Acta Sci. Pol., Administratio Locorum 22(4) 2023, 525–535.
https://czasopisma.uwm.edu.pl/index.php/aspal plISSN 1644-0749 eISSN 2450-0771 DOI: 10.31648/aspal.9012

ORIGINAL PAPER
Received: 29.05.2023 Accepted: 15.08.2023

THE APPLICATION OF GEOPLANNER IN THE MANAGEMENT OF LOCAL DEVELOPMENT

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ABSTRACT

Motives: Local development can be supported by GIS-based tools and many solutions are being developed. They can be helpful in supporting more sustainable decision-making processes in public administration and can be used by stakeholders taking part in shaping common space. However, many of these tools are not used by practitioners in their daily activities. Therefore, the added value of this research is to examine how local development might benefit from further implementation of GIS solutions.
Aim: The aim of this study was to verify whether a model designed in ArcGIS GeoPlanner is considered a useful tool by local stakeholders (representatives of public authorities and NGOs), and which issues in local development could be potential areas of application of similar models.
Results: The model was tested during a workshop focused on transforming the local food system of Wrocław, Poland. Most participants declared that they rarely use GIS-based tools (less than once a month) or that they do not use them at all; however, they were willing to incorporate these tools into their activities if they meet their needs. An ex-post evaluation revealed that the use of GeoPlanner can help strengthen a knowledge-based approach during social participation. Participants were eager to use different functionalities of GeoPlanner to modify land use structure guided by a real-time verification of indicator-based results. Finally, a too detailed model can also be perceived as not helpful in regional planning. The user-friendly interface of GeoPlanner helped users develop a shared understanding of urban systems and design action plans, and contributed to capacity building by local stakeholders and raising their awareness.

Keywords: ArcGIS, what-if scenarios, decision support system, food system, urban farming, land footprint

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INTRODUCTION

Local development planning has gained importance in the modern world as communities explore strategies for building resilient and sustainable economies (Forys & Cymerman, 2019; Furmankiewicz et al., 2021). It has become an essential instrument for protecting and promoting the distinctive cultural, social, and economic qualities of various regions and communities impacted by the advent of globalization. Local development planning can help improve community well-being by concentrating on local assets, abilities, and resources (Bazan-Krzywoszańska et al., 2017; Chodkowska-Miszczuk & Szymańska, 2014). Additionally, local development planning can aid in addressing a number of urgent global issues such as socioeconomic injustice, climate change, and the deterioration of democratic institutions (Kazak et al., 2023). Local communities can cooperate to create more just and sustainable societies by promoting a sense of local ownership and control over economic development and enhance social participation in decision making processes (Kołat et al., 2022; Kryk, 2019; Przybyła & Kulczyk-Dynowska, 2018; Przywojska & Podgórniak-Krzykacz, 2022).

By offering insightful information on regional spatial patterns and relationships, geographic information system (GIS) tools can be very helpful in assisting local development initiatives (Bazan--Krzywoszańska et al., 2019; Bieda et al., 2020; Kulesza & Florek-Paszkowski, 2018; Michalik & Zwirowicz--Rutkowska, 2023). Geographical data, including land use, population demographics, transportation networks, and natural resources, may be mapped and analyzed using GIS technology, which can help guide decisions about economic development, infrastructure design, and resource management (Coetzee et al., 2017; Giang & Vinh, 2014; Ilyushina et al., 2018; Jawecki et al., 2019; Kaczmarek et al., 2022). Local governments and development organizations can better understand the regional economy and spot opportunities for investment and expansion by combining GIS data with other sources of information, such as commercial and social data (Iwaniak et al., 2016, 2017; Jędruch et al., 2020; Kazak et al., 2018). Additionally, by facilitating the display and exchange of data with stakeholders, fostering collaboration and informed decision-making, GIS systems can promote community engagement and participation (García Castro et al., 2020).

Despite their universal character, GIS-based tools are less frequently employed in practice for a variety of reasons. First, the development and upkeep of GIS systems may be time- and resource-consuming and requiring specific technical know-how. In case of using commercial software it could also be a significant financial commitment. It may be an obstacle especially for smaller organisations. Secondly, GIS data gathering, conversion and maintenance frequently require a lot of work and time, particularly in case of more popular big data and dynamic (real-time) datasets. Additionally, problems with compatibility across various GIS applications and data formats might make it difficult to smoothly incorporate GIS systems into current workflows and systems. Finally, a barrier to the widespread implementation of GIS technology is decision-makers' and stakeholders' lack of knowledge and comprehension of its potential advantages. All these elements lead to the situation where although many tools and systems are being developed, they are not commonly used by local stakeholders (Uran & Janssen, 2003). Therefore, the research question in this research was whether a model designed in the web-based ArcGIS GeoPlanner planning tool can be considered by practitioners as useful tools and which issues in local development are considered by them as potential fields of application. The aim of the research was to verify this aspect.

MATERIALS AND METHODS

In order to verify the possibility of the application of GIS tools in local development, a model built in ArcGIS® GeoPlanner℠ (Version: 3.7 Build: 72) has been prepared. The application of the model was tested during a workshop organized within the framework of the FoodSHIFT 2030 project (Horizon 2020, Grant Agreement #862716: Food System Hubs

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Innovating towards Fast Transition by 2030) which was held in May 2023 in Wrocław (Poland). The main goal of the FoodSHIFT2030 project is to develop more sustainable food-systems within 9 European city-regions (Athens, GR; Avignon, FR; Barcelona, ES; Bari, IT; Berlin, DE; Brasov, RO; Copenhagen, DK; Oostende, BE; Wrocław, PL). Therefore, for this reason, analyses were conducted for the status quo as well as for alternative food systems scenarios. Typically the FAL (FoodSHIFT Accelerator Lab) is responsible to host such workshops. FALs comprise of: (1) Lab leader – usually a Small Medium Enterprise (SME) or a Non-Governmental Organization (NGO); (2) Lab host – usually a municipality; (3) Lab assistant – university or research unit. Therefore, this workshop presented a realistic and practical perspective on the organization of a FAL activity. The workshop was attended by a total of nine participants, including representatives from municipal and regional authorities, as well as non-governmental organizations (NGOs). The small size of the workshop group was due to the nature of teamwork and the aim to ensure that participants were able to actively participate at each stage of the tasks. Participants took part in ex-ante and ex-post evaluations.

The model includes non-spatial and spatial data. Non-spatial data covered two types of data from Statistics Poland. Variables taken into account included population, and average consumption of selected foodstuffs (divided into 39 categories) per capita in households), recommended diet based on the EAT-Lancet dietary advice (Hirvonen et al., 2020), and the local land footprint needed to provide one kilo or liter of given type food (Poore & Nemecek, 2018). Spatial data included the national register of borders (General Office Geodesy and Cartography), European land cover and agricultural land based on Corine Land Cover 2018 (Copernicus Land Monitoring Service, 2023), Natura 2000 protected habitats, crop yield forecasting (Joint Research Centre), complexes of agricultural suitability of soils on arable land (IUNG), and topographic data in vector representation tiled from satellite imagery maps (European Environment Agency, 2019). The model incorporated participants' evaluations and assumptions to calculate the suitability and the impacts of land use changes proposed during the workshop (i.e., community gardens, urban farms, agro-parks) on food production and demand of citizens.

RESULTS

Ex-ante evaluation

Before starting the workshop participants filled out an ex-ante evaluation form. There were 3 representatives from the City Hall, 2 from the Marshal's Office (regional authorities), and 4 from NGOs (including EcoDevelopment Foundation; Community Garden 'Motyka i Słońce' in Warsaw; and the Krzyżowa Foundation for Mutual Understanding in Europe). As participants did not represent specialized GIS units in their organizations, but they specialized rather in local and regional development or food-related topics, they stated that they rarely use GIS solutions (less than once per month) or do not use such tools at all. However, 8 out of 9 participants expressed their willingness to start using them if they would be helpful in their work. Only one person reported being familiar with GIS-based scenario tools like GeoPlanner. When asked about their expectations from the workshop, participants indicated knowledge about the basic functionality of GIS (3 participants), functionality associated with selecting suitable locations (2 participants), topics related to food system – not associated with GIS (3 participants), and one person did not specify any concrete expectations.

Geodesign Workshop

First, the workshop participants were introduced to the Metropolitan Foodscape Planner (MFP) method (Arciniegas et al., 2022), which allows the comparison of actually available agricultural-productive land with the area footprint estimated to meet the food habits of residents. The data and assumptions that were used to calculate the footprint were discussed, as well as the four scenarios that were prepared using the GeoPlanner solution (Fig. 1).

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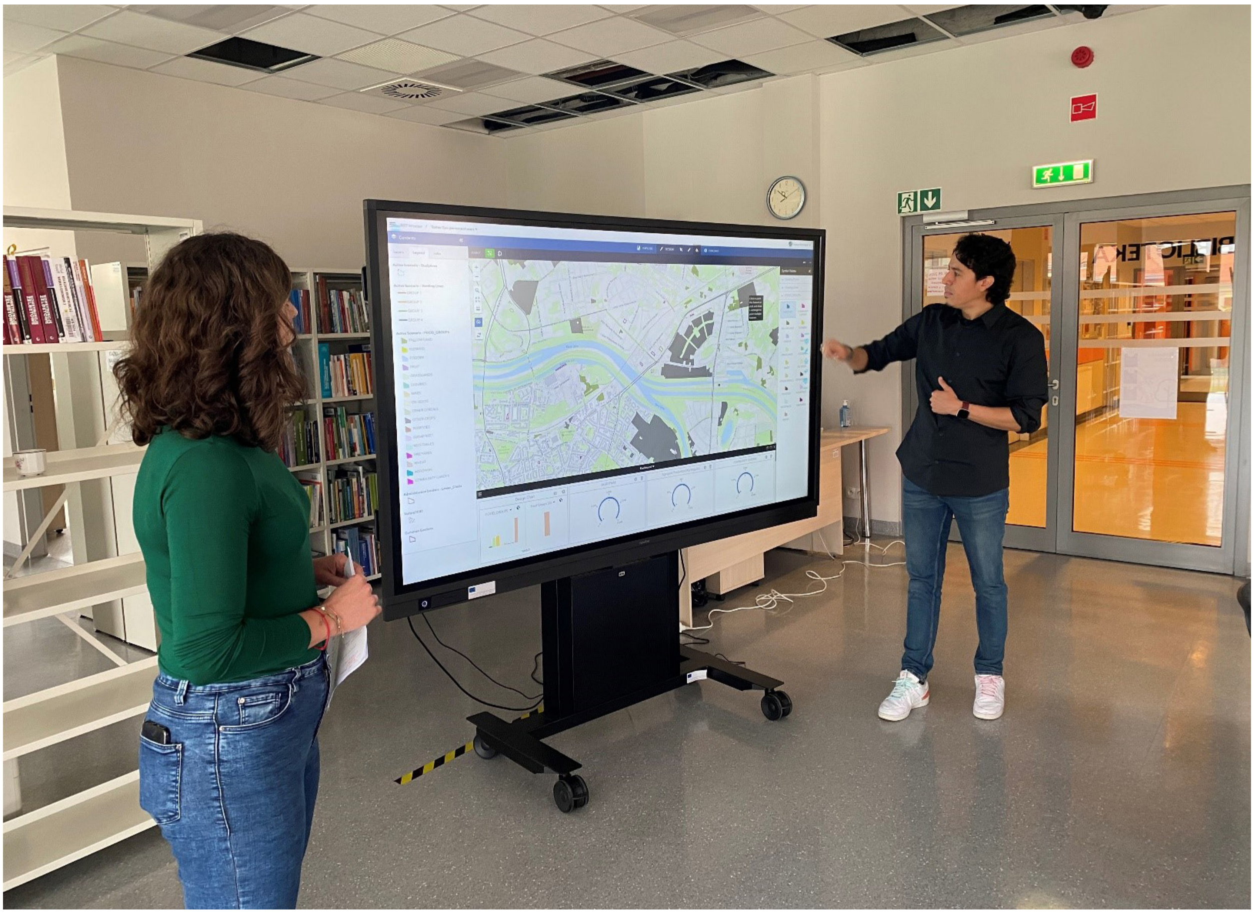

Fig. 1. Presentation of functionalities of the model
Source: own picture.

Four scenarios were prepared for the workshop:
- Scenario 1: land footprint for current eating habits of officially registered residents of Wrocław,
- Scenario 2: land footprint for current eating habits of estimated number of residents of Wrocław city (those not registered as well as those registered) estimated by the Municipal Water Supply and Sewerage Company in Wrocław,
- Scenario 3: land footprint with dietary change to EAT-Lancet for officially registered residents of Wrocław,
- Scenario 4: land footprint with dietary change to EAT-Lancet for estimated number of residents of Wrocław.

The results of the MFP analysis (Table 1) for the urban core of Wroclaw showed that, in the case of the first scenario (status quo), 46,000 ha of land are required to satisfy plant-based food needs and 182,000 ha are required for meat-based needs. In case of the second scenario, it was 61,000 ha for plant-based, and 241,000 ha for animal-based food production. For both, first and second scenarios including current eating habits, the annual land footprint per capita was quantified as 0.357 ha. However, in case of third and fourth scenario, the area needed to satisfy plant-based needs was quantified as 66 thousand ha and 88 thousand ha, and for meat-based as 180 thousand ha and 239 ha. The change to this diet would involve a land footprint of 0.385 ha per capita. The difference between the land footprint for current food habits and EAT-Lancet can be seen in a 54% increase in the consumption of flour products, a 20% decrease in the

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Table 1. Results obtained using MFP tool

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Land required to satisfy plant-based needs [ha]	46,000	61,000	66,000	88,000
Land required to satisfy meat-based needs [ha]	182,000	241,000	180,000	239,000
Land footprint per capita [ha]	0.357	0.357	0.385	0.385

Source: own preparation.

consumption of potatoes, a 36% decrease in the consumption of meat, eggs, and butter, a 154% increase in the consumption of vegetable fats, a 519% increase in fruit consumption.

Moreover, an additional category in EAT-Lancet is appearing – unrecorded in the Polish diet due to its marginal share – legumes. During the workshop it was pointed out that although the land footprint for current habits is lower than for EAT-Lancet (7.36% lower), this does not mean that these habits are healthy. EAT-Lancet assumes that the diet is healthy, nutritious, affordable, and environmentally friendly. This is evidenced, for example, by more than 5 times too low consumption of fruits regarding current eating habits.

Fig. 2. Modification of the model by participants during workshop
Source: own picture.

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In the next step, participants worked on agricultural land use change. This step showed how land use change can affect the convergence to the area (land footprint) needed to meet the food needs of residents. Workshop participants were able to, on the one hand, change land use to groups of crops identified in the MFP model (e.g. fruit, grasslands, oil seeds, potatoes, vegetables), and on the other hand, plan land use changes for agricultural cooperative solutions (ie. community gardens, urban farms, agro-parks). Wanting to see how changes in land use would affect the fulfilment of current eating habits, they worked mainly on the second scenario. Participants began working jointly on paper versions to draw a set of preliminary concepts for land use change. In the second stage, they made changes using an interactive map table (that is an 86-inch touch screen) (Fig. 2). The participants were divided into two groups, the first working in the urban area of the city of Wrocław, and the second on the metropolitan area, covering both the city together with suburban areas.

The approaches used by the participants differed from each other (Fig. 3). Participants in the urban group focused primarily on land changes in the context of creating new community gardens and agro-parks. Participants in the metropolitan group, on the other hand, paid attention to the accuracy of data from the European Commission's Joint research Centre. The high level of generalization of the data resulted in smaller patches representing a different type of crop (e.g., vineyards) being aggregated to the larger dominant ones in the neighborhood (e.g., wheat).

An important observation is that all participants were eager to use the reference layers (presented as web-based feature layers) and the base maps (topographic, aerial photography, OpenStreetMap) that had been prepared for them. They paid attention to such aspects as the quality of soils, the suitability of soils for growing specific types of crops, and whether there were any protected areas, such as Natura2000, in the areas of possible change. What is more, the workshop participants also used their knowledge of current land use or took into account potential spatial problems that could be unfavorable for locating a particular solution like a community garden or agro-park (e.g., significant proximity

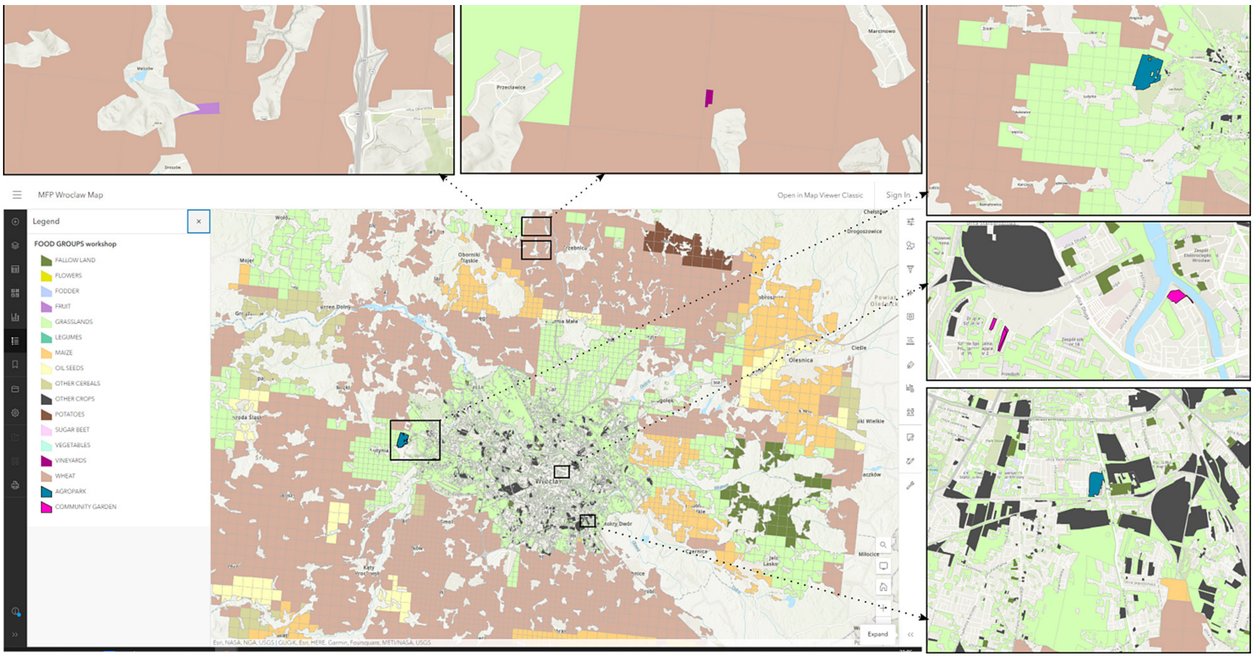

Fig. 3. Some changes made by participants on model during the workshop
Source: own picture.

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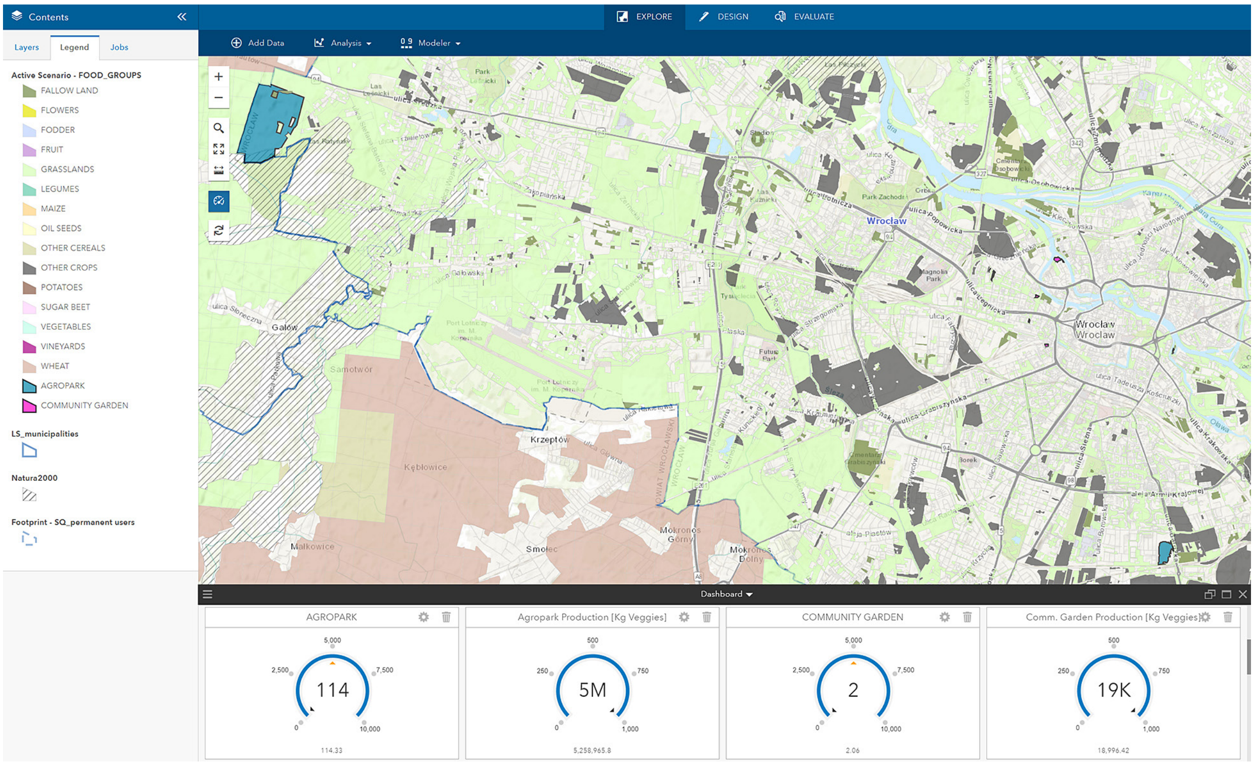

Fig. 4. Screenshot of the model in GeoPlanner. Charts at the bottom show hectares per land use and food production in kg
Source: own picture.

to roads). In addition to unsuitable spatial factors (proximity to roads, proximity to protected areas), participants also took into account existing social problems. In this case, they relied on their knowledge of the incidence of vandalism in similar areas, around which gardens or agro-parks could potentially be located (Fig. 4).

The advantage of working with the combination of the GeoPlanner solution and an interactive MapTable simplify the use of a designed system. Users do not need to be experts in GIS to make land use changes. Moreover, several attempts to change land use (including splitting a polygon if needed) make participants courageous in changing current land use. Participants working in the administrative sector concluded during the workshop that the model that was presented could be used to work with residents as a decision-support tool for food system development.

Ex-post evaluation

Some aspects of ex-post evaluation appeared already during the workshop as participants shared their comments while working on the study analysis. First of all they mentioned that having all data collected in one place gave them more holistic understanding of the study area. Participants referred especially to the data on soil quality and the network of facilities associated with local food system. Secondly, participants did not limit their actions to basic functions like land use modifications of specific polygons, but also they took an advantage of more advanced changes like changing geometry of polygons. By such changes they influenced not only categories but also topological structure of land uses. Participants highlighted that the outcomes of indicator calculations used during the workshop would be helpful for

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discussing the alternatives with other partners and thus to the decision making processes. They also liked the fact that once they have an idea for alternative scenario, they can verify its impact on targets instantly. Using current approaches it is more common that decision makers suggest scenarios of actions, then these scenarios are analyzed by analysts separately, and results are sent back to decision makers with a degree of delay.

After finishing the workshop participant were asked to answer two ex-post questions. All of attendees stated that workshop met their expectations. 7 out of 9 of them said that they would be interested to use such solution in their work. Most common tasks that they mentioned for potential utilization of the model were land use and food system planning. One person wrote that she/he could see a potential to use the approach in co-creation activities with local communities. One participant representing an NGO highlighted that such a tool would not be helpful for current tasks but could be useful for planning new activities using such systems. A person from another NGO noted that using such model could be helpful in increasing credibility of arguments used during discussions. Those participants who did not anticipate any applicability of the model in their work were representing regional authorities. When it comes to features of the model that would make people less interested in using the tool, 2 participants highlighted technical barriers associated with understanding the GIS environment. Finally, participants were asked for their feedback concerning the workshop itself, in order to improve promotion of GIS solutions. The only response collected here was a suggestion to divide the workshop into shorter tasks in order to go through the model step by step. There were no other suggestions.

CONCLUSIONS

Based on the user feedback, these stakeholders of local development management and planning expressed their intentions to incorporate GIS-based solutions in their regular activity. However, solutions should address their tasks, therefore, the promotion of GIS tools should not be based on what software developers want to show but on the needs of potential users, reflecting the most common problem defined two decades ago by Uran and Janssen (2003). Participants were clearly able to see the potential for using GIS-models more widely in land use and food system planning which overlapped with the topic of the workshop. None of them referred to a different field of application which raises the question as to whether they were able to link the available functionalities for food system planning with other domains. Nevertheless, it is worth highlighting the opinion of one participant that knowing about available functionalities could boost future actions and plans by planning new more ambitious tasks at a higher level than existing ones.

Secondly, the use of models similar to the one designed in GeoPlanner for this workshop could be helpful during the process of public participation. Rather than relying on subjective points of view and ideas, a model can help to evaluate different scenarios and compare them based on quantitative indicators. As a result, it is possible to increase the role of knowledge-based discussion and to refer to an impact supported by defensible evidence more than relying on opinions and feeling. That could help in minimizing social conflicts that can appear during social participation processes, that commonly appear during management of common goods (Furmankiewicz et al., 2019).

Finally, the results from the workshop shows that representatives of a city hall and NGOs are willing to introduce a GIS-based solution like GeoPlanner in their work, while representatives of regional authorities are less interested in that. This statement can be biased by a small sample and repetition of the workshop with employees of different units from regional authorities could change the situation, however, the underlying question may be whether the model fits regional needs. The level of precision of data (sizes of analyzed individual objects) could be high enough to carry out the task at a local/municipal level but to carry out regional tasks it might be necessary to generalize and simplify datasets and models. This

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limitation has also been observed while implementing other decision support systems like CommunityViz (Aggett & McColl, 2006; García Castro et al., 2020).

The main limitation of the obtained results may be the GIS experience or exposure of participants who took part in the workshop. Our findings do not refer to general understanding of GeoPlanner models worldwide, as representatives of public authorities and NGOs may differ in their background and IT skills. In order to state a more universal opinion on it similar studies should be carried out in other places, preferably including different socio-cultural context, as it may refer not only to level of knowledge but also to willingness to explore new approaches enhancing public stakeholder participation in decision making processes.

Based on the workshop we can define four main ways how GeoPlanner could possibly support local development management:

1. Shared Understanding: By working together with GeoPlanner, participants can develop a shared understanding of urban system and its challenges. The visual and interactive nature of GeoPlanner can help communicate complex issues more effectively than text or tables alone.
2. Action Plan: Based on their analysis, participants could develop an action plan with specific steps to improve an existing system. This plan could include both short-term actions and longer-term strategies.
3. Capacity Building: Participants could gain new skills in GIS and spatial analysis, which they could apply in their work. The workshop could also increase participants' understanding of local system and its complexity.
4. Awareness Raising: The workshop could raise awareness about the importance of a sustainable and equitable a system among participants and their organizations. This could lead to increased support for policies and programs that improve a system (here the example was the planning of food systems).

Author contributions: authors have given approval to the final version of the article. Authors contributed to this work as follows: J.K.K., G.A., D.W. developed the concept and designed the study, M.Ś., G.A., R.A., G.C. collected the data, J.K.K., M.Ś., G.A. analyzed and interpreted the data, J.K.K., M.Ś. prepared a draft of an article, G.A., D.W., G.C. revised the article critically for important intellectual content.

Funding: This research was undertaken as part of the 'Food System Hubs Innovating towards Fast Transition by 2030 – FoodSHIFT2030' which has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement number 862716.

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