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EXPLORING THE WALKABILITY CONCEPT IN A POST-SOCIALIST CITY THROUGH GIS ANALYSIS. THE CASE STUDY OF IAȘI, ROMANIA

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Abstract: The walkability concept is widely researched and applied in western societies, being a major benchmark for creating a friendly urban environment by the local authorities. While in these countries the concept has a strong tradition, in Eastern Europe it has not received enough attention yet (neither from researchers nor local stakeholders). The present study aims to explore the possibilities of adapting this concept to the post-socialist city by analyzing the walkability potential in a medium-size city (Iași, Romania). The three main objectives envisaged by this research - delineating Walkability Areas, exploring their internal structure and highlighting patterns in regard to the urban structure of a post-socialist city – are accomplished by using the specific GIS tools and statistical methods. The results reveal a heterogeneous construction of the six walkability areas resulted, shaped by the socialist legacy and market economy transition. A walkability score, computed in order to quantitatively assess these differences among them, represents an effective tool for decision makers as it spots the major dysfunctionalities each of the walkability areas. The emergence of the concept in the post-socialist city favors the construction of a more livable urban environment.

Keywords: *walkability areas, socialist heritage, service area, quantitative assessment, spatial patterns*

I. INTRODUCTION

Walking behavior is widely considered a core issue for a healthy lifestyle ("WHO | Obesity and overweight," n.d.); different disciplines, such as medicine, public health, environmental psychology, urban planning, sports science etc.(Andrews, Hall, Evans, & Colls, 2012) are highly concerned about optimizing the community design, as to facilitate walkability (Bridge & Watson, 2010).

A large body of scientific literature approached the numerous advantages of a walkable residential environment. Health implications of walkability are widely referred in most of the studies:(L. Frank, Kerr, Chapman, & Sallis, 2007) demonstrated that the walkable environments are more prone to incidental walking and record a lower frequency in obesity, as other authors highlighted that even light or moderate physical activity is able to substantially reduce the risk of developing different diseases (Hu, 2003) and that the built-up context plays an important role in physical activity level(Ewing, 2005), (Handy, Cao, & Mokhtarian, 2005),(Handy, Cao, & Mokhtarian, 2006). Besides the health related consequences of a walkable environment, other types of implications were studied: the economic and social exchanges are considered to be more active in a walkable community, thus enhancing its economic value (Leinberger & Alfonzo, 2012), favoring economic resilience (Litman, 1999), improving security(Leslie et al., 2005), reducing crime (Foster & Giles-Corti, 2008), (Gilderbloom, Riggs, & Meares, 2015) and even increasing the real estate property value (Diao & Ferreira, 2010), (Gilderbloom et al., 2015).

The definition of a walkable environment differs from author to author, but (Azmi & Karim, 2012) cite two relevant conceptual dimensions of walkability: the first one was elaborated by (Abley, 2005)and refers to "the extent to which the built environment is friendly to the people living, shopping, visiting, enjoying or spending time in an area" while (Leslie et al., 2007) adds that suitability for travelling to work is an important feature of a walkable environment; the second one highlights the fact that walkability is also dependent on the human behavior in the study area(L. D. Frank et al., 2006). Hence, there is no possibility to find any "one size fits all" walkability measure, as it depends on trip purpose and residents socio-economic features (Manaugh & El-Geneidy, 2011). "Walkability can thus be understood as a "match" between residents' desires and expectations for types of destinations, their willingness to walk a given distance and the quality of the required path." (Manaugh & El-Geneidy, 2011).

These reflections on walkability concept mainly originate from western societies - US, Western Europe, Australia(Leslie et al., 2007),(Owen et al., 2007) where the current urban problems – such as car dependency and car oriented infrastructure, low physical activity rates, fast-food consumption –have started several decades ago and now they are experiencing the related consequences: social isolation, obesity and other health impacts (Papas et al., 2007), (Buys, Snow, van Megen, & Miller, 2012), energy shortage and air pollution (Goodwin, 1996), (Sperling, 1995). On the other hand, post-socialist cities faced a shorter experience in this respect, as the centralized economy rationalized car usage or other consume-oriented lifestyles (Stanilov, 2007). Still, the recent economic and political shifts changed the urban lifestyles at a high pace and created chaotic urban environment, by attempting to import evolution models from western societies. The most obvious change can be seen in the increase in the car ownership and related consequences (Pucher & Buehler, 2005). These transferred features were specific for the western city some decades ago. Hence, the transport policies in post-socialist countries should start focusing on newer, inhabitant-oriented approaches, rather than developing car related urban infrastructures and encouraging car usage, in order to minimize the consequences which the more advanced economies had already faced. Therefore, the walkability concept – highly researched and successfully applied in western societies – holds great usefulness and positive impact upon transition societies on multiple extents.

The present paper attempts to identify and analyze different patterns of walkability areas (WA) in a post-socialist city, through the case study of Iași, Romania. The study explores the effects of planning policies from both centralized and market economy phases on the development of these WA, by highlighting the relationships between urban environment and the concept of walkability. There are three main objectives of the paper: defining the WA based on accessibility to different facilities; analyzing the internal structure of these areas through fieldwork and spatial analysis of the economic activities; highlighting the general characteristics of WA in regard to the urban structure.

II. BACKGROUND

Various approaches and methods were presented in different studies as an attempt to tackle the problem of the walkability level of a neighborhood, which can be grouped into two main categories: objective and self-perceived methods. (Andrews et al., 2012) points out several studies discussing the advantages and risks of each type of measures, insisting on the idea that even the objective walkability measures are often criticized of not being linked enough to the self-perceived one, there is still considered that objective factors remain the most relevant, particularly due to the lack of residents' knowledge on their environment (van Lenthe & Kamphuis, 2011).

The present approach attempts to create an objective method of assessing walkability. A large amount of work has already been performed in this direction and includes various methods. Most of the studies calculated a general walkability index for each unit composing the study area, taking into consideration different issues. One of the first attempts to calculate a walkability index took into consideration land-use mix, residential density and street connectivity(L. Frank, Schmid, Sallis, Chapman, & Saelens, 2005). This model was highly cited and improved during the last years: the same authors added the retail floor area to the three initial variables(L. Frank et al., 2006)(Dobesova & Krivka, 2012); (Leslie et al., 2007) revaluated the index by correlating it with results of a field survey and the population characteristics; (Giles-Corti et al., 2013)elaborated a GIS tool to calculate this walkability index; (Villanueva et al., 2014)studied the variation in walkability for different buffer sizes and life stages, using the three initial variables. Other approaches were proposed too: (Glazier et al., 2008) used Principal Components Analysis to select relevant factors from a variety of variables; (Porta & Renne, 2005) evaluated the walkability by clustering the dwellings according to numerous urban fabric and street connectivity indexes; other authors performed detailed, multi-criteria dynamic analyses on a sample of street segments – audit tools (Millington et al., 2009)(Galanis & Eliou, 2012) ;(Moniruzzaman & Páez, 2012); (Wey & Chiu, 2013). Many walkability indexes were converted for public use, through websites, social media or mobile applications, allowing users to calculate the walkability level for different areas, such as their neighborhood ("Walk Score Methodology," 2015);("The Copenhagenize Index of Bicycle Friendly Cities," 2015) which mainly takes into consideration the distance to the most important amenities and facilities.

Besides objective methods, the subjective methods complete the walkability measurements, either by testing objective indexes through surveys (Azmi & Karim, 2012; Dyck, Cardon, Deforche, & De Bourdeaudhuij, 2011; Lindelöw, Svensson, Sternudd, & Johansson, 2014; Reyer, Fina, Siedentop, & Schlicht, 2014) and GPS tracks (Dobesova & Krivka, 2012) or by using questionnaires for assessing features related to perception of the environment(Granié, Brenac, Montel, Millot, & Coquelet, 2014; Park & Kang, 2011; Sutikno, Surjono, & Kurniawan, 2013). Other studies use mental mapping for measuring walkability indexes(Filion & Hammond, 2003).

Whatever the method, most of the studies are concentrated in the USA (Grasser, Van Dyck, Titze, & Stronegger, 2013), where the urban environment has slightly different features from the European city, especially Eastern-European one. Therefore, it is important to adjust the methodology to the local context.

III. DATA, METHODS AND ANALYSIS

The present methodology includes three main steps for exploring the current state of potential WA located inside of Iași Municipality: firstly, a service area-based (SA) methodology was proposed for delineating potential WA, then geo-spatial detailed data was collected through field work for the resulting WA; finally a comparative analysis, based on various statistical measures, was performed for the six WA identified.

III.1 Study area

The current paper applies its methodology on the urban environment of Iași Municipality, located in the N-E of Romania. Having a population of 290422 (“Rezultate | Recensamant 2011,” n.d.) Iasi is the largest city in the N-E Region, and the fourth largest from Romania. The present urban landscape is mainly the result of the socialist period (1940-1989), when a “systematized evolution and a planned spatial specialization occurred, by the construction of a large industrial platform (in the south – eastern part of Iasi) and of the workers’ districts endowed with all the socio-economic utilities”(Stoleriu & Stoleriu, 2004). During the post-socialist transition, the industrial decline determined economic reconversion to tertiary activities while the workers districts preserved some of the past relicts (dense and systematized urban morphology, high population density in collective dwellings, and lack of local identity); for instance approximately 75% of population is located inside of these dormitory districts. At the same time the market economy triggered the urban functions and activities diversification, leading to subsequent shifts in population lifestyle. Hence, these highly populated districts shifted from standard socialist urban cells – consisting of collective dwellings grouped around a center including small public places and basic facilities – to more friendly urban environments, holding a greater functional diversity and complementarity both at district and city scale. Our hypothesis is that this spontaneous socio-economic transition leaded to a favorable context for the WA to emerge mostly on post-socialist districts.

III.2 Data collection

In order to perform the proposed analysis two types of data were processed:

At the urban city scale, four types of facilities (Bus Stations, Churches, Shopping Centers and Community Open Spaces) were digitized using base maps provided by ESRI. Then, SA were calculated using Open Street Map road network and population census data (Iasi Mayor’s Office). At WA scale, all economic activities and facilities (green areas sqm, Schools, playgrounds) were mapped by field work.

III.3 Data analysis

III.3.1 Delineation methodology for WA using spatial analysis

While other studies take into account the entire urban area for highlighting the spatial variations in its walkability value, the present study proposes a different method where potential WA are delineated based on accessibility to different urban facilities.

The first step of the current spatial analysis consist of creating four SA (using Network Analyst Extension from ArcGIS 10.2), for the most frequently visited facilities: bus station (300 m SA), church (300 m SA), Shopping Centre (450 m SA), Community Open Space (350 m SA). These facilities were chosen based on researches from the academic main stream (L. Frank et al., 2007) and were adapted to the local cultural context. The threshold distances were estimated according to the spatial distribution frequency of the chosen facilities.

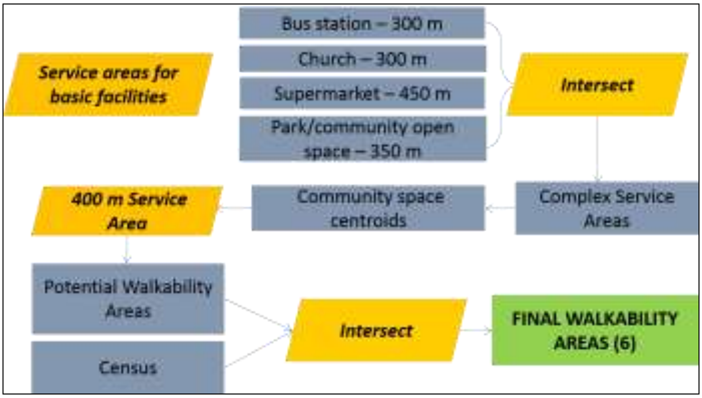

Fig 1. Methodological Framework

The four SA were intersected resulting a complex SA; the potential WA were spatially modeled based on a new 400 m SA. Final WA were computed by intersecting the potential WA with population census; considering that demographic mass is important for WA, only the areas recording at least a medium population density were used.

III.3.2. Creating a walkability score for WA

In order to explore the patterns of WA, a final walkability score (WS) was computed by calculating different partial indicators based on data obtained from the field work: density of schools (per 1000 inhabitants), playgrounds (per 1000 inhabitants), pavement (km/sqkm), junction (per sqkm) and population (pop/sqkm), economic activities (per 1000 inhabitants), Shannon entropy index, specialization index, facility deficit index, green areas (sqm per 1000 inhabitants). For calculating the final WS (ranging between 0 and 10), the partial indicators were firstly standardized and then summed up.

FWS=$St_{0\text{-}1}$ (EAD)+ $St_{0\text{-}1}$ (Sh) +$St_{0\text{-}1}$ (SI) +1/$St_{0\text{-}1}$ (FDI)+ $St_{0\text{-}1}$ (GA)+ $St_{0\text{-}1}$ (S)+ $St_{0\text{-}1}$ (P)+ $St_{0\text{-}1}$ (PD) + $St_{0\text{-}1}$ (JD) +1/$St_{0\text{-}1}$ (PopD)

Where:

FWS = Final Walkability Score, $St_{0\text{-}1}$ = Standardized values for each index between 0 (min) and 1 (max), EAD = Economic Activity density, SH=Shannon Entropy Index, SI = Specialization Index, FDI = Facility Deficit Index, GA=Green areas density, S=school density, P= Playgrounds density, PD=Pavement density, JD=Junction density, PopD=Population Density

$$EAD = EA_{WA} * 1000./_{Pop} \quad (1)$$

Where:

EAD=Economic Activity density, EA_{WA} = Number of economic activities in the WA, Pop_{WA}= total population of the WA

Green areas density (GA) and Schools density (S) are calculated similarly to EAD (1).

$$Sh=\frac{-\sum_{T_{WA}}^{i=1}(N_i WA/N_T WA)*\ln(N_i WA/N_T WA)}{\ln(T_{WA})} \quad (2)$$

Where:

Sh= Shannon Entropy,T_{WA} = Number of economic activity types in the WA,$N_i WA$ = Number of economic activities of type i in the WA, $N_t WA$ = Number of total economic activities of all types in the WA

$$SI= \frac{\sum_{T_{WA}}^{i=1} N_i WA/_{N_i tot}}{T_{WA}} \quad (3)$$

Where:

SI=Specialization Index, $N_i WA$ = Number of economic activities of type i in the WA, $N_i tot$ = Total number of economic activities of type i in all WA taken into consideration, T_{WA} = Number of economic activity types in the WA

$$FDI = (T_{tot} - T_{WA})/_{T_{tot}} \quad (4)$$

Where:

FDI = Facility Deficit Index, T_{tot} = Total number of economic activities types in all WA taken into consideration, T_{WA} = Number of economic activity types in the WA

$$PD = {PL_{WA}}/{S_{WA}} \quad (5)$$

Where

: PD=pavement density, Pl_{WA}=Pavement length, S_{WA}=WA Total Area

Junctions Density (JD) and Population Density (PD) are calculated similarly to PD (5).

IV. RESULTS AND DISCUSSIONS

By applying the above mentioned methodology, 6 WA resulted. Their patterns are analyzed at three different scales: (1) the city scale, aiming to explain the presence of WA in relation to the urban structure, (2) WA system scale, highlighting the differences between different WA, (3) WA scale, focusing on the internal structure of each WA.

IV.1 Spatial distribution of WA inside of the city

The main features of the city zoning have a strong influence upon the spatial distribution of WA. In spite of a heterogeneous urban fabric, the city can be divided into some major land use characteristics:

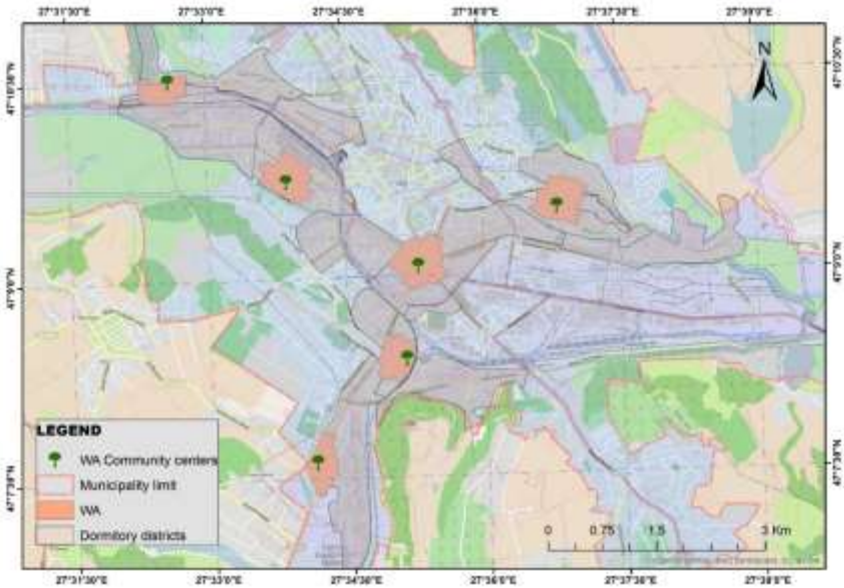

Fig. 2 Spatial distribution of WA inside the Iasi City

The North-Central area of the city overlays the pre-socialist structures, holding a diversity of functions among which the residential one is not the most representative.The South South-East area of the city has an industrial function, built during the socialist period. Nowadays the industrial decline and the industrial relocation created numerous brownfields facing renewal.The Western side of the city is characterized by the presence of collective dwellings districts holding the greatest population density of the city. The post-socialist period lead to a favorable economic context inside of collective districts leading to a more livable environment and the emergence of WA. The WAs follow a western pattern, overlapping the main collective dwelling districts, excepting Oancea WA which is centered upon Tătărași district, built in the Eastern part of the city, as to serve the industrial platform nearby. Still, the spatial distribution of WA is dispersed and balanced across the city leaving extended uncovered areas between them.

Therefore WA cover only a reduced part of the districts, mainly due to the lack of community open spaces; even considering that there was a favorable context for the economic transition, leading to the emergence of diverse facilities aroused from private initiatives, there were no political strategies for extending and creating new community open spaces. Hence, there is a double mismatch between the WAs and population distribution (Table 1): on the one hand WAs serve only 22% of the city population; on the other hand the existing WA cover a reduced area (less than 2% of the city) generating a great pressure upon urban the environment and low serving capacity

Table 1. Overview upon the six WA

Walkable area name	Population	% of Iasi population	Area (sqkm)	% of Iasi area
Oancea	8425	3.12	0.35	0.37
Voievozilor	16770	6.21	0.34	0.36
Podu Ros	8649	3.20	0.41	0.44
Mimoza	8461	3.13	0.2	0.21
CUG 2	8632	3.20	0.25	0.27
Clopotari	9703	3.59	0.25	0.27
Total	60640	22.46	1.8	1.92

. Even though the area of the WAs should be approximately equal (according to the proposed methodology) there are great differences among them (ranging from 0,2 to 0,45 sqkm) (Table 1). The main reason for these inequalities is the presence of different functional barriers both inside and at the edge of the WAs: Mimoza WA is spatially restricted by the presence of railway at the southern edge and by the built-up area limit at the northern edge; Clopotari WA has a reduced area owing to two edge barriers (railway and main arterial road) and one internal barrier (Nicolina River); CUG 2 WA is constrained by the presence of industrial area (in the Eastern side) and by the built-up area limit (in the western side).

These WAs experience a lack of central-place facilities (Park & Kang, 2011), for example administrative services, cultural institutions, educational facilities, recreational spaces, commercial streets, entertainment places (pubs, restaurants, clubs); even the job density does not follow the population distribution. Hence, the majority of population has to travel outside of WAs for working purposes.

IV.2 Final Walkability Score

By adding the ten partial indicators, a final walkability score, ranging from 1 to 10 was calculated. This score created a hierarchy (Table 2) containing three main categories:

In the first category – where the final WS records the highest values – two WAs are included (PoduRoș and Oancea). These WAs present a great economic density and diversity due to low values for Shannon's Entropy and Facility Deficit Index; at the same time, they record high values for density of economic activities and Specialization Index. For Podu Roș WA, these high values are explained by the central position of WA inside the urban system, hosting over-local functions. On the other hand, Oancea WA is a good example of a mostly self-sufficient district, where the variety and density of economic activates cover the population density. Both WA are well equipped in terms of facilities; Oancea has the highest density of playgrounds and pavement, being a friendly living environment and PoduRos benefits from the presence of numerous schools and community open spaces (four parks) and a good connectivity assured by the junction density.The high values for junctions and pavements density reveals a pedestrian oriented structure, which increases the level of mobility and interaction.Finally, this category takes advantage from the medium population density, offering adequate service capacity both for facilities and economic activities.

Table 2 Final walkability score

Walkable Area Name	Economic activities (per 1000 inhabitants)	Shanon's Entropy	Specialization Index	Facility Deficit Index	Green Area (Sqm per 1000 inhabitants)	Schools (per 1000 inhabitants)	Playgrounds (per 1000 inhabitants)	Pavement density (km/sqkm)	Junctions Density (per sqkm)	Population Density (pop/sqkm)	Final Walkability Score (standardized)
PoduRos	25,09	0,83	0,35	0,28	1503,06	0,46	0,23	73,17	729,27	21095,1	9,11
Oancea	17,69	0,88	0,25	0,42	1305,64	0,24	0,95	65,71	822,86	24071,4	8,16
Voievozilor	12,46	0,81	0,29	0,28	1013,71	0,36	0,48	55,88	494,12	49323,5	7,06
Mimoza	16,22	0,89	0,35	0,35	827,33	0,12	0,59	48,00	452,00	34528,0	6,60
Clopotari	6,18	0,95	0,21	0,58	360,71	0,31	0,00	48,00	460,00	38812,0	4,84
CUG 2	4,14	0,91	0,14	0,66	695,09	0,00	0,00	52,00	370,00	42305,0	4,00

Mimoza and Voievozilor WAs belong to the second category which records medium values for the WS. While Mimoza faces rehabilitation process and has a peripheral position inside of the urban structure (being crossed by two major axes), Voievozilor WA – although it is a consolidated urban community, holding high absolute values for the partial indicators – still records a lower WS due to a high demographic pressure on economic activities and facilities. From the economical point of view, both WAs record medium density for economic activities; however, Voievozilor has lower values for specialization and deficit indexes due to a great economic diversity, while Mimoza records higher values for the same indicators, revealing a different economic pattern (being specialized in furniture equipment). For the facilities, both have medium values for almost all the indicators excepting the density of schools, where Mimoza faces a deficit.

The last category contains the WAs with the lowest WS (CUG 2 and Clopotari). CUG 2 WA overlays a contact zone between an industrial and a residential area situated at the edge of the city; its emergence is due to the presence of a major transit axis which favored the location of some economic activities. Clopotari WA is locked in the urban system by the presence of functional barriers which drives most of the interaction to the western direction (Figure 3). Both WAs record the lowest values for all partial indicators related to economic activities, highlighting the low economic density and diversity mostly comprising convenience stores and other basic activities. The same pattern can be observed for facilities, the two WAs being poorly equipped and not offering a friendly living environment.

IV.3 Spatial patterns of Walkability Areas

The last level of analysis consists of examining the internal spatial patterns of each WA.Firstly, the six WAs have different geometry and spatial arrangement in relation to their main fabric. This pattern is mainly imposed by the major axes, which channel internal and external flows, favoring the economic activities and facilities concentration. On the other hand, the same major axes split WAs, reducing the probability of interaction among different parts of the same WA.

Secondly, their internal structure reveals three different patterns in concentration of the population, economic activities and the location of community open space. (1) In most of the cases there is an approximate overlapping of the three features mean centers. This pattern is specific for Podu Ros, Voievozilor and Cug 2 WAs (Fig. 4 – c, d, e), where there is a strong relation between community open space and the major axis: in two of the cases (c, d) the closeness between community open space and major axis favors the overlapping of the three mean centers, while in Voievozilor (e) the overlap is favored by the axial role that the community open space plays itself (due to its bigger size and double linear shape).(2) In two of the other cases there is a mismatch between the mean center of the community open space and the other two. This pattern is driven by the peripheral position of the community open space (due to the road network structure and the limiting barriers) while the mean center of population and economic activities concentrates either along the major axis (a) or in the geometric center of the WA (f). (3) the third case (Oancea WA – b) has a triple mismatch due to its heterogeneous internal structure; while the population is approximately evenly distributed around the community open space, the commercial activities tend to concentrate on the north-eastern part, near the major axis.

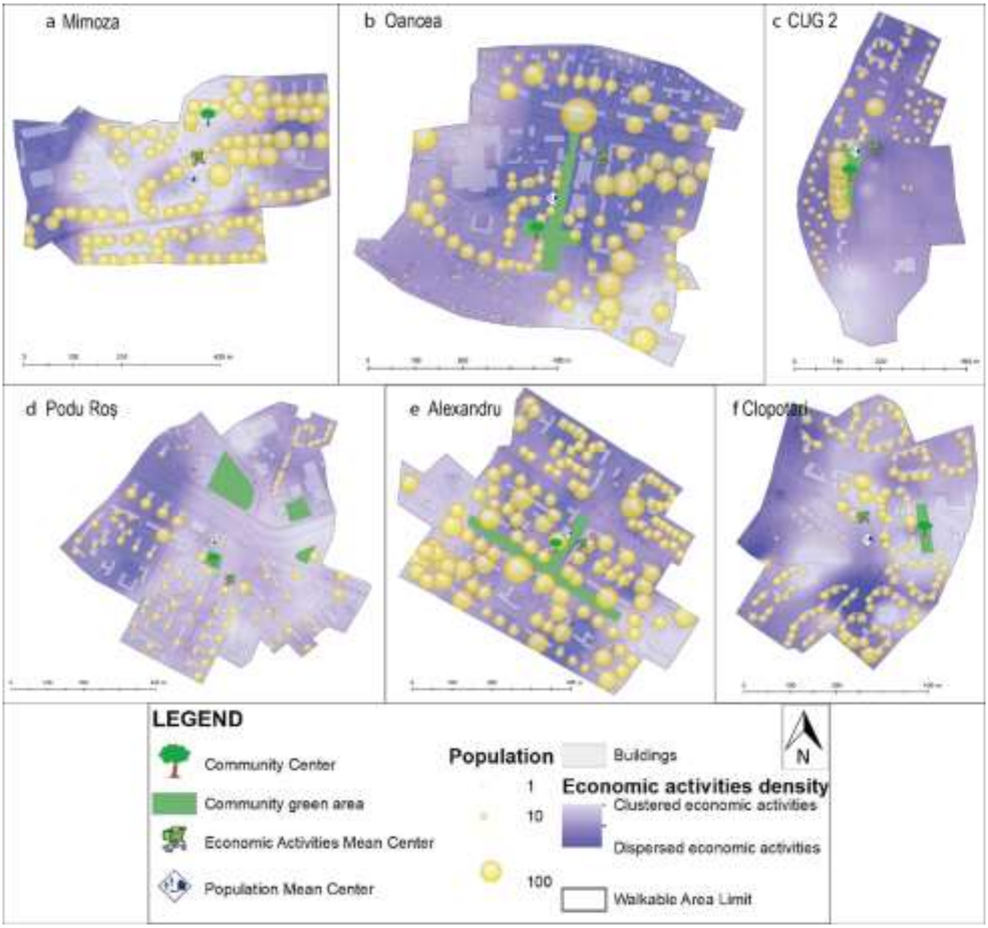

Fig. 3 Spatial patterns of each WA in relation to the built-up environmnent

Furthermore, there are important differences among WAs in term of their built-up area functionality. The residential area is composed by a high density, vertically disposed collective dwellings in Mimoza and Voievozilor WAs, by medium density areas, dominated by four-floor collective buildings in CUG 2 and Podu Ros WAs and by mixed areas, where individual residences and different types of collective dwellings are mixing in Clopotari and Oancea WAs. On the other hand, in most of the cases other functionalities are also present. While Mimoza and CUG 2 WAs host former industrial zones facing reconversion into supermarket (a) and event hall (c), in other WAs sanitary zones (b) or university area (d) can be found.

Finally, economic activities are concentrated in several poles for most of the WAs (b, c, e,f) while there are approximately even distributed for two of the WAs (a,d).These patterns highlight different manners of practicing the urban space, revealing different types of WA, either cohesive and livable or disrupted by the presence of the over-local functions.

V. CONCLUSIONS

The present research examined the walkability potential of Iasi city by delineating and analyzing six WA in order to understand the functionality of WA related to the urban environment of a post-socialist city.

The resulted WA are evenly distributed across the urban system and especially among the socialist districts. On the other hand, even if they overlap upon highly populated districts consisting in collective dwellings they serve only 22% of total population, covering 2% of the surface. Their size and shape is influenced by some major forces (their centrality, the functional barriers or the major axes splitting or delimiting WA and network connectivity).

Even though collective districts inherited similar features from the socialist period(Stoleriu, 2008), the resulted WA were shaped differently by the post-socialist transition leading to economic diversity and different forms of facilities. Consequently, the spatial distribution of population, economic activities and community open space is different for each WA.

Hence, the 6 WA could be ranked by the proposed WS; while the partial indicators emphasis specific dysfunctionalities inside of each WA, the final ranking offers a possible priority list for further administrative intervention on WA.

The present approach follows the research main stream using GIS and statistical methods on designing a useful tool for public and private initiatives(Leslie et al., 2007). However, using the frameworks proposed by the current scientific studies may not fit to the cultural background and the local context. Therefore our service area-based methodology(Manaugh & El-Geneidy, 2011)is adjusted to the eastern European context where cities are facing problems regarding data availability at the neighborhood level; moreover, the heterogeneous built up structure of a post-socialist city restricts the existence of potential WA, so that their emergence is based on the presence of facilities rather than on population distribution.

This study has demonstrated the occurrence of WA which fits the eastern European background, thus enlarging the applicability area of the walkability concept which was mainly studied in highly developed countries(L. D. Frank et al., 2006). Even if there is a low concern of the local authorities on these issues, the implementation of the walkability concept in post socialist cities may help preserving a friendly urban environment as well as preventing further urban dysfunctionalities.

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