Eliciting residents' preferences for urban function change using online geo-questionnaires

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Abstract

The paper presents a method for elicitation of development preferences on an example of a local land use plan in Poznań, Poland. The method involves collecting development preferences in the form of sketched polygon features from a large number of participants using an online geo-questionnaire. The paper outlines a method for producing aggregated maps of magnitude, and direction of public preferences towards the development and urban function designations, and discusses usability of the results in local development planning and other areas of urban governance.

Keywords: geo-questionnaire, urban planning, public participation GIS, development preferences

1 Introduction

One of the ways of seeking public input during planning process is eliciting preferences of stakeholders including members of the public. Such preferences might substantiate technical knowledge of planners with local knowledge and everyday experience of lay members of the public [10, 12], making planning process more inclusive, allowing to anticipate conflict between stakeholders [3], and thus providing a basis for socially acceptable, legitimate, and sustainable land use changes.

Several public participation geographic information system (PPGIS) studies to date have sought to elicit development preferences and their spatial dimensions using various techniques in a variety of settings. In an early article, Talen [12] suggested incorporating local knowledge and preferences of residents into GIS databases available for planners. Dragićević and Balram [6] used Web GIS to identify areas of ecological value and assess degree of agreement between conservation and development preferences in small stakeholder groups in topics ranging from urban green areas to conservation. In a series of studies on conservation, forestry, and tourism planning, Brown and colleagues engaged residents and visitors to express their development preferences through mapping landscape values and locations appropriate and inappropriate for development [1, 2, 3, 4].

In previous studies preferences toward land use change have been expressed by marking places and areas that require change, have less value or where development should go. The studies have also used points and/or polygon markers to spatially denote preferences on a map. Brown and Pullar [2] evaluated differences between the two types of markers, and suggested the use of points instead of polygons in future PPGIS applications. However, their study was limited to a specific context of mapping landscape values for a large geographical region. In this paper we present a method for eliciting development preferences using polygons for a small urban area. The choice of polygons is dictated by the fact that both current and designated urban functions have specific boundaries and can be expressed more accurately by polygons than by points.

The research reported in this paper follows the Web-based approach to PPGIS [8] and focuses on a particular method of soliciting and collecting public input about various aspects of spatial organization called *geo-questionnaire*. The roots of the method are in the work of Kyttä and her colleagues who have used geo-questionnaires as part of softGIS methodology in urban planning context [7, 9, 10, 11]. Similar tools have also been used in a variety of applications ranging from conservation planning [4] to public health [5].

In the remainder of the paper we explain the purpose of geo-questionnaire, its functional capabilities, briefly present technologies used in building an online geo-questionnaire,

describe a real-world application of geo-questionnaire in urban development planning, and discuss the obtained results.

2 The Method

In order to elicit urban development preferences we used geo-questionnaire, an online questionnaire with integrated mapping capabilities. In geo-questionnaire, questions are accompanied by interactive maps providing rich geographical context and allowing a responder to mark location or spatial extent corresponding to question's answer. Spatial attributes are collected through an interactive map, which allows sketching points, lines, or polygons. Each of geographical features, present or newly sketched on the map, may also be linked to questions pertaining to the feature's functional use and answerable in a pop-up bubble. Individual user answers to questions and sketched features are not visible to other participants.

The geo-questionnaire used in the study reported here was built using client-server architecture. The framework Geodjango and Postgres database with PostGIS extension were used on the server side. The client side was built using two JavaScripts frameworks jQuery and OpenLayers, as well as HTML and CSS code. Answers to the geo-questionnaire questions were stored in a form of GeoJSON files and communicated through REST services. The responders had a possibility to toggle between one of the two layers available in the geo-questionnaire: a satellite view and a street map view using tiles provided by Mapbox (Fig. 1). The street map was based on OpenStreetMap data.

The purpose of the geo-questionnaire application was to elicit development preferences and their spatial footprints from a group of residents of the City of Poznań (pop. 550 thousand) in Western Poland, interested in a local development plan "Park Kasprowicza" encompassing a centrally-located city park. The questions were formulated by the researchers in close collaboration with the city planners responsible for preparing the development plan for the area. The questions reflected terminology and variables used in local urban planning processes and used during traditional (face-to-face) public meetings.

The geo-questionnaire consisted of six Web pages; each page was devoted to a different theme: 1) Place of residence and visited places on the area (with a map), 2) Preferences for land development, 3) Preferences for the preservation of current urban functions (with a map) 4) Proposed changes of urban functions (with a map), 5) General information about participants, 6) Information about reasons for participation in public consultation. This paper reports on the analysis of answers to questions on pages 3 and 4 of the geo-questionnaire (Fig. 1), which prompted the participants to draw polygons describing spatial extent of areas that should either change or preserve their current function, and provide a rationale for change/preservation preferences.

3 Participants

We recruited the participants using a variety of recruitment methods including: (1) 18090 postal invitations sent to every third household located within 2000 m radius around the study area; (2) advertising in and communicating with local media including newspapers, local TV and Websites, and social media portals (e.g. Facebook); and (3) posters distributed within 2000 m radius around the study area.

Figure 1: Screenshot of Web page 4 of the geo-questionnaire. The application allows users to sketch polygons and provide attribute information in a pop-up bubble. In this example a user is proposing urban function change from recreational to single-family housing. The user has an option of providing detailed characteristics of plan designation such as the minimum and maximum number of floors or maximum percentage of built-up surface, as well as an open-ended comment.

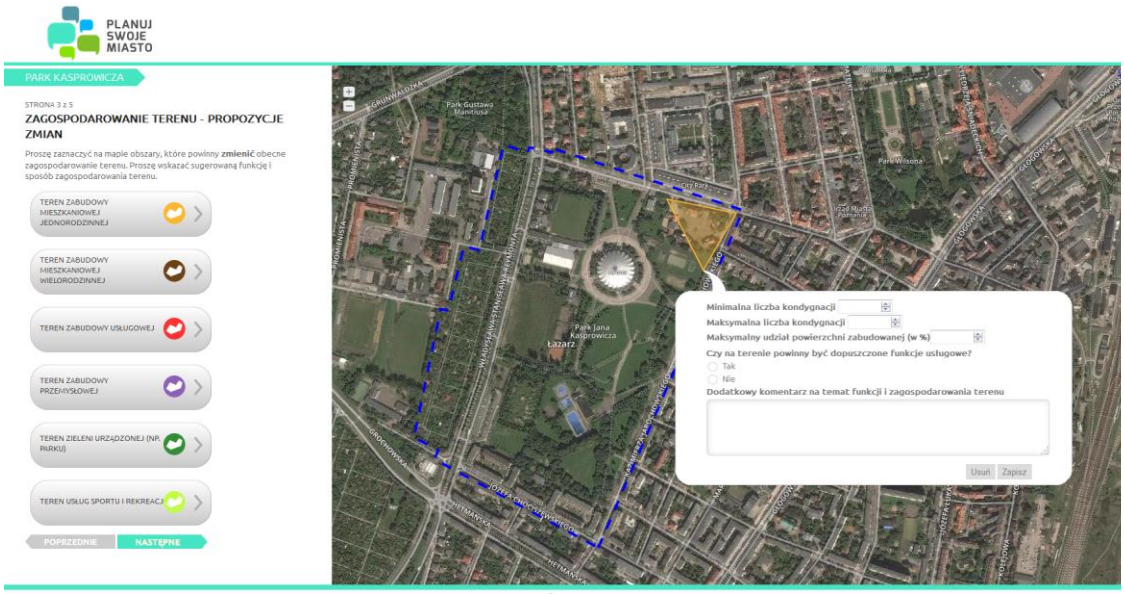


Figure 2a: Aggregated preferences for land use change in four categories CH1 to CH4. The categories CH5 and CH6 are not shown for the sake of brevity. Please refer to Fig. 2b for the legend.

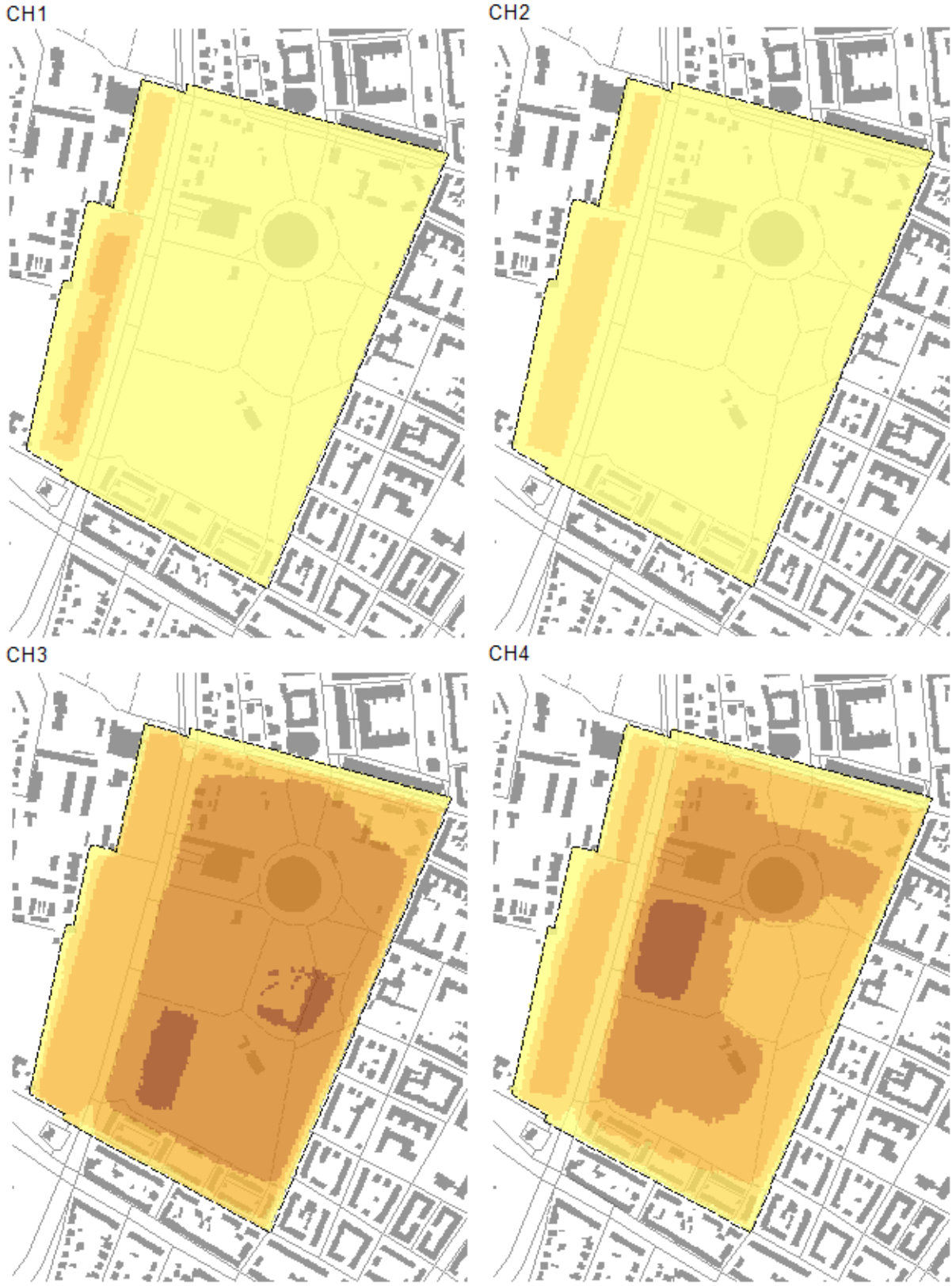
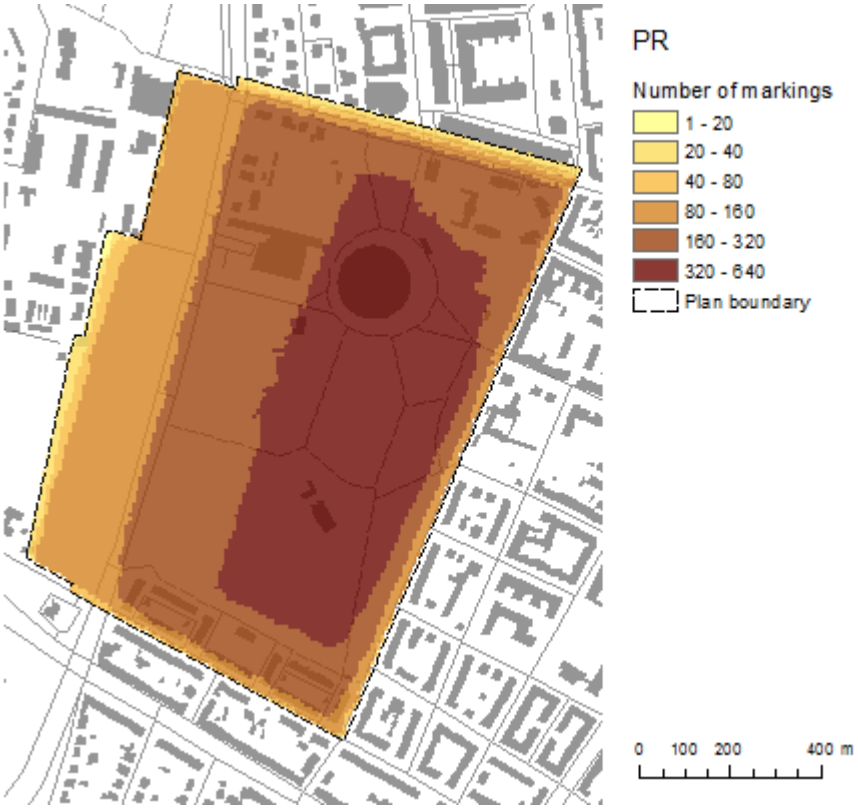


Figure 2b: Aggregated preferences for preservation of current land use (PR).



Overall, 1085 participant responded over the period of one month (between 13th October 2014 and 17th November 2014). The majority of the participants lives within 2 km from the perimeter of the plan area, and represents the population between 15 and 74 years of age. The residents between 25 to 39 years of age are overrepresented in the sample. Interestingly, 74.5% of all participants have higher education compared to 22.6% in the population of Poznań. The participants sketched 2932 geographical features, of which 1859 were polygons representing development preferences used in this study (see Tab. 1 for the breakdown of sketched features).

4 Analysis of geo-questionnaire results

The analysis of answers given to the geo-questionnaire covers map sketches and written text. The paper reports only on the analysis of sketches. The analysis involved aggregating the polygons collected through the geo-questionnaire using vector overlay and rasterization operations. The goal of the aggregation was to obtain a raster layer, in which the value of each grid cell would represent the number of polygons overlapping the cell. The geoprocessing operations were run in ArcGIS 10.2. Specifically, *Union* overlay operation was run on each of the 7 layers (PR and CH1-6) representing preferences for preservation or change. This resulted in creating new polygon features and in particular, for the areas of overlap, in creating polygons with identical geometries (perimeter and area). Following *Union* overlay, *Dissolve* operation was run in order to calculate the count of polygons with identical geometries. Polygon boundaries were dissolved based on common geometry (area and perimeter) resulting in retaining one polygon in place of multiple overlapping polygons, and in creating a new attribute field *count* in the polygon attribute table with the attribute value representing the number of overlapping polygons. Finally, the seven preference layers with their dissolved overlapping polygons were rasterized with the grid cell size of 5 meters using *Polygon to Raster* operation. Each cell received a value from the field containing the count of overlapping polygons. Figure 2a presents the resulting maps depicting preferences for urban function change, and Figure 2b presents a map of preferences concerning the preservation of current function (PR).

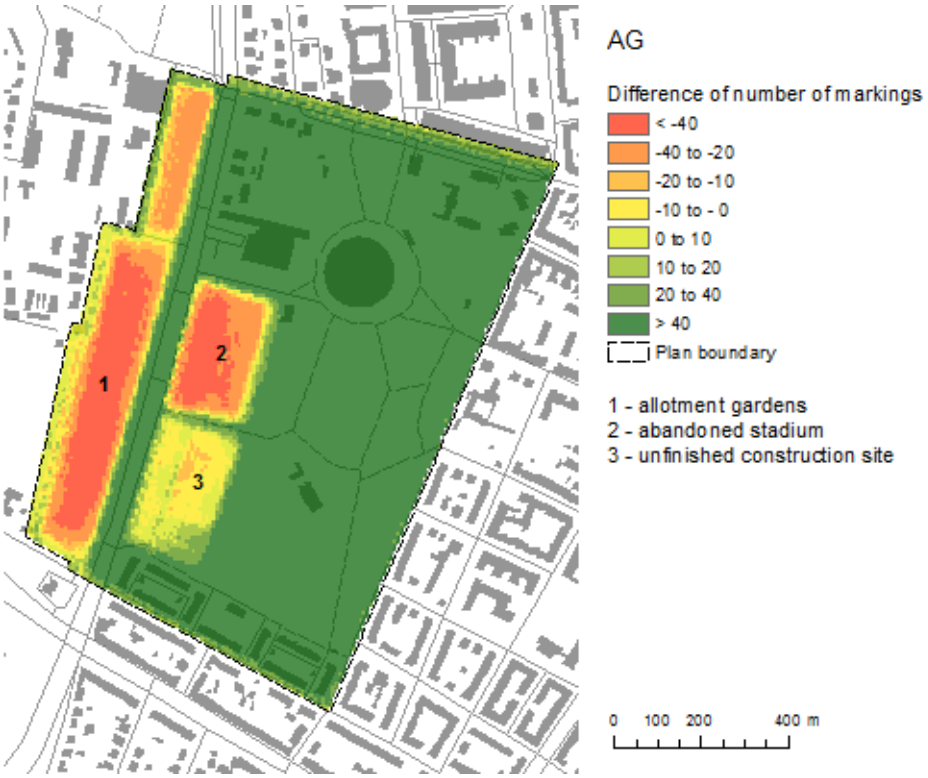
To calculate an aggregated map (AM) representing the degree of divergence between preferences for and against urban function changes, we subtracted the sum of all function change maps (n = 6) from the preservation map (PR) using a local map algebra operation available in ArcGIS 10.2 Raster Calculator (1). The resulting aggregated map is presented in Figure 3.

$$AR = PR - \sum_{i=1}^{n} CH_i \qquad (1)$$

where: AM is the aggregated map, PR is the preservation map, and CH are the urban function change maps.

received suggestions for other land uses. It is rather clear that

Figure 3: Difference between preferences for and against urban function changes. Negative values signify areas where the preferences for change dominate, positive values signify areas where the preferences for preservation dominate, and values around zero signify ambivalence.



5 Interpretation and Discussion

Both categories of maps: the maps depicting preferences for specific development categories (Fig. 2a), and the aggregated map (Fig. 2b) provide a clear summary of the collective opinion of a relatively large set of preferences of individual participants represented by 1859 polygon sketches. It is easy to discern features marked by high level of preference agreement from features marked by preference divergence. There are several ways, in which these maps can be interpreted.

The map of aggregated preferences (Fig. 3) shows areas with the dominance of preferences either toward preservation or toward change. In particular, the map shows three areas of preferred changes: the allotment gardens (1), the abandoned stadium (2), and the unfinished construction site (3). Such a map may provide planners with general insight into where change in current function would be the most or the least acceptable, but beyond that it requires a further look.

The maps of preferences for each category of function change provide further insight into acceptable developments and changes (Fig. 2a). The area of allotment gardens is the only area with a considerable number of suggestions in favor of housing development (CH1 and CH2), which was strongly opposed in other parts of the plan area. The same area also this is the only area considered by some participants as a possible target for a radical change in function, from recreational (i.e. gardening) to residential. That said, the area covered by the allotment gardens located in the western part of the plan area received considerably less markings than the other areas comprising the plan. In the area of the abandoned stadium most markings suggested changes to sport and leisure services (CH4). Most of the markings focused on the unfinished construction site suggesting change to green areas (CH3). Preferences towards the preservation of the current function dominated in the eastern part of the study area occupied by a park, a swimming pool, and a multi-purpose event venue.

Each of the markings gave the participants a possibility to add comments and select land use parameter values, which could be further analyzed. For instances, comments pertaining to the area of allotment gardens reflect the nationwide debate in Poland on their role in cities. Critical comments pointed out the inefficient use of space by a few individuals effectively excluding access to a prime urban green land by others. Comments made in favor of preserving the gardens argued that they provided an important form of recreation for some people, mostly the elderly. The areas presently occupied by the abandoned stadium and the unfinished construction site represent land without a defined use and are perceived as

unattractive and the waste of valuable land in the central area of the city.

The maps give clear image of the collective opinion, which may provide valuable information for planners in reaching a socially acceptable local development plan. However, the interpretation of participant comments accompanying the map sketches revealed several issues related to data quality and usability. One of the issues pertains to the spatial extent of individual markings with many sketches covering areas that only partially correspond to comments linked to marked entities. This presents a challenge in interpreting comments related to a large scale/small area plan and introduces uncertainty in the quality of such interpretations. Analyzing and explaining the relationship between uncertainty in data on resident preferences, obtained through the geo-questionnaire, and the quality of generated information is a topic for further research.

6 Conclusions

The article presented an application of geo-questionnaire method for elicitation of development preferences in a local development plan of an urban area in Poznań, Poland. We collected the preferences in the form of sketched polygon features from a large group of residents using an online geo-questionnaire, aggregated them using vector overlay operations, and calculated a degree of divergence between preferences for and against current urban function designations. The geo-questionnaire-based method allowed collecting a vast amount of data from over 1000 residents. The aggregation methods produced informative and comprehensive maps indicating footprints, magnitude, and direction of public preferences towards the development. The preliminary evaluation of the results suggests that the geo-questionnaire method may be useful not only in supporting local development planning but also in other areas of local governance open to a meaningful public involvement. Future research will focus on data quality and usability assessment, and the relationship between motivation to participate and data content and quality.

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