Exploring the Relationship between Indoor Playrooms and Population in Skopje

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Abstract – **Play has a crucial role in childrens' growth. It teaches them new skills, strengthens their self-confidence, and promotes creativity. Both indoors and outdoors offer play opportunities, but a nearby playground is crucial as it provides a safe and fun place for children to exercise and explore. This can lead to a healthier lifestyle and improved social skills through interacting with other children. In this paper, we analyze the spatial relationship between indoor playrooms and the population in the study area in Skopje. Our study is based on publicly available data on indoor playrooms, including their location, user satisfaction ratings from customers, and data on population density in the area. Our goal is to find potential locations for new indoor playrooms and improve existing indoor playroom offerings through interpolation, hot spot analysis, and spatial data analysis with multiple ring buffers. Our analysis reveals spatial areas of high population density that offer opportunities to improve indoor playroom products and services.**

Keywords – GIS; indoor playrooms; population; Interpolation; Mutltiple Ring Buffers; Hot Spot Analysis

I. INTRODUCTION

Indoor playrooms offer multiple benefits for children, including physical, social, and cognitive development [1]. Physical benefits include increased exercise and movement, improved motor skills, and improved coordination. Social benefits include the opportunity to interact with other children and develop social skills such as sharing, taking turns and conflict resolution. Cognitive benefits include the opportunity to engage in educational activities and develop problem-solving skills, such as jigsaw puzzles, educational games, and reading materials [2]. Indoor playrooms have become an increasingly popular trend in urban areas, especially high-density cities, to provide a safe and engaging environment for children to play and socialize. With more families living in high-rise buildings or without access to outdoor spaces, indoor playrooms provide a space where children can release their energy and develop their social skills. In this article we will examine the importance of indoor playrooms in relation to population density analysis and why it is important to research this growing trend.

To better understand the spatial distribution of business objects, particularly those related to population, as well as their density, it is crucial to understand their geographic location and model them appropriately. An effective approach that is widely used in various research disciplines for optimal site planning and spatial analysis of the customer base is the use of Geographic Information Systems (GIS). GIS refers to a computerized system designed to collect, store, manipulate, analyze, and manage spatial or geographic data. This system provides a powerful platform for integrating diverse sources of information, including maps, satellite imagery, and other location-based data, enabling researchers to create a visual representation of the data and uncover patterns and relationships that may not be readily apparent through traditional analysis methods. GIS has gained attention in recent years as an important research area in urban planning [3]. GIS is a powerful spatial analysis and visualization tool that enables researchers to study and understand the relationships between the built environment, population density, and access to amenities such as indoor playrooms.

In line with this notion, a recent study by the authors in [4] delved into the use of GPS, accelerometer, and GIS data to scrutinize the extent of physical activity in school playgrounds among teenagers. The results suggest that certain types of play equipment, such as soccer fields and climbing equipment, can encourage physical activity among both boys and girls, while the location of play equipment also plays a crucial role. This study can have practical implications for the design and development of playrooms in schools and other similar environments. The researchers also identified areas where physical activity was comparatively low, such as playgrounds without any play equipment and playgrounds designed for younger children. In recent years, GIS has been used extensively to identify the most favorable locations for the development of new facilities or attractions, such as: wind farms [5], rainwater harvesting systems [6], fire stations [7], photographic studios [8] or book-related services in relationship with schools location and population [9] and many more. Several of these studies have considered the geographic location of stores in relation to the population based on factors such as age, socioeconomic status, or ethnic groups.

The goal of this study is to show users and allow them to explore critical features related to indoor playgrounds. The geodatabase contains essential attributes such as company name, location, and geographic location coordinates. Furthermore, additional attributes have been assigned to each indoor playroom to give users a better understanding of the services they offer. The rating of customer user satisfaction and the number of reviewers per facility give a clear indication of the quality of the services offered. In addition, the project will conduct a density analysis of the population within the city limits of Skopje, focusing on their proximity to indoor playrooms. This analysis provides valuable visual insight into the accessibility of these recreation centers to residents of the area of interest. This will enable us to improve customer service and identify potential new locations for the construction of additional indoor playgrounds. However, it must be emphasized that this is an approach based on current available data, as the selection of a suitable location for starting a business depends on many other factors in addition to population size.

The remainder of this paper is structured as follows: Section II provides an overview of the data collection process and methodology used for mapping indoor playrooms and population densities in a given area. In Section III, we analyze the relationship between the locations of these facilities and the distribution of population clusters and discuss the implications of our results for identifying new business opportunities. Finally, we summarize our main observations and conclusions in Section IV.

II. Materials and Methods

To map and analyze the necessary data for indoor playrooms and population density, we used ArcGIS software [10]. It is worth noting that the data and analysis presented in this study are limited to the selected geographical location around in the city of Skopje.

A. Data collection and geodatabase

In this section we provide an overview of the data collection process and geodatabase creation for the indoor playrooms and population density analysis in selected area in the city of Skopje. The data collection process involved gathering information about the location of indoor playrooms, the names of their respective companies, and the XY coordinates of each object. Additionally, we collected data on customer satisfaction ratings and the number of reviewers for each facility. This is done by web extraction from several different web sources, such as the Google Search, "Zlatna Kniga" [11] and "Reklama 5" [12]. In total, we collected information on 41 indoor playroom objects.

The data collected for the indoor playrooms and population density analysis is carefully sorted and organized into relevant attributes to describe each object of interest. To effectively manage and analyze this data, an Excel spreadsheet was created. Each row in the table is identified by a unique object ID, and each column corresponds to a specific attribute of interest, given further:

- Name – name of the indoor playroom
- Address – location of the indoor playrooms
- Latitude and longitude – Latitude and longitude expressed as decimal degrees
- Rating – user satisfaction rating according to Google.
- Customers – number of users.

The first step in the conversion process is to import the Excel spreadsheet into ArcGIS software, which then we convert into a geodatabase. The procedure can be performed in ArcMap by selecting and then adding data. This is done using "Add XY data" option and finally connecting to the desired database/document. This process automatically analyzes the latitude and longitude coordinates and we set the coordinate system to the WS 1984 geographic coordinate system. Once all the required parameters are set, the geographic coordinates are displayed as points on the map. Thanks to the use of an accurate coordinate system, most of the displayed coordinates are quite accurate. To label the features of the newly formed layer we use the Label Features tool in ArcMap. To simplify data manipulation and facilitate communication, the necessary map and shape layers we downloaded from a freely accessible website [13]. By organizing the data in this way, we can more easily identify trends and patterns in the distribution of the indoor playroom facilities and population clusters in the desired region.

B. Data on a map

A crucial next step entails the improvement of the visual representation of objects on the map, as they are currently presented solely as dots. Upon creating each object, we use the Symbology tab to modify the associated symbol to more accurately resemble the object that is of interest. Similarly, the Labels tab enables the user to adjust the font size, thereby enhancing clarity and legibility. Notably, the map depicting Skopje alongside the municipalities of Dracevo and Novo Lisice has been obtained from the [13] webpage and named Skopje_Boundary.shp. The map was created via the Export Data function of the gis.osm shapefile and SQL expression, after eliminating all markers except the relevant city borders. By using the Merge tool we merge the above-mentioned polygons, leaving one large shape that is within the city limits of Skopje. This remaining shape is critical for interpolation in the final stages of the project. Geographical objects have been appropriately symbolized, as shown in Fig. 1. In particular, the red icon representing a children's playroom serves a purely aesthetic function and does not affect the results.

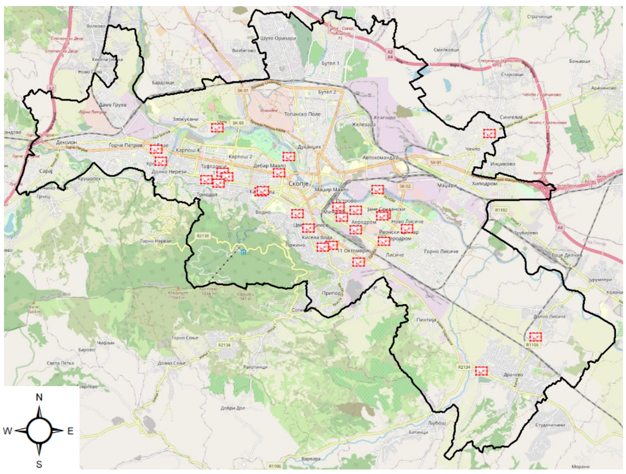

Figure 1. Mapped locations of indoor playrooms objects on the map.

The next step in our analysis involves the import of population density data, which is essential for assessing the child population in Skopje by considering women population density under 50 years [14]. We assume that at least one child accompanies this population. Population density data can be added and viewed in a similar manner to the previous indoor playgrounds data using the ArcMap software with XY Data tool. The program automatically analyzes the longitude and latitude coordinates, which are then displayed as points on the map. It is important to note that while we have population density data for the entire territory of the Republic of North Macedonia, our focus is solely on the city of Skopje and its borders.

III. Results and Disscussion

Spatial interpolation uses points with known values to estimate values at other unknown points and this is a very powerful tool. Spatial interpolation can be used to provide contours for graphical display of data, to calculate some properties of the surface at a given point, or to change the unit of comparison when using different data structures in different layers [18].

A. Interpolation Map

Using the IDW interpolation method [15], we generate an interpolation map from a table containing the locations of indoor playroom objects based on their user satisfaction ratings recorded as rating attributes in the geodatabase. This process enables the identification of zones with better or worse services rated by the customer. This creates of a layer with a heat map showing all the indoor playroom objects, visualized and presented according to the user rating provided by the customers themselves, in this case the children's parents. In order to achieve this, we first need to constrain the space inside the shape itself. This is done from the Geoprocessing - Environments menu. The Processing extent option is used to constrain the workspace by using the Skopje_Boundaries layer created earlier. The Mask option in the Raster analysis is also used to create a mask around this shape layer, giving the heatmap the shape of the layer and a more aesthetically pleasing appearance.

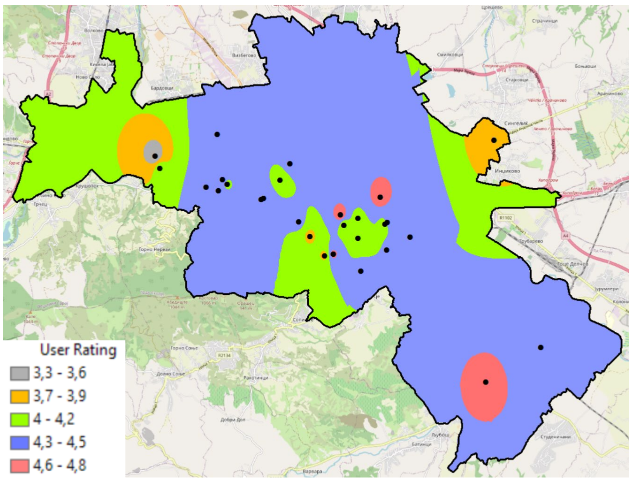

Figure 2. IDW interpolation map for the rating of indoor playrooms objects on the map.

As shown in Fig. 2, the heat map represents all indoor playroom objects where people can bring their children to play and reflects the user satisfaction rating given by the customers themselves. By examining the map results, we found that most of the indoor playrooms have an average rating of 4 stars and some of them outside of the city center have ratings above and below 4. It is important to note that the user satisfactory rating considered not only the feedback from the children, since most of them may not know how to leave ratings, but rather the opinions of the parents about the indoor playroom service. Our next step in the analysis is to relate these results to population densities and their geographical distribution.

B. Hot spot analysis with multiple ring buffers

Population density is a crucial factor that must be taken into account when determining the optimal location for a business object, including indoor playrooms and their services. The accessibility of the location for the target group of customers, in this case children and parents, gives the object a competitive advantage. Our analysis focuses on examining the placement of indoor playroom objects in relation to clusters of targeted population data and the distances between their locations.

In the initial phase of our analysis, we will generate ring buffers to study the optimal location for indoor playroom objects in terms of clusters of female population data and location distance. To achieve this, we will use the Multiple Ring Buffer tool available in ArcGIS software. The Multiple Ring Buffer tool is available in the Proximity toolbox and once the distances are entered the rest of the parameters are set to the default values. Since we have already mapped the indoor playroom objects, we will perform this analysis in addition to these existing data points. Multiple Ring Buffer Analysis is responsible for creating multiple buffers at specific distances around each indoor playroom. The buffers can be displayed without overlapping to avoid discrepancies. For each indoor playroom in selected area, we will create three distance buffers with distances of 100, 300 and 500 meters.

Analyzing population data is a crucial step in understanding the distribution and patterns of people in different regions. Spatial analysis is an effective tool for identifying high and low value clusters within a population dataset. In this regard, the ArcGIS Optimized Hot Spot Analysis (OHSA) tool was instrumental in identifying and visualizing these clusters using different layers of data. Here we discuss the clustering part of the analysis using the ArcGIS OHSA tool over high-resolution population density data [16]. The ArcGIS OHSA tool is a spatial analysis tool that can be used to identify spatial clusters of high and low values. The tool is used to analyze many types of datasets where the spatial distribution of values is important. ArcGIS OHSA tool uses a statistical approach to identify areas of high and low values, taking into account surrounding values and the overall distribution of values within the dataset. We can represent the hot spots, cold spots and middle value areas with different prominent colors. The mean values can be visualized with a color gradient from light to dark to show the deviation from the overall mean value. This allows for a better understanding of the distribution of data on the population density of target population and areas that require attention. The results of the OHSA are presented in Fig. 3.

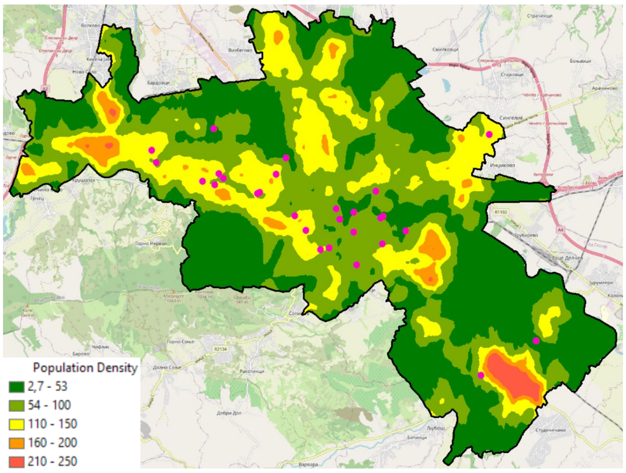

Figure 3. Population clustering as a result from OHSA. Red color depicts a densely populated area, while green covers lightly populated area.

After performing the optimized hot spot analysis with the ArcGIS tool, the output obtained is a point layer that can be difficult to interpret due to overlapping features. To overcome this limitation, we need to convert the point layer to a raster format that can provide a clearer picture of the spatial distribution of the target population. In addition to the optimized hot spot analysis, we also need to integrate the results of the Multiple Ring Buffer tool to get a comprehensive analysis of the distribution of the targeted population. The Multiple Ring Buffer tool is used to create concentric buffers around a point layer so that each ring represents a specific distance from the center of the object. In our case, the center would be the location of the indoor playrooms. By combining the results of the optimized hot spot analysis and the Multiple Ring Buffer tool, we can create a raster layer that shows population densities in various concentric zones around the indoor playrooms objects.

To represent the distribution of the clusters obtained from the earlier analysis, we used an interpolation, specifically using the Kriging tool [17]. The kriging interpolation technique, similar to inverse distance weighting interpolation, is used to generate a surface by analyzing a set of sample points. However, kriging interpolation excels as a geostatistical approach, in contrast to the deterministic nature of IDW interpolation. Although both methods can accept feature classes as input, they rely on the proximity of neighboring sample points to construct the surface. We ran Kriging interpolation on the point features extracted from the optimized hot spot analysis, specifying the NNeighbors attribute as the z-value field. As with the previous IDW task, we configured the environment settings to handle the expansion and masking parameters for the administrative border region of the Skopje_Boundary.shp file.

The resulting interpolation results are shown in Fig. 4 along with the location of indoor playgrounds and multiple ring buffers. Analysis of the results shows that most of the indoor playrooms are in and around the city center where the population density is high. However, we observe that the northern, eastern, and southern regions of Skopje have a lower density of indoor playroom facilities.

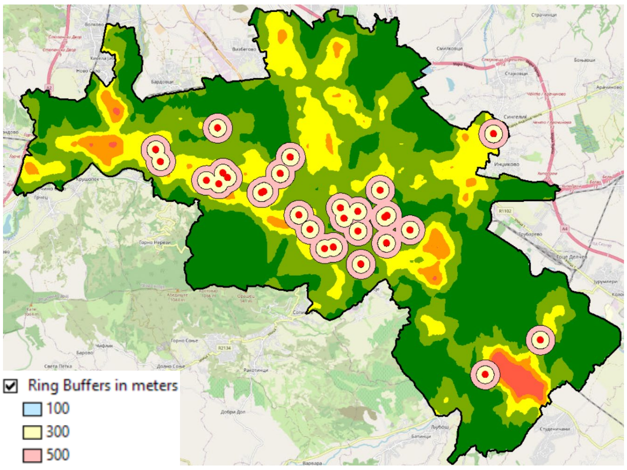

Figure 4. Population clustering map resulted from the OHSA combined with the Multi Ring Buffer tool markers.

Based on these insights, we recommend opening a new indoor playroom with a possible delivery service to attract new customers, improve service quality and increase customer satisfaction. The important thing to note is that the densely populated indoor game room establishments should try to improve their customer service, especially those with ratings of 4 or below. Despite the southeastern region's high population density, there is a shortage of indoor playrooms available to the public. This result suggests potential locations for new business opportunities, as the ability to travel from communities to downtown may not be easily accessible or affordable for some individuals.

IV. CONCLUSION

This research work focuses on mapping and visualizing the population density related to indoor playroom facilities and services within a given area in the city of Skopje. Our study provides an overview of the geographical distribution and valuation of the indoor playroom markets. Additionally, we identify areas with restricted accessibility by overlaying the locations of indoor play areas with the target audience. Our analysis confirms that the indoor playroom stores are poorly located and present significant access difficulties due to their central location, especially in the North, East and Southeast regions of the study area. To address this issue, we recommend considering opening new facilities in border areas. In summary, this study emphasizes the importance of addressing disparities in accessibility in urban areas in order to better serve the needs of the community and improve their quality of life.

Future research could expand our findings by including an analysis of the average travel time and costs incurred by people using these services. Additionally, including a rating or satisfaction factor from the target audience could provide further insights to balance store placements and move to a more distributed location model.

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