GEOMATICS AND ENVIRONMENTAL ENGINEERING • Volume 18 • Number 5 • 2024

https://doi.org/10.7494/geom.2024.18.5.113

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A Roadmap for the Design of a Public-participation Geographic-Information System to Support Urban Ageing

Abstract: Geospatial technologies have the potential to transform the lives of older adults by providing them with necessary tools to navigate their local communities, access services, connect with others, and access valuable information. However, the usability and accessibility of such technologies often fall short of the needs of older adults. Many existing geospatial tools are not designed with the needs and preferences of older adults in mind; this can lead to usability challenges and limit their usage. This paper explores a participatory approach in developing an inclusive geodata-collection tool that is specifically tailored to older users' needs. The paper also highlights the importance of incorporating user-centered design principles, participatory design methods, and accessibility guidelines throughout the entire geodata-tool-development process. It also emphasizes the need for ongoing user engagement and feedback in order to ensure that the tool remains relevant and usable in the evolving digital landscape. This participatory approach has resulted in a tool that is easy to use and accessible for older adults; it is available in various languages, thus ensuring that the elderly can actively participate in the prototype's creation and contribute to the collection of the geospatial information that reflects their lived experiences and needs.

Keywords: public participation geographic information system, urban aging, older adults, age-friendly environments, age-friendly city

Received: July 19, 2024; accepted: September 23, 2024

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1. Introduction

Urbanization and aging are currently two dominating global trends, as one-in-six people are expected to be above 65 years old by 2050 [1–3]; in cities, one-in-four of their residents will be aged 65 and over by 2050 [4]. Therefore, studies and decisions regarding both urbanization and aging are very important for the future of everyone. Urbanization and aging have not yet received sufficient consideration, as two-thirds of governments mark aging as a concern for the coming decades [5]; only one-third of these (27 out of 81 governments) consider population aging to be a matter of significant policy concern for this decade [5]. Not prioritizing the needs of the aging populations and postponing proactive measures for decades is a rather age-insensitive approach [6].

As populations age worldwide, the challenges and opportunities that are associated with urban aging are becoming increasingly evident [7]. Nearly two decades ago, the World Health Organization [8] launched its Age-Friendly Cities and Communities agenda in order to support entities in their quests to become age-friendly and propagate the notions of active aging [9]. The WHO [8, 9] also proposed eight domains for pointing out the challenges that cities would encounter and in which actions were needed: outdoor spaces and buildings, transportation, housing, social participation, respect and social inclusion, civic participation and employment, communication and information, and community support and health services. Urban environments are homes to growing proportions of older adults; these individuals face unique challenges such as navigating their environments, accessing services, and maintaining their independence. Wayfinding through complex streetscapes, the walkability of neighborhoods, accessing public transportation, and finding adequate rest areas may become increasingly challenging for older citizens; these spatial aspects represent the foundation of the age-friendly movement [10]. Older adults may also face difficulties in gaining access to age-friendly housing, healthcare services, and recreational facilities; such problems can lead to social isolation, reduced mobility, and increased healthcare costs. Thus, an age-friendly urban environment is not merely a space in which a range of services are offered but also a place that facilitates and allows for the participation and contributions of older individuals [11].

Everyone can participate and contribute to their communities while maintaining their independence and health by living in age-friendly environments; well-being and health are also generally determined by one's physical environment [11–13]. Therefore, it is important to create age-friendly environments that can increase inclusivity while alleviating the challenges that can arise during the aging experience [12–16]. As mentioned by Pynoos and Nishita [17], enabling people to meet their basic needs, learn, grow, make decisions, be mobile, build/maintain relationships, and contribute to society are necessities for an age-friendly environment [9]. Age-friendly environments have now gone beyond merely supporting older adults in health-related issues and have begun to be designed while considering the fact that they also have different needs and preferences [18]. The current literature has emphasized the importance of comprehensive and inclusive support services for older adults by recognizing their varied abilities, thus enabling them to maintain their activities in urban environments and enhance the quality of their lives [19].

1.1. Geospatial Technologies for Supporting Urban Aging

Geospatial technologies offer a powerful and multipurpose set of tools that can be used to improve our lives in a wide variety of ways, such as enhancing decision-making processes, optimizing urban planning, strengthening public safety, empowering communities, improving education/research, and facilitating global collaboration [20]. To access the geospatial data, a web-based platform or application (which is called a geoportal) is needed. This is a useful tool for data collection and visualization for better understanding the spatial differentiations of features in city structures.

Geospatial technologies also offer a promising approach toward addressing the challenges that older adults face in urban settings [21]. Such technologies can improve the quality of life of older adults and the age-friendliness of urban environments by offering data and tools that facilitate mobility, access to services, and social participation [22]. The potential of geospatial technologies such as geographic information systems (GIS) offer a promising approach for addressing the demographic challenges that older people face in urban environments while enhancing their quality of life [23]. GIS can be used to collect, analyze, and visualize data that is related to the built environment, the availability of services and amenities (grocery stores, pharmacies, health centers, restaurants, etc.), and the distribution of social and economic factors [24]. Such data can then be used to identify those areas that are not well-suited to the needs of older adults, such as poorly-maintained recreational areas, dimly lit streets, or a lack of accessible transportation options. Also, geospatial data can be used to point out the urban environments that are well-developed and provide a sense of safety and security [25, 26]. GIS-based solutions may provide a valuable addition to the spectrum of available assessment tools for age-friendliness [26, 27] (which have often been qualitative or incomplete in nature [9]).

The question that was posed by De Longueville in 2010 ("Will tomorrow's Geoportals focus more on organizing communities of users sharing common interests?" [28, p. 299]) predicted today's widely used geospatial technologies [28]. It could also be foreseen that the geospatial web could offer a lot more than just online visualizations of geographic information by emphasizing its role in collaboration [28, 29]. Besides emphasizing the rapid developments in geospatial technologies, this question also highlights the importance of public participation in the development of geospatial technologies by identifying areas of common interest to communities and their needs [30].

1.2. Importance of Public-participation Geographic-Information System

As populations across the world age and the demand for inclusive urban planning grows, public-participation geographic-information systems (PPGISs) have emerged as a powerful tool for empowering disadvantaged groups as well as for addressing the challenges of urban aging [31]. In order to understand the challenges that older adults face and to support urban aging, specialized geodata-collection tools need to be developed by adopting public participatory approaches. Given the heterogeneity of older adults' technological skills and digital literacies [32, 33], developing an older-adult-centric geodata-collection tool that employs various methodologies is critical for promoting digital transformation without causing digital exclusion.

Older adults should be viewed as a diversified set of actors who utilize, adapt, and generate technology in a variety of ways [32] (as opposed to a homogeneous population of technologically inept laggards [34–36]). As mentioned by Ivan and Cutler [37, p. 133], "If the research methodologies incorporate stereotypical views of older people (e.g., that older persons lack interest and have poor digital skills), they will fail to predict and identify the needs of older persons." Thus, the lives of older adults can be improved by technology as well as by being aware of the importance of engendering confidence among older adults so that they will be able to use and master new technologies.

The comprehensive work by van Hoof et al. [9] on age-friendly cities and communities highlighted the lack of a standardized and measurable approach for assessing age-friendliness; this has been a major limitation in advancing the age-friendly agenda [38, 39]. Several qualitative methodologies have been employed in order to address this gap, often incorporating photography (for instance, the photovoice methodology) as a way to collect and analyze research data [32, 40]. These approaches may also involve citizen science programs that empower older adults to contribute as environmental-change agents and co-designers of age-friendly environments [41, 42]. One such initiative was conducted in Australia; it utilized smartphones to gather insights from older adults regarding the suitabilities of public green spaces for older adults [43]. Similar studies allowed participants to express their perceptions through self-captured photographs, followed by semi-structured interviews to delve into the meanings behind the produced images [44, 45].

Older adults can raise the awareness of the strong and weak age-friendly features of their cities by producing photographs that are supported by written comments. To achieve this aim, a geospatial data-collection tool was developed within the scope of this study; this catered to the participation of groups of older adults that enabled them to capture and upload photographs, augment them with written comments, and add geotags by using a smartphone or tablet. The aim of this study was to tailor a geodata-collection tool according to the needs of older adults and encourage them to actively participate in and provide input for urban aging.

Throughout this paper, the experiences and opinions that were gained while developing the geodata-collection tool are shared in order to be used as a roadmap for future studies.

The article is structured as follows: Section 2 delves into the details of the methodology, which is followed by explaining the design and development phases of the geodata-collection tool in Section 3. The results are discussed in Section 4. In Section 5, the preliminary outcomes that were collected by KoBo Toolbox are presented. Section 6 concludes the paper by summarizing the main findings and outlining research and directions to be pursued in the future.

2. Methodology

The study employed a participatory approach that aimed to incorporate individuals' voices and knowledge into our understanding and respond to the challenges and opportunities that face them and their communities [46, 47] in order to develop an inclusive geodata-collection tool that is tailored to the needs and preferences of older adults. To achieve this, a two-stage methodology was adopted. In the first stage, Figma was used to design the graphical user interface (GUI) and user experience (UX) of the geodata-collection tool. The first stage involved creating wireframes, prototypes, and mock-ups to ensure that the tool was user-friendly, accessible, and met the specific requirements of older adults.

Once the initial GUI and UX designs were finalized, the second stage involved the development of the geodata-collection tool using two parallel methods: (1) custom application development, and (2) adapting KoBo Toolbox [48]. Custom application development allowed for greater control over the tool's features and functionality, while KoBo Toolbox is a user-friendly open-source platform that simplified the development of the mobile data-collection applications. To evaluate the suitability of these two methods, the authors tested and evaluated both methods.

3. Design Process and Outcomes

3.1. Public Participatory Approach for GUI and UX Development

The public participatory approach involves active users in the design process to ensure that the resulting product or service meets their needs and preferences. This approach is particularly valuable when developing tools for older adults, as it allows for the identification of potential usability and accessibility challenges early on and provides opportunities to incorporate user feedback into the design process.

For this aim, groups of older adults (17 females and 13 males, totaling 30 people who were aged 65 years and over) from Bucharest (Romania, $n = 8$), Krakow (Poland, $n = 8$), Wrocław (Poland, $n = 9$), and The Hague (the Netherlands, $n = 5$)

were involved during the early stages of the development of the geodata-collection tool. Three co-creation sessions were held in each city between November 2022 and March 2023. The participants were older adults who found the subject to be interesting and were willing to share their experiences and knowledge. Each participant was invited to each co-creation session in order to strengthen the involvement and coherence in the developmental stages. It was essential to provide them opportunities to have deep and extended reflections on the development process; thus, an environment was created for co-creation sessions where the people could meet each other, have fun, and contribute to a meaningful participation [49]. All of the older adults were from various age groups and had different health statuses, living arrangements, levels of cognitive development, genders, and levels of technological experience; therefore, the participating older adults were different representatives with various abilities and living standards. All of them were living in the cities in which the co-creation sessions took place. Each co-creation session lasted for approximately three hours; during each session, audio recordings and photographs were taken based on the participants' consent. The methodology of the sessions received a Certification of Ethical Acceptability for Research Involving Human Subjects, which was obtained from the Ethic Committee at the National University of Political Studies and Public Administration (SNSPA) on May 23, 2022; this extended to all of the members of the project consortium.

With the co-creation sessions, the older adults could assess the design of the geodata-collection tool based on their knowledge, experience, and empirical expertise. In the co-creation sessions, interactive and creative methods were used to facilitate potential challenges due to those who may have had difficulties thinking and speaking about technologies [49]. Simple and intuitive design methods were used for those who might have had difficulties understanding, imagining, and using the technology. For the development of the graphical user interface (GUI), a vector graphics editor called Figma was used. Figma can be used for prototyping, and it works on any operating system that can run a web browser [50]. One of the important advantages of using Figma was that it was available online and allowed for real-time collaboration among the design team (i.e., one researcher from each city). It also allowed for designing vectors, graphic images, and user interfaces for web-based tools as well as testing them like real-life experiences. Figma is easy to use, intuitive, and flexible.

During the first co-creation sessions, the older adults reflected on their ideas about how an "ideal" geodata-collection tool should appear, and they illustrated their concepts using paper and colorful pens. Also, they collaboratively discussed the user-friendliness of websites and smartphone applications via the design of already-existing ones, the allocations and contents of the menu, the colors that were used, the button sizes, and the ease of finding needed information. Based on the information that was provided by the older adults after the first co-creation session, the first design phase of the geodata-collection tool was initiated using Figma.

Throughout the co-creation sessions, information was gathered about user experience (UX) to evaluate the usability of the geodata-collection tool. UX is defined as an overall experience that involves the emotions, thoughts, perceptions, and reactions that are felt by a user. This is crucial for the development process, as evaluations can find and correct significant usability deficiencies in an interactive application early on [51, 52].

First Design Phase

During the initial development of the geodata-collection tool, the interface was designed in Figma by selecting visuals such as how the interface would look, the arrangements of various elements (such as the logo and the buttons), the connections between them in terms of their hierarchies, and the flow of the geoportal (Fig. 1). Additionally, icons were designed for each of the domains of the age-friendly environments [25] (Fig. 2). Also, the choice of fonts, color schemes, graphic elements, and the style of the menu were selected. As seen in Figure 1, the flow maps out the path from the first screen (the screen on the left) of the geodata-collection tool to the final screen (the screen on the right).

Fig. 1. Flow of geoportal

Categories	Old Icons	New Icons
Civic Participation and Employment		
Communication and Information		
Finance		
Health Services and Community Supports		
Housing		
Outdoor Spaces and Buildings		
Respect and Social Inclusion		
Social Participation		
Transportation		

Fig. 2. Designed icons of domains of age-friendly environments

Since Figma allows for the creation of interactive prototypes, the participants from the four cities tested the geodata-collection tool in a real-life experience during the second co-creation session. After testing the prototype, the participants provided their feedback on the design. Overall, they found the interface design to be user-friendly and found the fonts, color schemes, sizes, and allocation of buttons very suitable. The participants from the four cities required some changes in the design and size of the icons; for example, the participants added that the first design of the icon for social participation should include more people instead of just two people talking (as this domain also entailed groups and activities). Moreover, all of the participants agreed that the dollar sign ($) in the finance icon should be changed. When the sign in the icon was changed to the euro sign (€), there was a difference in opinions among the participants in Poland and those in the Netherlands and Romania. The participants in Poland recommended that the icon should be the currency that is used by their respective countries; after the researchers explained that the euro (which is a more commonly used currency sign within the European Union member states) would be more easily understood by everyone, the icon design was finalized (as can be seen in Figure 2). The participants from the four cities also suggested having two different flows; the first flow starting with selecting one of the nine domains of age-friendly environments (following Dikken et al. [39]) and then uploading a photograph, and the second flow was the other way around. Besides, the participants preferred to have explanations for the domains of the age-friendly environments. Overall, the participants from the four cities co-created the prototype design.

Second Design Phase

Several changes were made to the geodata-collection tool before the start of the second design phase based on the participants' suggestions. The explanations for the domains of the age-friendly environments were added. Also, two flows were designed as suggested (Fig. 3). "Flow 1" started with selecting the domains of age-friendly environments, continued with uploading or taking a photograph and selecting a location, and ended with providing comments. "Flow 2" started with uploading or taking a photograph and continued with selecting a location, providing comments, and selecting an age-friendly domain as the final step. According to the feedback from the first design phase, the icon designs (including the colors and symbols of the domains of the age-friendly environments and their sizes) were changed (Fig. 2).

The participants got the opportunity to experience the geodata-collection tool by using the interactive prototype (which was as close to the final product as possible), thus giving them a realistic preview (Fig. 4). They interactively tested the prototype by using the researchers' smartphones. The participants could tap and swipe between the screens of the tool; they could interactively use and experience every step of the geodata-collection tool.

Fig. 3. Two geoportal flows were designed after first design phase (a), and closer look to Flow 2 (b)

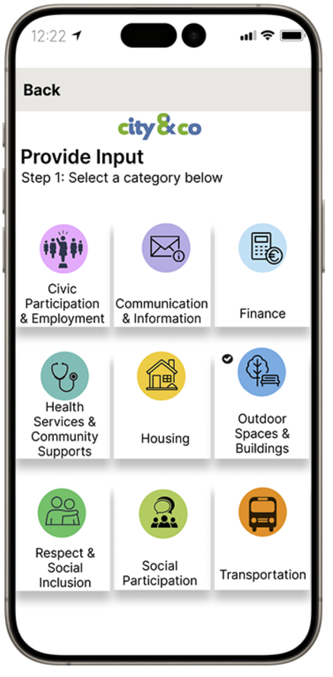

Fig. 4. Interactive prototype of geodata-collection tool

While the co-creators (i.e. participants) experienced the prototype, the interactions of the participants with the prototype were observed by the researchers. For example, attention was paid to whether they knew what to tap, swipe, or click in order to meet their expectations. Additionally, the positive and negative aspects of this experience were identified; by taking this feedback into account, problematic areas were detected, and the user experience was improved.

The designs that were developed during the co-creation sessions using Figma were used for the later stages. The development of the data-collection tool was then carried out using two different methods: developing a custom application, and adapting a free web-based open-source geodata-collection tool for the identified needs.

3.2. Custom Application Development

The technical development of the custom mobile application was anchored in advanced programming techniques and modern software-development practices. Utilizing the Flutter framework (a Dart-based user interface [UI] toolkit), the application was developed with a focus on performance, compatibility, and a seamless user experience (Fig. 5). Well-known for its efficient UI creation capabilities, Flutter facilitated a smooth native-like user experience; this is essential for older users, who require simplicity and ease of use. Being a language that was optimized for

UI development, Dart was used for its intuitive syntax and efficient performance [53]. Key technical considerations included the implementation of Global Positioning System (GPS) functionality for precise geolocation tracking – a critical component for research purposes. This was achieved through integration with device-specific GPS services, thus ensuring accuracy and reliability. Data annotation (another core feature) was facilitated through a combination of Flutter's UI capabilities and local storage solutions, allowing for offline data collection and synchronization with servers when connectivity is restored. The application's architecture was designed to be scalable and maintainable, with a modular structure that allows for easy updates and feature additions. This architectural choice ensured that the application could evolve in response to the needs that might have emerged during the project span and future technological advancements, thus reflecting a commitment to long-term usability and relevance. Hosting the application on a local test server facilitated an ongoing cycle of testing and refinement. This dynamic process enabled the immediate incorporation of user feedback, thus ensuring that the application's evolution was closely aligned with the needs of its intended users.

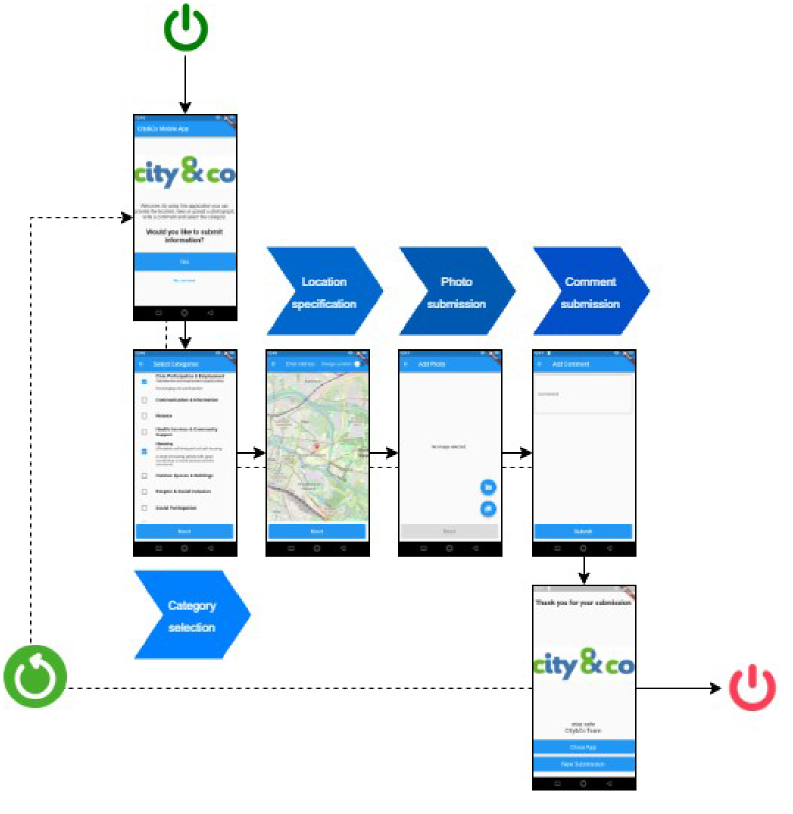

Fig. 5. User flow with exemplary screenshots on smartphone
(dashed lines mean navigate back to previous step)

3.3. Geodata-collection Tool Development Using KoBo Toolbox

For collecting geodata, a free web-based open-source tool called KoBo Toolbox was used; it allowed for the collection of data by surveys in the field using mobile devices such as smartphones and/or tablets. KoBo Toolbox is most commonly used by well-known humanitarian organizations such as the UN Refugee Agency (UNHCR) and the International Federation of Red Cross and Red Crescent Societies (IFRC). KoBo Toolbox was built specifically for the unique needs of collecting data in the field, such as working offline. It was also created to be intuitive and easy to use without requiring any technical training or special equipment. Multiple languages can be added and managed to the forms – either directly through the online Project Dashboard, or by adding them in a Microsoft Excel Form (XLS) and uploading them to KoBo Toolbox [54]. This feature makes KoBo Toolbox an easy-to-use tool for collecting data from diverse populations. Collecting geodata via an integrated map is easy with KoBo Toolbox, as it supports geolocation as a data type. Due to the opportunities that are provided by this tool, it is easier for older adults to collect data, and the protection of the collected data becomes safer. Once the survey is completed, the data gets synced and saved to the cloud automatically.

The GUI, which was developed through Figma during the co-creation sessions, was transferred to KoBo Toolbox (Fig. 6).

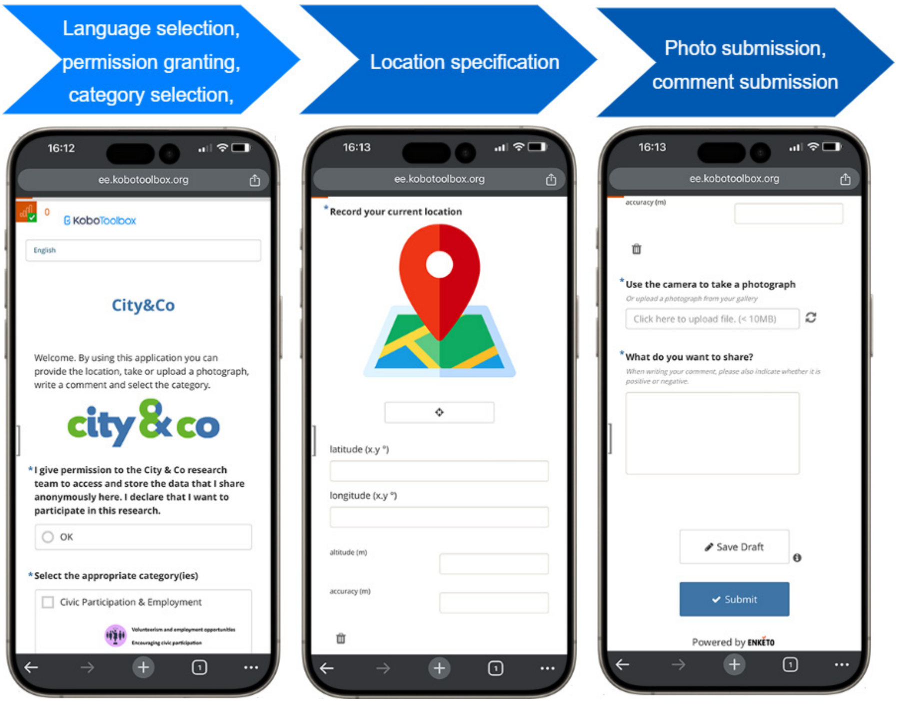

Fig. 6. User flow with exemplary screenshots on smartphone

4. Discussion

Geospatial data holds an immense potential for creating age-friendly environments that enhance the quality of life for older adults, as they can identify related indicators such as urban structural features, the activities of older adults, and socio-economic parameters [38, 55]. Since geospatial data can cluster urban areas based on their age-friendliness, urban planners and policy-makers can focus on those areas that need development in order to improve quality of life. Also, geospatial data that is obtained through tools that older adults can easily use provides a deeper understanding of their challenges and needs in urban environments [31].

The evaluation of two different development methods (custom application development, and adapting KoBo Toolbox) revealed that KoBo Toolbox emerged as the most-suitable option for older adults due to its user-friendly interface, accessibility features, and ability to collect geospatial data. KoBo Toolbox's user-friendly interface (with clear menus and simplified navigation) made it easier for older adults to learn and use the tool. The tool's accessibility features (such as screen-reader compatibility and support for assistive technologies) further enhanced its usability for older adults with disabilities. Additionally, KoBo oolbox's ability to collect geospatial data with one button was a crucial feature for the study, as it allowed older adults to accurately map their surroundings and record their experiences. The possibility of directly defining and evaluating interaction sequences and comparing multiple sequences in a prototyping tool (Flow 1 and Flow 2 – see Fig. 3) represented an innovative approach that opened up new possibilities for evaluation.

The geodata-collection tool via KoBo Toolbox has a web-based responsive design, which means that it can be accessed from any device with an internet connection. It also can work offline, which is useful when working in areas with limited connectivity. The tool is highly customizable and comes with a form builder, which makes it easy to create forms for data collection. It supports various data types such as text, numeric, geolocation, and images. The tool is secure, with data encryption and user-authentication features. The custom application is developed or designed outside and may not have offline working capacity depending on the build and host device. The customization needs to be developed, and geolocation requires GPS access plus an application programming interface (API) key. Security features must be developed, and the integration capability is mostly through APIs (not all platforms). Multiple-format exporting is possible, but it is more complicated than the geodata-collection tool via KoBo Toolbox.

When comparing the custom Flutter application with KoBo Toolbox, several aspects came into play (Table 1). The development of the custom application demanded considerable effort (including design, testing, and iteration), whereas KoBo Toolbox (as a pre-established tool) required significantly less time and fewer resources for deployment. In terms of maintenance, the custom application would necessitate ongoing updates and troubleshooting – in contrast to the streamlined maintenance and version control that is provided by KoBo Toolbox. Performance on older devices is another crucial factor; despite its optimizations, the custom app might struggle on lower-resource devices, while KoBo Toolbox is known for its broad device compatibility. Security is paramount in both, but KoBo Toolbox benefits from extensive testing and a wide user base, thus potentially offering more-robust security protocols. Taking these factors into account, KoBo Toolbox presents itself as a more practical and resource-efficient solution for this project – particularly in the contexts of ease of use, reliability, and operational demands.

Table 1. Comparison of geodata-collection tool via KoBo Toolbox and custom mobile application

Features	Geodata-collection Tool via KoBo Toolbox	Custom application
User interface	Leveraging pre-designed user-friendly interface	Custom designing and testing for target demographic
Offline capability	Built-in feature that requires no additional development effort	Developing and testing offline data capture and sync
Form customization	Utilizing existing tools for form creation and customization	Designing and programming custom forms
Data types supported	Inherent support for various data types	Ensuring support for required data types, considering performance on older devices
Geolocation	Inbuilt geolocation capabilities, no extra development needed	Integrating and optimizing GPS functionality for user base
Security features	Utilizing established security measures	Implementing and testing robust security protocols
Integration capabilities	Ready integration with various tools and platforms	Ensure compatibility and integration with specific research tools
Export capabilities	Inbuilt export functionalities	Customizing export functionalities to meet project-specific needs

5. Preliminary Outcomes via KoBo Toolbox

For analyzing the usability of the KoBo Toolbox and having a general idea of the tendencies in the positive and negative aspects that older adults perceive in urban areas (cumulated around the eight domains that were proposed by the World Health Organization [8] and the financial domain that was identified by Dikken et al. [39]), a user-testing session was initiated. A group of older adults (including former participants of the co-creation sessions) were invited to collect geospatial data via KoBo Toolbox from Krakow ($n = 16$) and Wrocław ($n = 15$) in Poland as well as The Hague in the Netherlands (n = 24) toward the end of November 2023. The user-testing session was started in Bucharest, Romania (n = 22) in mid-January 2024. Preliminary outcomes from the user-testing sessions showed data being available through the beginning of April 2024.

Based on preliminary results from the user testing, a total of 1,145 inputs were collected from the participants in the four localities. This number showed that older adults were actively using KoBo Toolbox to provide geospatial data about their urban areas. The same results also showed the positive and negative aspects of urban environments that older adults wanted to highlight. Figure 7 summarizes the number of provided inputs per each of the nine domains.

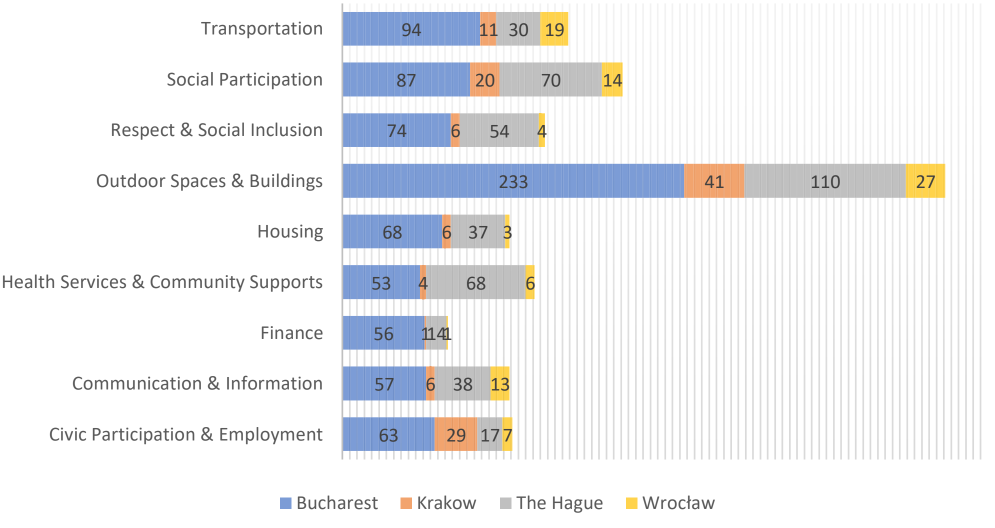

Fig. 7. Clustered bar chart shows preliminary outcomes from four cities categorized by nine domains

Similar to the findings of van Hoof et al. [56], more input (n = 411) was provided for the *Outdoor Spaces and Buildings* domain regardless of the city. The second domain with the most input was *Social Participation* (n = 191), which was followed by *Transportation* (n = 154). The least-mentioned domain was *Finance*, with 72 inputs (Fig. 7).

Since the data that was collected included photographs, this can be a powerful complement to spatial data. Photographs can capture specific locations, landmarks, or details of physical and social environments as well as municipal services that might be difficult to describe with text alone; for instance, a photograph of a broken pavement could highlight accessibility challenges, while a picture of a hidden entrance to a community center could reveal a lack of signage. These visual elements would enrich the spatial understanding of the collected data, providing a more comprehensive picture of a community through the eyes of older adults.

6. Conclusions and Further Work

PPGIS has the potential to play a significant role in enhancing the lives of older adults; the aim of this paper was to develop a geodata-collection tool with the use of the voices of older persons via co-creation sessions. This participatory approach held the key to unlocking the transformative potential of geospatial technologies for older adults, thus enabling them to actively participate in data collection, contribute to the creation of geospatial information that reflects their needs, and enhance their engagement with their communities. By embracing this inclusive approach, it can be ensured that geospatial technologies truly serve the needs of older adults, promoting their independence, well-being, and social connections in urban environments. Thus, this paper highlights the importance of incorporating user-centered design principles, a public participatory approach, and accessibility guidelines throughout the geodata-collection tool-development process.

An evaluation with older adults using the geodata-collection tool over a five-month period (recording and auditing public spaces in the four cities) was conducted. Through this evaluation, older adults could raise awareness of the strong and weak age-friendly features of their respective cities. In the further steps, city maps could be prepared for showing the results by using a hot-spot analysis. This analysis can depict spatial clusters of age-friendliness with high values (hot spots) and low values (cold spots). Using the written comments that were provided by the older adults, network analysis and theme extraction could be conducted for identifying the relationship between age-friendly domains and urban structural features. All of the findings could be presented in publicly available dashboards.

The findings of this study suggest that KoBo Toolbox is a valuable tool for collecting geodata from older adults. Its user-friendly interface, accessibility features, and geospatial data-collection capabilities make it an ideal platform for engaging older adults in participatory research initiatives. The use of KoBo Toolbox in this study demonstrated its potential to bridge the gap between older adults and technology, thus enabling them to actively participate in research and contribute to the development of inclusive urban environments.

With the developed geodata-collection tool via KoBo Toolbox, urban planners can identify those areas with high concentrations of older adults, assess the needs of these populations, and prioritize allocations of resources. In other words, they can use this tool to support urban aging. This paper also lays the foundation for developing future geodata-collection tools that will be versatile and applicable to a wide range of purposes, such as developing personalized mobility maps that show older adults' routes that avoid stairs, steeped roads, or other barriers (including falling risks). The insights and recommendations that were presented in this paper serve as a valuable resource for developers, researchers, and policymakers, guiding the creation of advanced geodata-collection tools that empower individuals of all ages and abilities.

Funding

This publication is based on work from the City&Co: Older Adults Co-Creating a Sustainable Age-friendly City project (JPI Project Number 99950200). This project was funded by the Taskforce for Applied Research (UTC.01.1), the National Science Center (UMO-2021/03/Y/HS6/ 00213), and the Executive Agency for Higher Education, Research, Development, and Innovation Funding (UEFISCDI) (Contract No. 298/2022) as part of ERA-NET Co-fund Urban Transformation Capacities (ENUTC), co-funded by the European Union's Horizon 2020 research and innovation program under Grant Agreement No. 101003758.

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NARODOWE CENTRUM NAUKI

Sfinansowano przez Narodowe Centrum Nauki w ramach programu EN-UTC, który otrzymał dofinansowanie na podstawie Umowy Finansowej nr 101003758 w ramach Programu finansowania badań naukowych i innowacji Unii Europejskiej Horyzont 2020.
Nr rejestracyjny: 2021/03/Y/HS6/00213

Funded by the National Science Centre, Poland, within the EN-UTC Programme that has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101003758.
Nr of registration: 2021/03/Y/HS6/00213

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J. v. H.: conceptualization, methodology, validation, investigation, resources, data curation, writing – original draft preparation, writing – review and editing, supervision, project administration, funding acquisition.

J. M. P.: conceptualization, methodology, writing – review and editing.

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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 that is reported in this paper.

Data Availability

Requests for access to the datasets that were generated and/or analyzed in this research will be considered upon inquiry to the corresponding author.

Use of Generative AI and AI-assisted Technologies

No generative AI or AI-assisted technologies were employed in the preparation of this manuscript.

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