know its scope. Given the aim of ensuring residents' convenience and proximity to essential services, understanding their typical travel distance or duration becomes foundational. Research indicates that people can usually sustain walking for 10 to 20 minutes [23], making the 15-minute threshold a standard scale for daily living circle. However, accurately delineating the scope of a 15-minute living circle based on real travel patterns remains a significant challenge.

2 A literature review on living circle delineation

Current studies on delineation can be classified into three types, theoretical and policies' scope based on road-enclosure, inferred scope based on geographic calculation, and real reachable scope based on real mobility data of residents. But the living circles in these studies are simplified into a regular shape, or violate the objective and real travel rules, or ignore the 15-minute time and travel mode.

2.1 Type 1: simplified rectangular scope through road enclosure

In most existing residential area planning theories, policies, and practices, e.g., Neighborhood Unit, Traditional Neighborhood Development (TND), Transit-oriented development (TOD), integrated community, NSURAPD, and SLCPG, the scopes are usually simplified into 'rectangles' bounded by roads. These theories have the prototype of the concept of living circle. The service facility radii are what these theories regarded as the maximum walking distances of residents and the radii of living circle. For instance, Clarence Perry, the theory proposer of Neighborhood Unit, believed that the tolerant travel distance for residents is about 400 m, which is the radii of a primary school [24]; Andres Duany and Elizabeth Plater-Zyberk, the theory proposers of TND, regarded 400 m as the appropriate radii for a neighborhood [24]; Calthorpe, the theory proposer of TOD, set the tone for TOD that the appropriate maximum walking distances of TOD are at roughly the quarter-mile (400m) and half-mile (800m) for bus and rail stop, respectively [25]; Shaoqin Zhuang, the principal of SLCPG, believed that this distance is about 1 km and the scope of living circle is about 3 km² based on service need surveys [3]; although Liangyong Wu, the theory proposer of integrated community, did not propose a specific number, he believed that community should be a broad residential area integrated multiple functions [26]. However, these conceptualizations are often simplified into 'rectangular block' enclosed by road boundaries, and lack consideration for residents' real travel patterns, extending beyond the residential area. For example, Perry proposed "a plot of land surrounded by car arterial roads [27] (about a few hectares)"; Shaoqin Zhuang proposed that "the smallest planning unit is a neighborhood (of about a few hectares)", and believed that the layout of facilities within this "square" can meet the needs of residents. In China, for most planning practices carried out are in accordance with NSURAPD, the living circle delineation is mainly based on the land parcel boundary [28], this part will be discussed in detail in chapter3.

A unique concept, the 15-minute city [9], addresses this limitation. Its connotation embodies a regional idea that go beyond the local and plan at a broader level, and it is proposed to include the travel range outside the residential area into the planning range of the residential area: 'neighborhoods within a city need to be fashioned with a combination of 15-minute walk or bike ride radii, so that urban residents can access most services and urban amenities' [29]. A literature believes that within 15 minutes, the radii of walking is 1.2 km, and the radii of cycling is 4.8 km [19]. The precise distances are not universally defined. Implementation challenges have led to variations in practice. In many European and American cities, the concept's practical application has often deviated. Instead of delineating the living circle, plans focus on the service circle of facilities, evaluating areas based on service facility accessibility [28][30]

[31][32][33][34][35][36][37]. Therefore, the reachable range of residents with a 15-minute walk or bicycle are rarely addressed. This is not conducive to matching the supply of service facilities with residents' needs.

2.2 Type 2: inferred scope via geographic calculation

Current researchers' delineations on GIS technical tools are based on 1.5 km buffer of community's center point [38] or 15-minute isochrone of community's centroid [39] or geometric barycenter [40]. However, these delineation methods are too rough, for they just calculated of travel distance from center point, but they violated the objective and true travel rules, and lacked logical reasoning about the reachable range.

2.3 Type 3: actual reachable scope using resident mobility data

Most studies focus on the numerical values of distance, for example, their findings show that more than 50% of walks were up to 800m and lasted up to 15mins [41], more than 80% of rides are less than 3 km [42].

Some studies visualized living circle scope by employing travel data like travel surveys, GPS tracks, and cell phone data. Loehach J E, Li Yin, and Huang Jianzhong used GPS data through Raster Convert, Convex Hulls, and TIN methods to measure the scale, distribution, and specific boundaries of the neighborhood activity spaces of different age groups [43][44][45]. Li Yin identified young people's concentrated activity within a 400m radius [44].

Defining the scope of living circle as the smallest area containing 50% of the residents' travel activities, Huiming Huang found the radii of the scope is 0.8—1.8 km [46], while Sicong Zou found the radii is about 1 km, and the area of the scope is about 392 hm² [47]. Contrasting with the SLCPG's 1.5 km radius, De wang discovered that the scope of 42.3% of Shanghai's communities exceeded this radius, especially in the suburbs [38]. Naess P also certified this conclusion [48]. Beijing's living circle radii averaged 11.69 in outer suburbs, 7.17 in inner suburbs, and 5.58 in downtown [49]. However, these visualizations are relatively general, for the travel time and mode are not discussed, so the real reachable scope of a 15-minute walk or ride is still unclear.

2.4 Framework of this study

This study explores the reachable scope of residents on foot within 15 minutes, to fill in the gap that current studies have and to offer insights for delineating 15-minute living circle. Firstly, the study outlines China's planning methodology for delineating 15-minute living circle, delving into national standards and pilot city planning, serving as the foundational point of inquiry. Secondly, a novel delineation method of the reachable scope of residents on foot within 15 minutes is introduced, based on the combination of isochrones of community exits (and entrances, unified as exits) or that of the farthest points of exit, with calculating time cost of each virtual travel through Gaode Map API. This method forms the core of the

research. Thirdly, the real scope of residents on foot within 15 minutes of Tangcheng 101 Community (TC101) is visualized based on cell phone data, and the discrepancies between the real scope and the farthest reachable scope are examined, providing a verification step to validate the accuracy of the core methodology. Finally, the findings are discussed, and implications for policymakers and urban planners are presented. One contribution is that the delineation methods integrated with Map API and big data technology of the scope of living circle are conducted. Another contribution of this study is that two categories of living circle were found: General living circle and Absolute living circle, and General living circle refers to the farthest scope where residents, those who live near to the exits, can reach within 15 minutes, while Absolute living circle refers to the scope where any resident, no matter where he lives in the community, can reach within 15 minutes.

3 Practice of living circle delineation in China

3.1 National standard for urban residential area planning and design

The NSURAPD was issued on July 10, 2018, and implemented since December 1, 2018. The purpose of this standard is to "adapt to the changes residential demand, promote the scientific, standardized and humanized planning and design of urban residential areas, and improve the quality and level of urban residential areas".

Based on the living need of residents, the main contents of this standard include the following aspects: The living circles at different hierarchies are defined; the principle and the indicators of land use, service facility, road and environment of urban residential area planning and design are stipulated.

Among them, the main contents related to the 15-minute living circle are:

- (1) The 15-minute living circle is defined and the delineation method and principle of its boundary is come up with.
- (2) To guarantee the land be developed reasonably and effectively, the land use of 15-minute living circle should be controlled by some criteria of per capita residential land area, residential land Floor Area Ratio, and the proportion of various types of land use.
- (3) The 15-minute living circle should provide service facilities according to standards from different levels. From the macro aspect, the principle and the land area per 1,000 people and the building area per 1,000 people for facilities (Public management and public service facilities, transportation station facilities, commercial service industry facilities, etc.) are stipulated. From the micro aspect, the service radii and time cost, building area and land area of individual facilities (school, shop, etc.) are stipulated [4].

The NSURAPD' delineation principle consists of the need of residents, road and administrative boundaries and number of residents. The 15-min living circle refers to a neighborhood where residents can meet their material and cultural needs within 15 minutes (800m-1000m). It is surrounded by city main roads or block boundary, supplying accommodation for 50000–100000 people (about 17000–32000 chambers), with enough facilities set. The 10-min living circle refers to a neighborhood where residents can meet their basic material and cultural need within 10 minutes (500m). It is surrounded by city main roads, sub-hierarchy roads or block boundary, supplying accommodation for 15000–25000 people (about 5000–8000 chambers), with many facilities set. The 5-min living circle refers to a neighborhood where residents can meet their basic need of living within 5 minutes (300m). It is surrounded by sub-hierarchy roads or block boundary, supplying accommodation for 5000–12000 people (about 1500–4000 chambers), with community service facilities set [4].

3.2 15-minute living circle planning in pilot cities

In August 2021, Tangshan was chosen as a pilot of living circle planning of first thirty cities listed in 'Opinions on Promoting the Construction of Urban 15-minute Convenience Living Circles' issued by Ministry of Commerce. Under the guidance of Tangshan Bureau of Commerce, 'Plan for the construction of convenient living circle in downtown Tangshan 2021–2035 (abbreviated as PCCLCDT)' was planned by Tangshan Planning and Architectural Design & Research Institute. There are two key processes of 15-minute living circle planning of Tangshan: the delineation of living circles and the setting of facilities for each living circle.

The PCCLCDT has three hierarchies: 15-min living circle, 10-min living circle, 5-min living circle (Attached Fig. 1, Fig. 1). PCCLCDT's boundary is nearly the same with the boundary of Tangshan's built-up area. One 15-min living circle may contain many 10-min and 5-min living circles. There are 48 15-min living circles, 290 10-min living circles and 4907 5-min living circles. The delineation is mainly based on administration boundaries, road boundaries and block size. In terms of road boundary, most of the living circles are divided by city main roads and branch roads. In terms of administration boundary, most of the 15-min living circles are based on Jiedao (Sub-District) office administrative areas. These living circles overlap with the corresponding management scope of some Jiedao offices (Fig. 1b and c). Similarly, 10-min and 5-min living circles are based on the administrative area of residents' committee (居民委员会) (Attached Fig. 1). In terms of block size, for the 15-min, 10-min, and 5-min living circles, the length of the block is about 2 km, 1 km, 0.5 km respectively. Take Tangcheng 101 as example. Tangcheng 101 is a rectangular residential area, the mobility of its residents is easy to describe. This community is located in the city center, and it is a well-known neighborhood where the rich live, with the mean price being 24,000 rmb/m². Consisted of villas and apartments, this community supplies accommodation for 900 families, with a floor area of 307,692 m². The largest range represents the 15-min level living circle, the middle one represents the 10-min level living circle, and the smallest one represents the 5-min living circle, which just overlap the boundary of the residential area itself (Fig. 1a). This means that in government's opinion, the residents are regarded only doing activities within three rectangles in 15, 10, 5 minutes rather than outside of them, which is obviously wrong.

3.3 Insufficiencies of delineation

The reason and purpose of delineating living circles into 'rectangles' rather than 'circles' based on administration and road boundaries is to avoid overlapping between one living circle and another, and avoid the problem of unclear responsibility of overlapped area, then the subject responsible for public service facility setting of responsibility of every circle can be clarified. In terms of block size, the purpose of delineating the city into units with a certain length at each level is to guarantee the accessibility within a short time and distance. Take the 15-min living circle as example. If the length of block is controlled less than 2 km, or a grid of 2 times 2 km is drawn, the travel distance to the facility which is in the center of the grid ideally will be less than 1.414 km ($\sqrt{2}$), the fact that the travel time less than 15 minutes can be guaranteed. But this can only be achieved in an ideal image, usually the facilities are distributed anywhere on the grid, not just the center. Let's consider an image that four facilities (e.g., school) are located in the corners of grids farthest from a resident, the resident will need almost 30 minutes to reach the facility, because the nearest distance of school will be 2.828 km ($2\sqrt{2}$) (Fig. 2). Therefore, this 'rectangle' delineation method based on administration boundary, road boundary and block size are unreasonable.

Through the standard and Tangshan case, it can be summarized that the delineation principle is mainly based on the road and administrative boundaries, especially, the size of block, to guarantee residents' service facility accessibility from home within a short time and distance. But above analysis has proved that the control of length of block less than 2 km failed in guaranteeing accessibility within 15 minutes. Even the number value is changed into a smaller one than 2 km and guarantee the accessibility, this method still has insufficiencies. It ignores realistic travel of residents. The travel will beyond the road and block boundary and residents will make use of the facilities outside the block. Therefore, it is not necessary to set facility only inside the block, which is a bit too wasteful. To explore an exact scope of the residents' usual travel activities and set facility in this scope help solve these problems.

4 Methods

4.1 Study area and data description

(1) residential area

The TC101 was selected as the residential area. Its boundary was drawn based on Gaode map. The length and width of it are 620 m and 490 m respectively. The size is a normal block size in Tangshan (more about TC101 is in Chap. 3). It has 4 corners. The experiment was conducted in the QGIS 3.20.3 and PyCharm 2021.2.3 and Jupyter Notebook.

(2) exits of residential area

Like most of the communities in China, TC101 is a gated community where residents leave the community from exits to start their travels. The exits of it should be marked first (Fig. 3). For the

residents living close to exits reach much further than others living far away from exits within the same time, the reachable scope is made up by the travel of the residents living close to exits, with the distance from these residents' homes to the exit being ignored, approximately equal to the union of isochrones of exits. Based on Baidu Map and Street View, there are eight exits at all in TC101, which are marked as 1 to 8.

(3) 'destination' points around residential area

To clear the scope of 15-minute isochrones of exits, a point grid of 12080 points with a 2500 m radius was drawn based on Centroid of TC101. The interval between two points are 40 meters. These points can be regarded as the destination points (D) when the exits are regarded as the origin points (O).

4.2 Analysis steps

(1) Calculate time costs of OD points

Then the time costs of travel from each exit to each destination point were calculated by 'Route planning' through Gaode Map API. 'Route planning' is tool when the longitude and latitude of the OD and the travel mode are input, the walking time cost will be output in the python [50]. The total number of calculations is $12080 \times 8 = 96640$. Therefore, the technical basis of this method is big data.

(2) Acquire the 15-minute isochrone of each exit

The D points with a cost time less than and equal to 15 minutes were kept. Now, for each exit, it has own 15-minute scope consisted of these grid points kept, and the 15-minute isochrone made up by the points at peripheral.

(3) Combine isochrones of exits

Eight 15-minute isochrones of eight exits were are unioned to form General living circle of TC101, which refers to the farthest reachable scope that the residents of TC101 can reach from home. These residents are those who live closely to the exits, so General living circle is the circle for some people rather than all people (Fig. 3, Fig. 4).

(4) Mark the farthest point of each exit

Absolute living circle refers to the scope that all residents of TC101 can reach within 15 minutes from home. The Absolute living circle is smaller than General living circle (Fig. 5, Fig. 4). The first step of drawing Absolute is finding the farthest location of each exit by real distance, which can be called farthest point of exit (abbreviated as FPE). After 10000 random points of TC101 boundary are generated, the FPEs on the boundary are also found by 'Route planning' through Gaode Map API. There are 8 FPEs of TC101, namely as 1_F et al (Fig. 5).

(5) Calculate time costs of OD points and acquire the 15-minute isochrone of each FPE and each corner

Similar to step (2) and (3), then the time cost of both 8 FPEs and 4 corners to D points were calculated through 'Route planning' and only D points with a time cost less and equal to 15 minutes were kept. Twelve 15-minute isochrones were acquired (Fig. 5, Attached Fig. 2).

(6) Combine isochrones of FPEs and corners

The third step is combining these twelve 15-minute isochrones of these FPEs and corners by taking the intersection rather than the union of these ranges (Fig. 5). The reason we don't simply take out the intersection of exits' isochrones is that if we only intersect the isochrones of exits from 1 to 8 without considering the isochrones of FPEs, the problem that some zones which some residents cannot reach within 15 minutes will exist and these zones will be included into Absolute living circle incorrectly. For example, for the exit 1 at the right down corner of TC101, there is a zone circled by ellipse beyond 1_F's isochrone. The reason is considering the isochrones of FPEs rather than other points is that the scope of all people can reach is the target, so for certain exit, if the scope of which people living in the farthest of the exit can reach, any resident of TC101 can reach. That is, for the area around a certain exit, the isochrone of its FPE's is smaller than the isochrone of any other point. Take the exit 1 as an example, the Fig. 5 shows that 1_F's isochrone is smaller than 2_F's isochrone near exit 1. The reason that the 4 corners are considered is that in the ideal situation, the Absolute living circle is decided by isochrones of 4 corners (especially the farthest corner of the exit), no matter where the exit is and the size of residential area (Attached Fig. 3).

5 Results and discussions

5.1 General living circle and Absolute living circle

(1) shape: rhombus

Two categories of 15-minute living circles of TC101 were found by combination of the exits and FPEs' isochrones, they are General living circle and Absolute living circle.

Both types of living circles are not rectangular, but they are not circular either, but closer to rhombus, which is a rule that goes against people's experience. This finding is also different from that of some researches, where the scopes are fan-shaped [44] or circular [39][40]. Especially the General living circle, its diamond-shaped characteristics are very obvious. The sides of the community are facing the corners of rhombus General living circle, and the corners of the community are facing the sides of rhombus General living circle (Fig. 4). The reason is that the directions facing the exits (that is, the directions perpendicular to the TC101 community's four sides) towards straight roads, and the travel paths are also straight; while in other directions, there is no straight road to reach directly, and people must go through several turns, so the travel path is usually curved, resulting in the longest distance that can be reached in other directions within the same period of time (such as 15 minutes) being shorter than the direction facing the exits. At least for a grid-shaped city, the diamond-shaped characteristics of the living circle can be understood in this way.

(2) radii: about 1.3km and 300m

The scope of General living circle is much bigger than that of Absolute living circle. Out of the considering the real situation that people are likely to do activities at the exit closest to them, the General living circle is more meaningful. It is also easier to be implemented than Absolute one, for one thing, the calculation is simpler, for another, no matter what the size of the community is, a General living circle can be formed, but an Absolute living circle cannot be formed when the community is too large, like a famous super big community named Huilong guan in Beijing, where residents do not share any space because they cannot reach a common area within 15 minutes.

The radii of two living circles are about 1.3 km and 300 m, with the length and width of TC101 is 620 m and 490 m respectively (Fig. 4). The value 1.3 is close to the value 1.2–1.5 of some researches [19][38], but is bigger than the rule of 1 of SLCPG and 0.8-1 of NSURAPD. The number of the radii and the area of the living circles should vary with the size of the community, but the minimum scope of the General living circle is about 3 km² (when the residential area is very small, close to 0), the minimum scope of the Absolute living circle is 0 (when the residential area is very large), and the maximum scope of the Absolute living circle is about 1 km² (when the length of long side of residential area is equal to the radius of 15-minute walk isochrone, $L = R$) (Attached Fig. 3).

5.2 Validation of living circle scopes by phone data

(1) Select the cell phone data of residents

To examine the scope made up by the isochrones in 4.1, another method was applied through visualizing residents travel behavior with cell phone data. The cell phone data was from Smart Footprint Company, whose mother's company is China Unicom, the earliest network communication company established in China in 1994. The date of data is between 01.10.2020–31.10.2020. Every piece of data contains the longitude and latitude of start and end points, the travel time. There are 34014 pieces of data whose start points' location are within the boundary of TC101.

(2) Identify the data of residents' travel on foot

Because the cell phone data has no statement on travel mode, it is necessary to identify the data of pedestrian mode first. For that, the real travel time was acquired by 'Route planning' through Gaode Map API, with the model set as walk, bike, electronic bike, bus, and car. For each piece of data, compare the time cost from cell phone data and Gaode Map API, the mode that spent the time closest to the time in cell phone data was regarded as the travel mode of the data. For example, the time of a phone data is 10 minutes, the time of a route by walk is 12 minutes, the time of a route by bike is 4 minutes, then the mode of this piece of data will be judged as walk. After deleting 2194 data getting no results of the real travel time by 'Route planning' caused by technological problem, there are 1898 of 34014 data whose travel modes were judge as 'walk' (Fig. 6).

(3) Select the data that the travel time of residents is less than 15 minutes

After identifying the travel mode, the data of which the travel time of residents on foot are less than 15 minutes were kept. There is a dataset with 36 remaining data (Fig. 6), most of which are within the General living circle, and the real travel range almost coincides with the farthest reachable range, which shows that our method of delineating the General living circle is correct (Fig. 7). If we want to verify that the scope of Absolute living circle is correct, we need to prove that the distance between any space in Absolute living circle and any space in the community are within a 15-minute walk. On the other hand, if it takes more than 15 minutes to walk from a certain space in the Absolute living circle to a certain space in the community, then this Absolute living circle is wrong. The dataset proves that no such space exists. That is, the time costs from the destination points to the origin points in the living circle are within 15 minutes. Therefore, based on current data, the Absolute living circle scope is correct.

5.3 Suggestions

(1) planning: delineation of living circle should take into consideration reachable and real scope of residents' travel

Comparing the three categories of living circles, i.e., the scope of the government's planning, the scope of General living circle representing the farthest reachable range, and the scope of real walk travels within 15 minutes, it is obvious that the scope of the living circles of government's planning is inconsistent with the scope of the General living circle and the actual travel living circle, which means the government's method ignored the reachable scope where resident do activities and the government is likely to ignored the residents' service needs behind their travel behavior (Fig. 7). This will lead to two bad facility-mismatched consequences. First is the low facility accessibility, if some facilities are set in the zone beyond the General living circle, people in TC101 would hardly use them by taking green travels because they are too far to reach within 15-minute walking. Second is the deficiency of facility supply, if some populous areas are equipped with few facilities, this area may lack necessary services.

Therefore, the delineation method of 15-minute living circle and the new method should take into consideration reachable and actual scopes. A simple method is to delineate living circle only based on General living circle, while a complex method also based on real scope, that is, to modify the scope according to the scope of actual travel space. The 15-minute living circles of neighboring communities delineated by these methods will overlap each other. In the next step of facility layout planning, it is sensible to set the most important facilities in Absolute living circle, secondary facilities in General living circle, and the least important ones in other areas for a community, which makes the important facilities more available for most of residents. Furthermore, if different aged group live in different part, target facility for certain aged group by drawn their living circle.

(2) governance: unified planning and adjustments to facilities of living circles spanning residential areas

The responsible subject of living circle construction, especially in the overlapping areas of several living circles, must be the administrative bodies superior to the local residents' committee, such as Jiedao office or even District government, and the unified planning of service facilities and other elements of

physical environment should be made under their leadership. This will create at least two benefits. Firstly, the subject for living circle planning can control the planning, construction and government of the projects in the whole process, and allocate the appropriate funding for each project. Secondly, a unified planning process can help avoid duplication of facilities in different communities and, at the same time, alleviate space contention issues caused by insufficient space, because the subject can allocate public resources more rationally and scientifically. To make the unified planning more powerful, the public participation is indispensable. The government subject should listen to the opinion of the communities and residents concerned in the whole process from planning compilation to planning implementation, making the unified living circle planning a plan integrates the will of all levels.

6 Conclusions

The greatest significance of this research is that two living circle concepts are proposed, and the suggestion for living circle planning were put forward from planning, and governance views. The consequences can not only help the planners, but also help the policy makers of community planning and facilities planning.

Current facility planning employs a homogenized layout with certain service radii, ignoring the consist proportion of people served. So, the NSURAPD is issued with a goal that planning living circle and setting service facility to meet the need of certain group rather than homogenization [51]. Living circle analysis in this study can help match the facility with target group, because the irregular living circles represents the reachable scope of residents living in the different parts of a community.

Despite the valuable insights gained from this study, certain limitations should be acknowledged. The study focuses on a specific case community in Tangshan, limiting the generalizability of the findings to other geographical contexts. The distribution of residential area exits may affect the scope of living circle. Conducting similar analyses in diverse urban settings, e.g., with non-grid urban form, will provide a more comprehensive understanding of living circle scope.

Declarations

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Author Contribution

Y. Z. conceived the study, conducted the analysis, and wrote and revised the manuscript.

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Figures



Figure 1

Delineation method of living circles in the Living Circle Planning of Tangshan. a) Three hierarchies of Tangcheng 101 community living circles. b) Delineation of 15-minute living circles in the Living Circle Construction Plan of Downtown Tangshan 2021-2035. c) Delineation of Jiedao office administrative areas, which is one of the bases for delineating 15-minute living circles. (color should be used in print)

Data Extraction and Analysis Framework

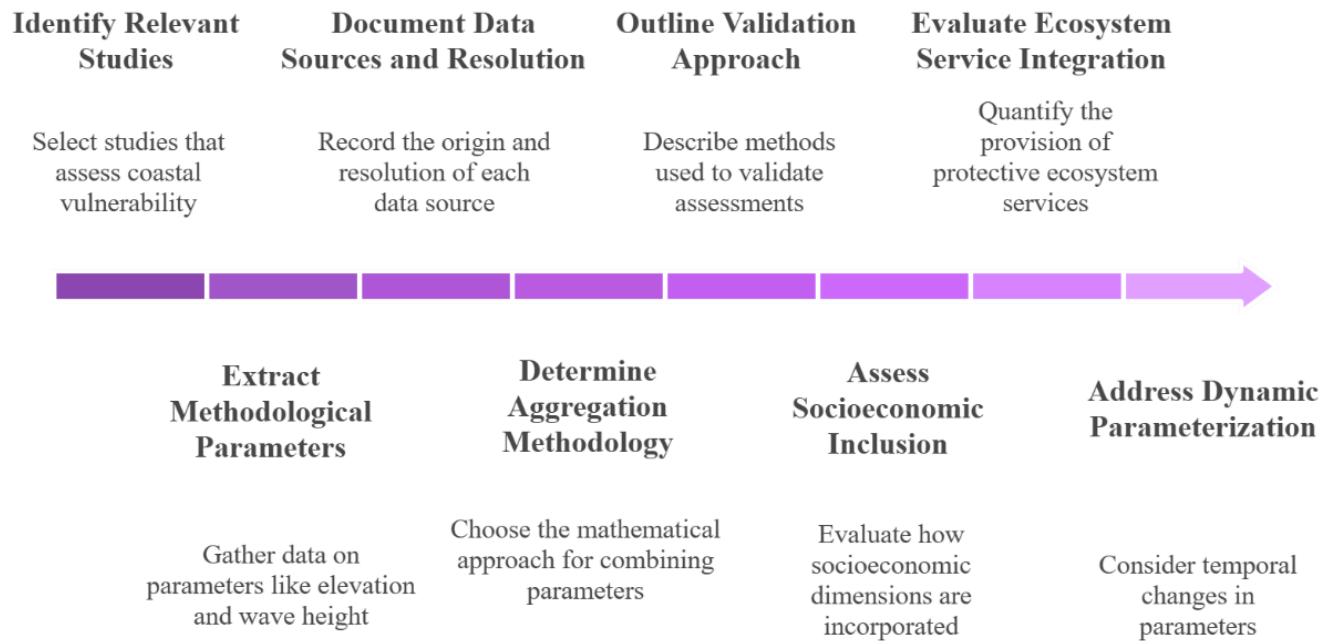


Figure 2

Facility planning after delineation and the exploration of reason of delineation from facility accessibility view. a) The unreasonable proof of delineation method based on the block size of 2*2 km. b) The commercial center facility planning in Plan for the construction of convenient living circle in downtown Tangshan 2021-2035. (color is not necessary in print)

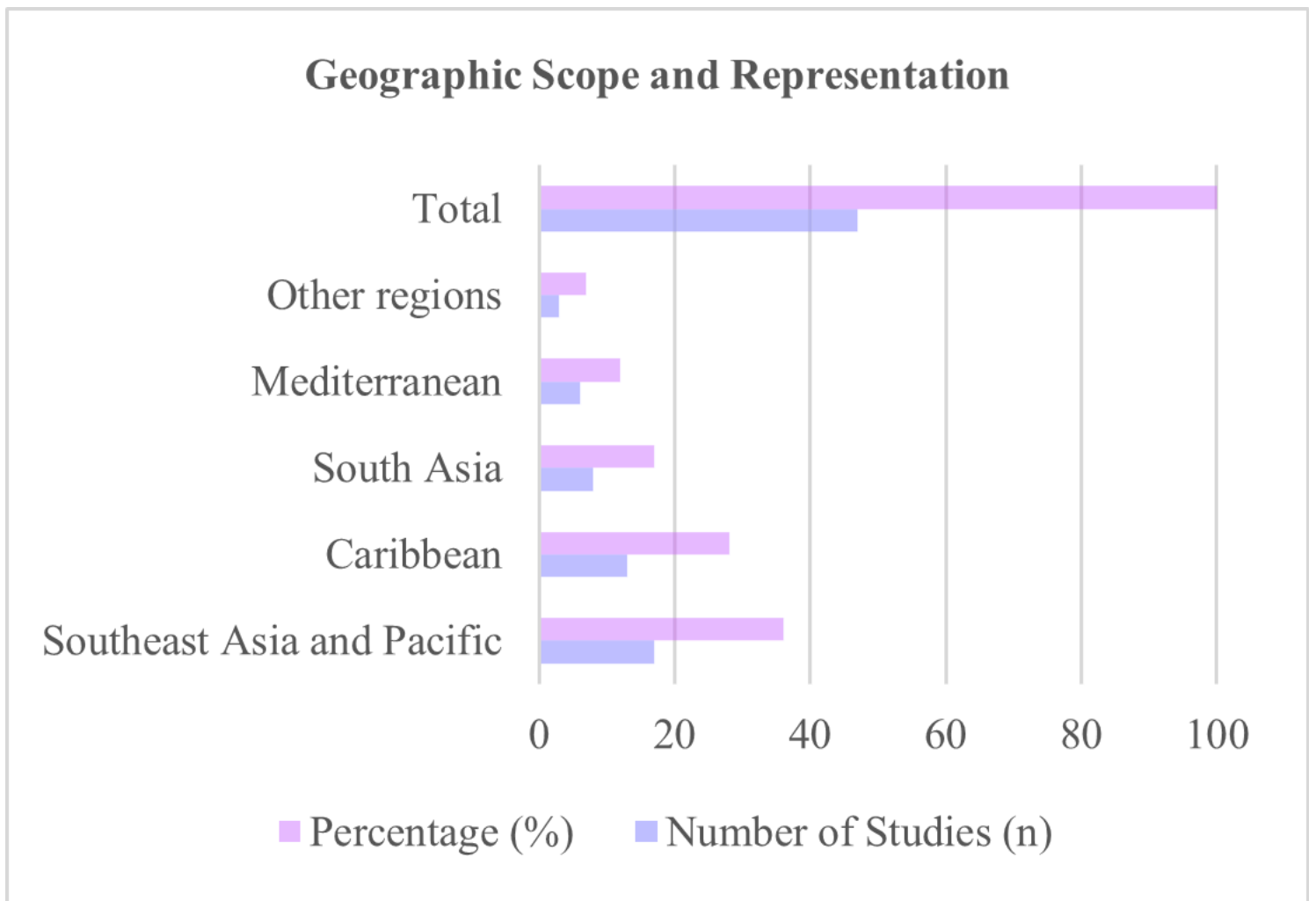


Figure 3

The steps of delineating the General living circle of TC101 (color should be used in print)

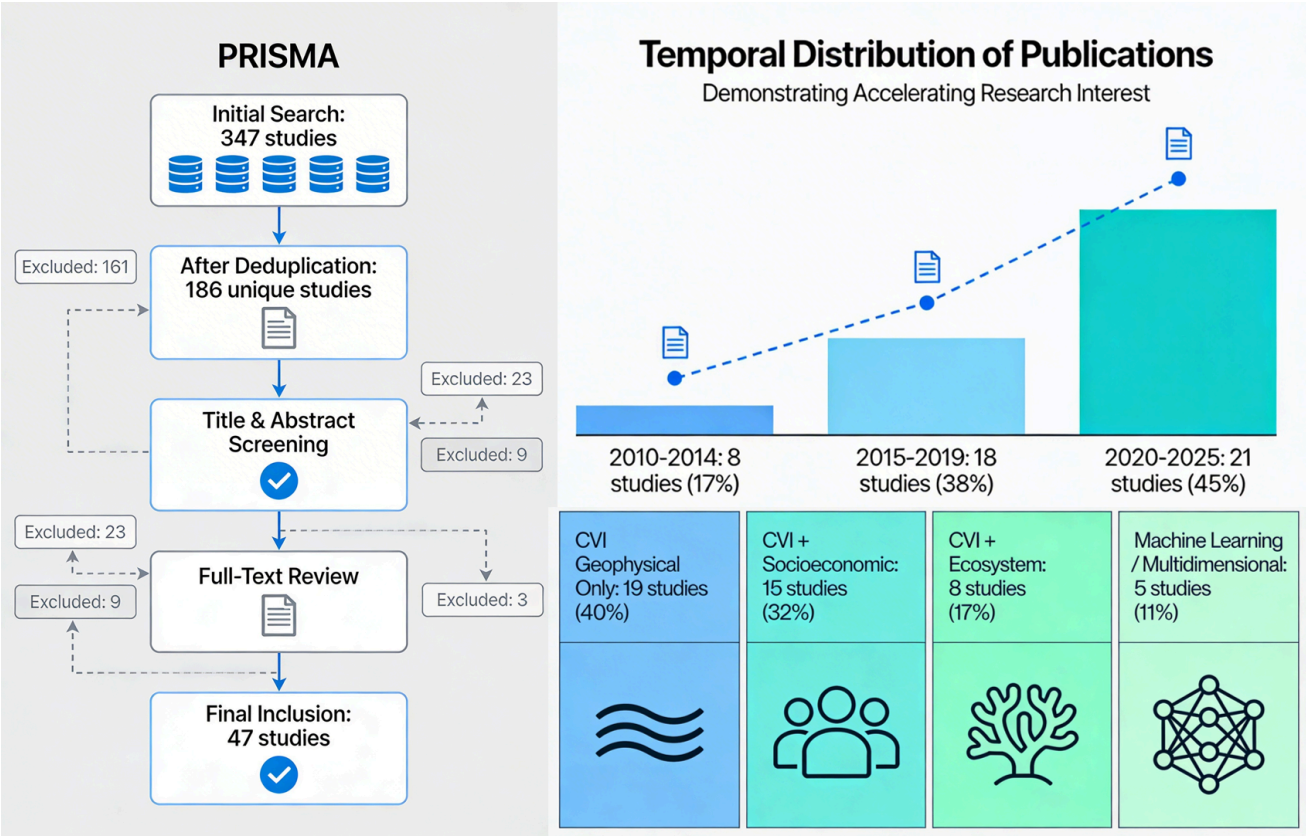


Figure 4

General and Absolute living circles of TC 101 (color should be used in print)

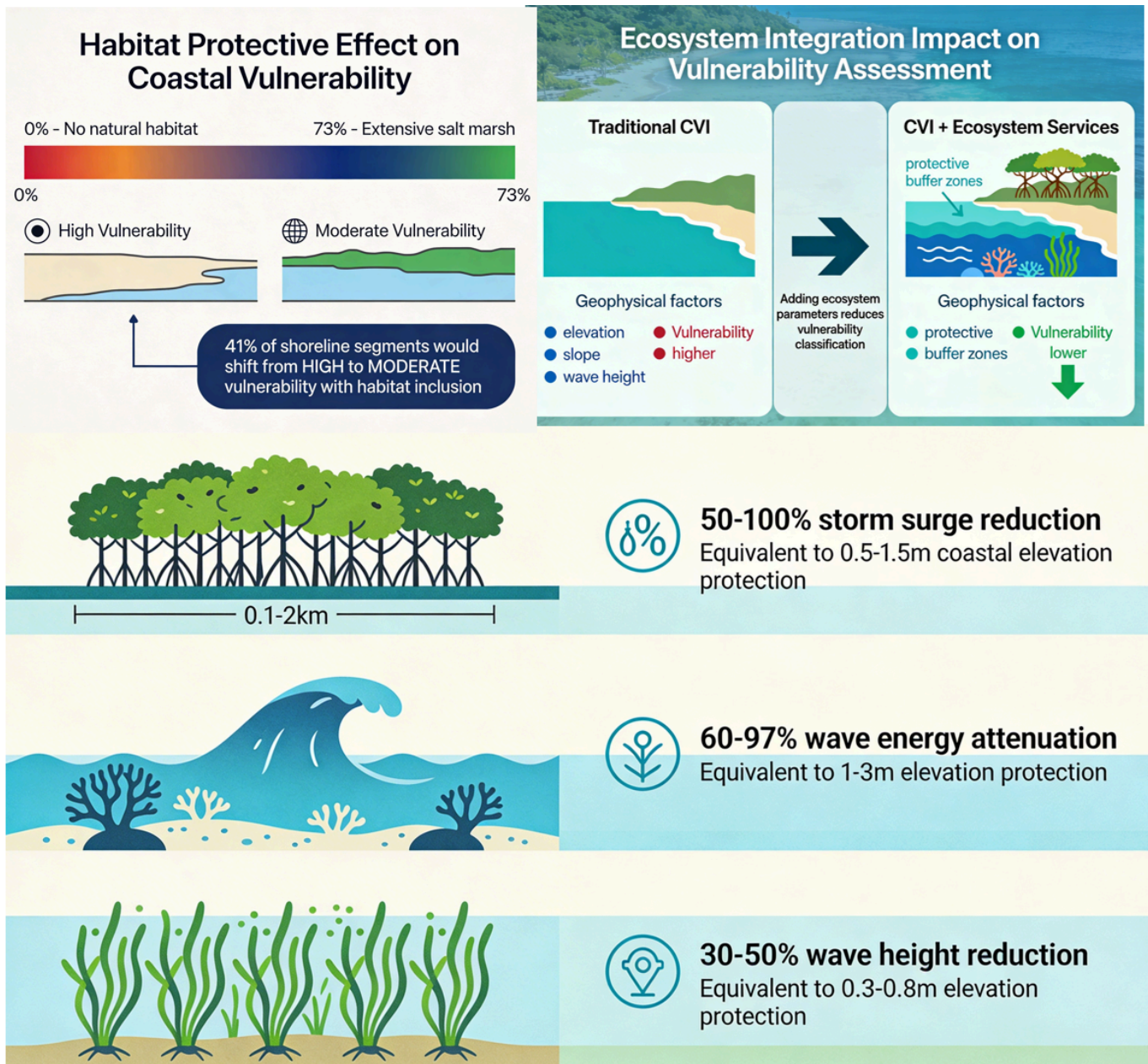


Figure 5

The steps of Absolute living circle delineation (color should be used in print)

Evolution of Coastal Vulnerability Assessment Methodologies

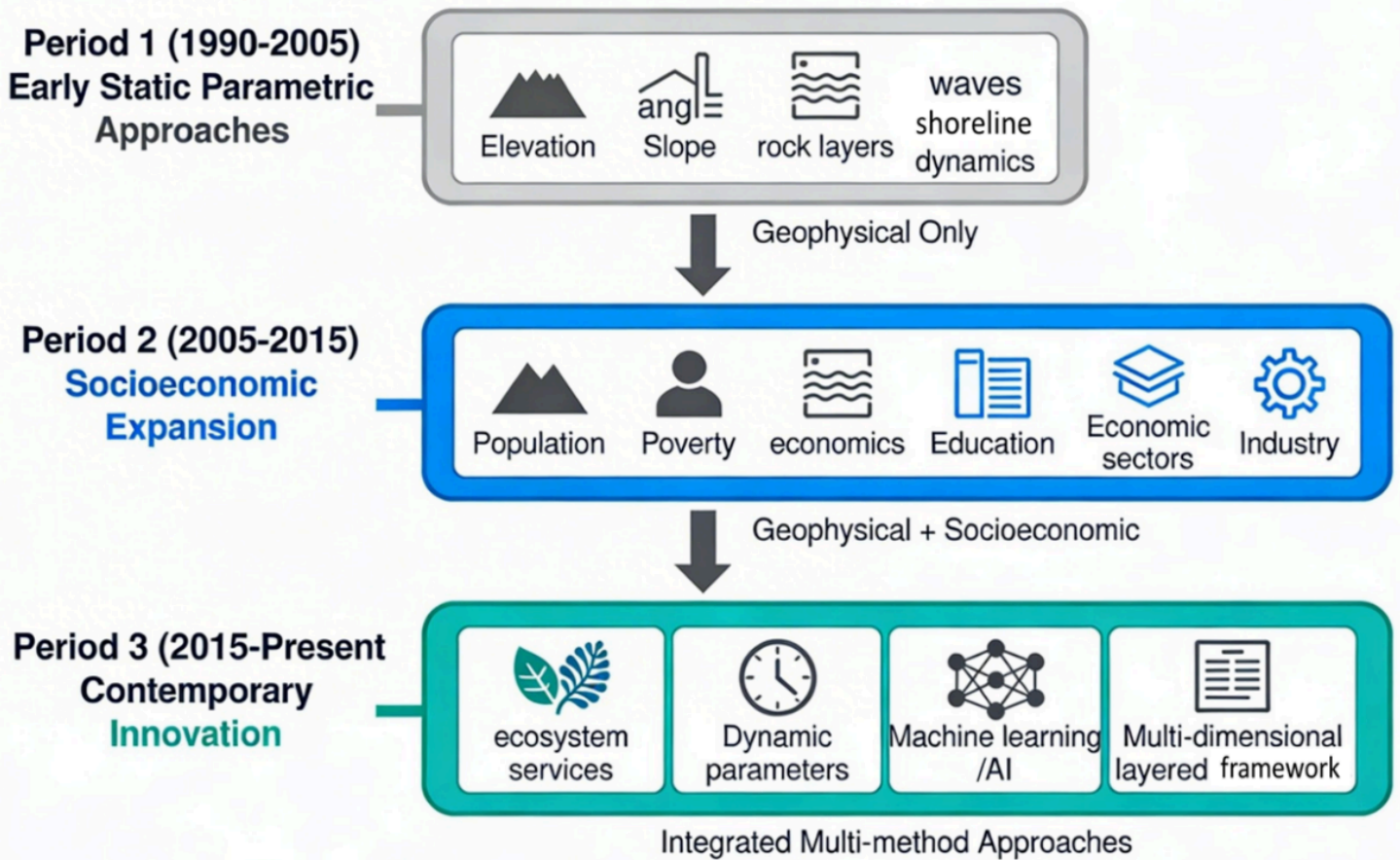


Figure 6

The distribution of real walk travels based on cell phone data and its 15-min scope of living circle, and the number shows the time cost (seconds) of walk (color should be used in print)

Mangrove Protective Mechanisms — Coastal Cross-Section

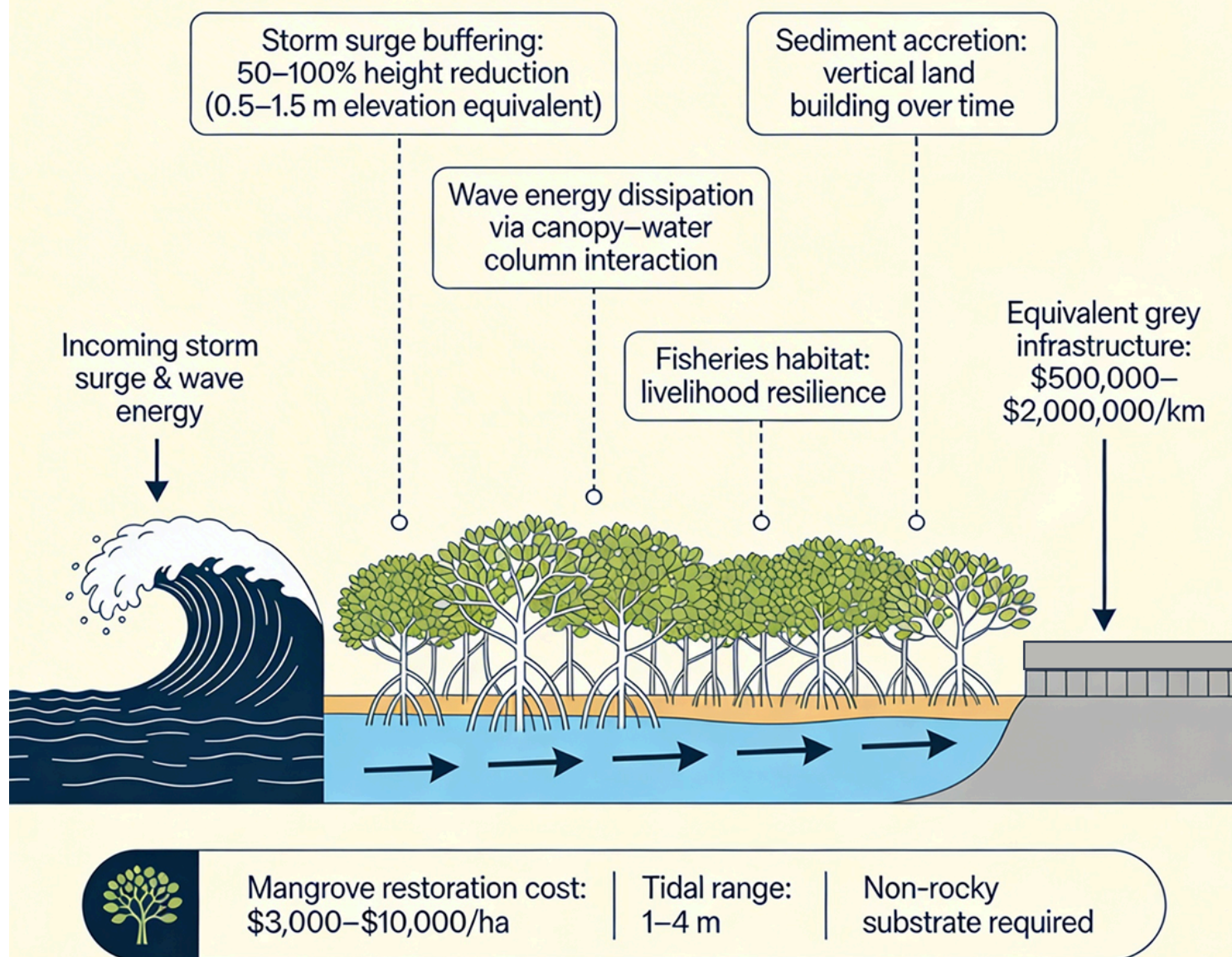


Figure 1. Mangrove-based NbS: Protective mechanisms and elevation-equivalent benefit.

Figure 7

The comparison of three types of 15-minute living circles, they are the scope of the government's planning, the scope of General living circle representing the farthest reachable range, and the scope of real walk travels within 15 minutes (color should be used in print)

Supplementary Files

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