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# URBAN GROWTH AND THE SPATIAL STRUCTURE OF A CHANGING REGION: AN INTEGRATED ASSESSMENT

*Luca* **SALVATI**
Consiglio per la Ricerca e la sperimentazione in Agricoltura,
Centro per lo Studio delle Relazioni Pianta-Suolo (CRA-RPS), Rome, Italy

**Abstract:** The present study assesses changes (1949-2008) in the structure of a Mediterranean urban area (Rome, Italy) in three phases (compact growth, medium-density growth, low-density growth) of its recent expansion which reflect different economic contexts at the local scale. Using a quantitative approach based on land-use indicators and landscape metrics, distribution and fragmentation of built-up areas were analyzed from high-resolution and diachronic digital maps covering the investigated area (1,500 km$^2$). The analysis of the (changing) urban structure during the study period allows for an indirect evaluation of planning impact on Rome's expansion. City's morphology changed rapidly due to urbanization. While in the first examined phase (1949-1974) metrics indicated compactness and densification trends, the fractal dimension of urban settlements increased in the subsequent period together with patch fragmentation, dispersion and shape complexity. The study identified the indicators better characterizing Rome's expansion as a contribution to the understanding of long-term urban dynamics in the Mediterranean region.

**Key Words:** *compact growth, exurban development, urban morphology, fractality, Mediterranean region.*

## Introduction

Recent landscape transformations observed in Europe are mainly associated to the dispersed expansion of large- and medium-size cities caused by population de-concentration (Kasanko et al. 2006) and the spatial (re)balancing of activities observed since the late 1980s (Longhi and Musolesi 2007) and mainly associated to suburbanization processes (Bruegmann 2005). By linking form and functions, suburbanization may reflect novel socioeconomic phenomena in the Mediterranean region (Couch et al. 2007), generally characterized by cities with compact and dense morphologies (Schneider and Woodcock 2008), fragmented and polarized economic structures (Turok and Mykhnenko 2007), socially-cohesive areas with moderate class segregation (Leontidou 1990).

Suburbanization causes subtle transformations in the morphology of sprawling cities. Land fragmentation, polarization in urban and non-urban uses of land, landscape simplification and homologation, are processes observed in Mediterranean peri-urban areas (see, for instance, Paul and Tonts 2005 for Barcelona, Chorianopoulos et al. 2010 for Athens, Salvati and Sabbi 2011 for Rome). The resulting morphology is scattered and fragmented, with an increase in fractal dimension as the most evident change (Alphan 2003, European Environmental Agency 2006, Terzi and Bolen 2009, Salvati et al. 2012).

While the impact of various types of urban expansion (e.g. dense, dispersed, fragmented) on landscape composition is relatively well known in southern Europe (Attorre et al. 2000, Alphan

2003, Weber et al. 2005, Catalan et al. 2008, Ioannidis et al. 2009), the long-term effect (from both structural and functional point of view) on traditionally compact but rapidly changing urban areas is less explored (see, for instance, Munafò et al. 2010) and it deserves further investigation.

Based on these premises, the present study integrates a traditional landscape metrics analysis with a Morphological Spatial Pattern Analysis (MSPA) to investigate the long-term changes (1949-2008) in the form of a semi-compact and dense Mediterranean city (Rome, Italy) in three phases of its recent expansion (Gemmiti et al. 2012). These phases reflect quite different socioeconomic contexts: (i) economic informality and spontaneous expansion in the phase of compact and dense expansion (1949-1974), (ii) the consolidation of the traditional tertiary sector (construction, commerce, public services) and the growing importance of city's sub-centres in a partly deregulated planning system observed during a phase of 'medium density, discontinuous expansion' (1974-1999) and (iii) the declining importance of the public sector together with the growth of high-qualifications and creative sectors primarily found in the last phase featuring 'low density, dispersed' expansion (1999-2008). The study identifies the indicators characterizing these three phases as a contribution to the understanding of long-term urban expansion processes in southern Europe.

## Materials and Methods

### *Landscape indicators*

Landscape metrics have been extensively used to detect spatial patterns caused by urbanization (Alphan 2003, Weber et al. 2005, Catalan et al. 2008, Terzi and Bolen 2009). The selection of variables, the procedure for the construction of indicators and the identification of the thematic dimensions adequate to describe changes over time in Rome's morphology have been set up in the present study according to general criteria of comprehensiveness, reliability and easiness in calculation (Li and Wu 2004). As far as landscape metrics, nine well-known metrics computed at the class level have been selected with the aim of being used also by stakeholders and planners not confident with spatial analysis and geographic information systems (Uuemaa et al. 2009). The selected indicators provide a comprehensive description of urban form and can be easily derived from land-use maps using simple computational tools for ArcGIS package (ESRI Inc., Redwoods, USA). The 'Patch Analyst' software for ArcGIS 9.3 was used in the present study. The selected landscape metrics were grouped into five themes (fragmentation, patchiness, patch complexity, shape and fractal dimension) according to Li and Wu (2004).

Together with landscape metrics, mathematical morphology, a framework for analyzing the shape and form of objects (Soille 2003), was also considered in the present study. The Morphological Spatial Pattern Analysis (MSPA) implements a series of image processing routines to identify hubs, links (i.e. corridors), and other features that are relevant to ecological landscape assessment (Vogt et al. 2007). The basic landscape elements identified by MSPA are: (i) core areas, (ii) islets, (iii) bridges, (iv) loops, (v) branches, (vi) edges and (vii) perforation areas. For each land-use class, pixels classified as the ‘core’ area are the inner part beyond a certain distance to the boundary, ‘islets’ are those parts that are too small and isolated to contain a core area. Each core area is surrounded by ‘edges’ and ‘perforations’. Perforated areas are identified as the transition zone between ‘core’ areas and a different land-use class while the ‘edge’ class represents the transition zone between ‘core’ and ‘non-core’ areas within the same land-use class. Core areas are also connected each other by 'loops', 'bridges' and 'branches'. Loop areas represent corridors which connect to the same core, bridges connect at least two distinct core areas and branches connect a core area with a non-core area within the same land-use class. The seven landscape categories illustrated above cover a wide range of spatial patterns which are of interest in urban morphology, land-use dynamics and the analysis of landscape composition and structure.

Guidos software was used to carry out urban landscape classification based on MSPA. The surface area of the seven landscape categories was calculated for the four investigated years (1949, 1974, 1999 and 2008). The layer of built-up areas for each year was converted into a raster (grid) map covering the target area by using the 'spatial analyst' tool available in the ArcGIS software. MSPA processing starts from the identification of core areas, which is based on the connectivity rule used to define neighbours and the value used to define edge width (Soille and Vogt 2009). Connectivity was set for a node pixel to its adjacent neighbouring pixels by considering eight neighbours (a pixel border and a pixel corner in common).

*Land-use maps*

Land-use data were obtained from the elaboration of four compatible digital maps classified according to the Corine Land Cover (CORINE) classification system: (i) the Italian Istituto Geografico Militare (IGM) topographic map scaled 1: 25 000 and referred to 1949, (ii) the 'Agricultural and forest map of Rome province' scaled 1: 25 000 and produced by the Cartographic Service of the Prefectural Authority of Rome in 1974, (iii) the 'land-use map of Latium region' (scaled 1: 25 000) produced in 1999 by the Cartographic Service of the Regional Authority of Latium through digital ortho-photo interpretation (Terraitaly: IT2000, 1998-1999, 1 meter pixel) and projected in UTM 33 ED50, and (iv) an original land-use map (scaled 1: 25 000) derived from photo-interpretation of digital ortho-images released from the Italian National Geoportal related to 2008 (Italian Ministry for Environment, Land and Sea) with a 0.5 meters pixel related to 2008 and projected in UTM33 WGS84. Based on a minimum mapping unit of 1 hectare and a comparable CORINE-like land classification system, built-up areas were defined homogeneously in the four available maps and include (i) compact urban fabric, (ii) dispersed urban fabric and (iii) industrial areas and infrastructures.

*Study area*

The investigated area includes the municipalities of Rome and Fiumicino (Latium, central Italy) for a total surface area of 1,500 km$^2$ consisting of nearly 90% lowlands and 10% uplands. The lowland area (the so called 'Agro Romano') was placed over the alluvial plain of the Tiber River and was partly occupied by human settlements (Munafò et al. 2010). Although urban areas occupy an important (and increasing) part of the region, the majority of the area still consists of forests, pastures and cultivated land (Salvati and Sabbi 2011). Industrial areas are located in the eastern part of the 'Agro Romano' while traditional rural landscapes can be still found in the western part of the investigated area (Attorre et al. 2000).

According to previous studies (Munafò et al. 2010, Salvati and Sabbi 2011, Salvati 2012), compact growth occurred in Rome mainly between the early 1950s and the 1980s while a more dispersed expansion was observed during the most recent period. Until the early 1980s population grew in urban areas at a higher rate compared to the suburban area. At that time, the difference in population density between the two areas was high and the ratio of suburban to urban population increased slightly from 27% in 1951 to 35% in 1981. Since the early 1980s, the population declined in the urban area while it rose in suburban areas at a relatively high rate (1.5% *per year*). As a consequence, population density in the suburban area increased from 256 inhabitants km$^2$ to 342 inhabitants km$^2$ and the ratio of suburban to urban population rose up to 47%.

## Results and discussion

Following Salvati (2013), three time periods have been selected with the aim of investigating the impact of different urbanization phases on the city's form (1949-1974: 'compact growth', 1974-1999: 'medium-density, discontinuous' expansion and 1999-2008: 'dispersed low-density' expansion). From the morphological point of view, the three phases are characterized by a different growth rate of built-up areas. The highest increase was observed in the 'compact growth' phase (5%) decreasing rapidly in the subsequent two expansion phases (reaching 0.7% in the 'low-density, dispersed' phase). Rome's settlements covered 6.6% of the investigated area in 1949 and expanded to 14.9% in 1974, 25.9% in 1999 and 27.5% in 2008 (Table 1) with the population increasing from 1.6 million inhabitants in 1951 to 2.7 million inhabitants in 2011. Built-up area per-capita increased from 59 m$^2$ in 1949 to 153 m$^2$ in 2008. The annual growth rate of per-capita built-up areas was found higher in the 'medium-density' expansion phase (2.9%) compared with those observed in the 'compact' and 'low-density' phases (respectively 1.4% and 1.2%).

*Table 1*

**Selected indicators describing Rome's expansion between 1949 and 2008**

| Variable | 1949 | 1974 | 1999 | 2008 |
|---|---|---|---|---|
| Urban fabric surface area (km$^2$) | 98 | 223 | 388 | 412 |
| Built-up area (%) | 6.6 | 14.8 | 25.8 | 27.4 |
| Resident population (inhabitants) | 1,651,393 | 2,781,385 | 2,792,632 | 2,684,801 |
| Annual change in urban fabric (%) | - | 5.1 | 3.0 | 0.7 |
| Built-up surface per capita (ha) | 0.59 | 0.80 | 1.39 | 1.53 |
| Per capita annual change in urban fabric (%) | - | 1.4 | 2.9 | 1.2 |

Rome's urban footprint was illustrated in Figure 1. City's morphology was relatively dispersed in 1949 with a progressive densification in 1974, determining a relatively compact urban form (Munafò et al. 2010). Taken together, indicators provided in Table 1 suggest that the last thirty years were characterized by settlement scattering around the main urban centre and along the coastal rim, confirming previous findings (Salvati et al. 2012).

The landscape metrics investigated in the present study are reported in Table 2. Overall, metrics indicate compact growth during 1949-1974 and progressive settlement dispersion in the following period. The highest value of the median patch size was observed in 1974 (6.4 ha) declining sharply in 1999 (3.1 ha) and 2008 (2.7 ha). The highest variability in patch size was observed in 2008, indicating patchiness caused by low-density urban expansion. Fragmentation metrics also showed a marked increase over time: edge density increased three-fold during 1974-1999 and mean patch edge reached the highest value in 1974 while decreasing afterwards. Morphological complexity described by the two shape indexes (MSI and AWMSI) increased as well between 1949 and 2008. The fractal dimension measured by MPFD and AWMPFD followed the same trend.

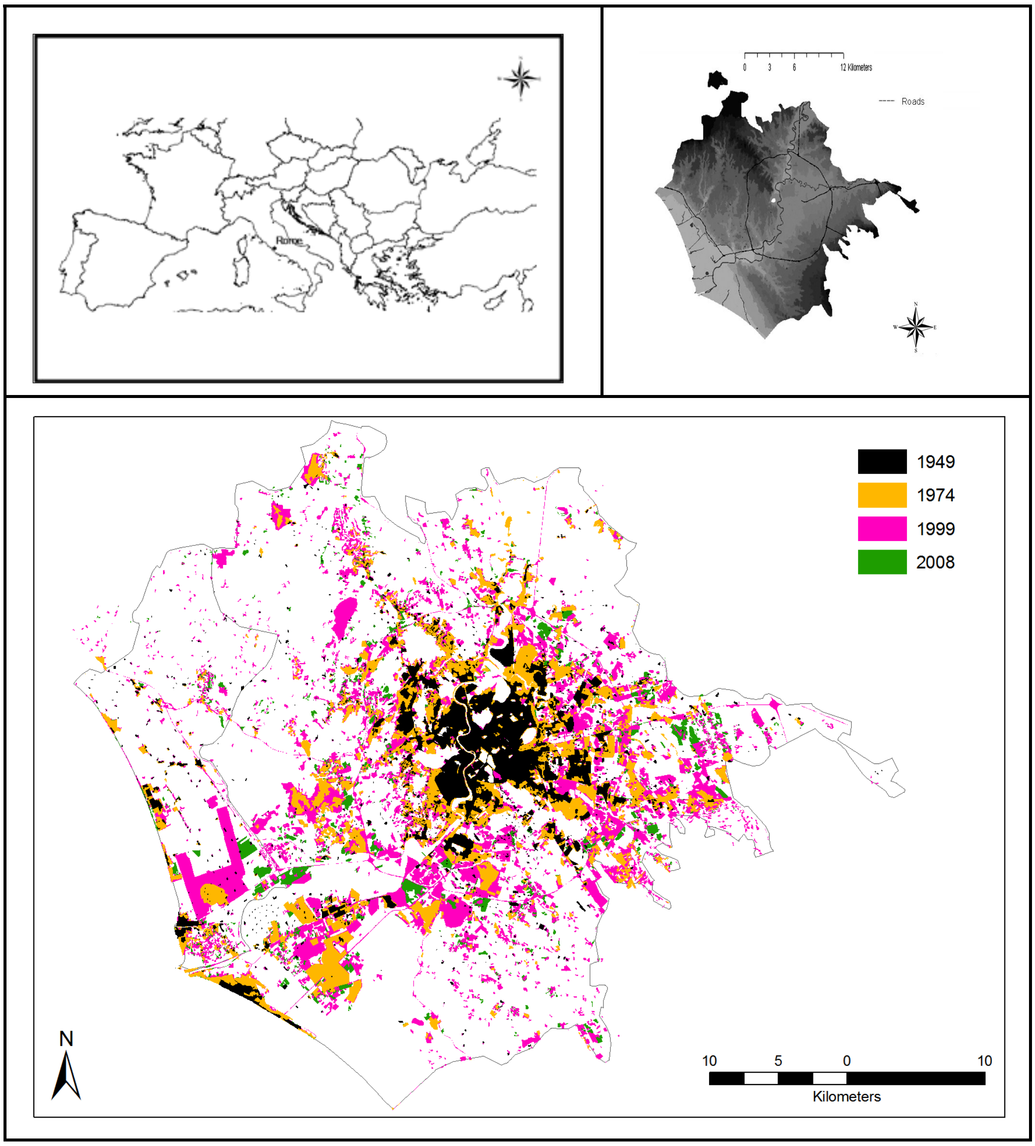


*Fig. 1 –* **Rome's position in Europe** (upper left). **The study area illustrating elevation and the main road network** (upper right) **and Rome's urban expansion between 1949 and-2008** (lower panel)

Results of the MSPA (Table 3) confirm the spatio-temporal trends illustrated in the analysis of traditional landscape metrics and they demonstrate that the phase of dense urban expansion (1949-1974) produced a more compact morphology in Rome. Core urban areas increased from 34.9% in 1949 to 42.3% in 1974 with the number of 'core' urban patches doubling in the same period. Urban patches classified as 'edge', 'loop', 'bridge' and 'branch' increased in class area and frequency at the expenses of urban patches classified as 'islets', which declined from 23% to 8% and from 64% to 14% respectively, in terms of class area and frequency.

*Table 2*

**The evolution of selected landscape metrics in Rome by year**

| **Theme** | **Variable** | **1949** | **1974** | **1999** | **2008** |
|---|---|---|---|---|---|
| Fragmentation | Median Patch Size | 0.9 | 6.4 | 3.1 | 2.7 |
| | Coefficient of Variation of Patch Size | 5.5 | 7.4 | 5.8 | 9.1 |
| | Mean Patch Edge | 798 | 3456 | 2057 | 2534 |
| Shape | Mean Shape Index | 1.35 | 1.71 | 1.67 | 1.70 |
| | Average Weighted Mean Shape Index | 2.0 | 5.5 | 4.4 | 8.3 |
| Patch complexity | Edge Density | 9.5 | 11.4 | 35.5 | 33.4 |
| | Mean Perimeter to Area Ratio | 768 | 421 | 410 | 437 |
| Fractal dimension | Mean Patch Fractal Dimension | 1.34 | 1.31 | 1.33 | 1.33 |
| | Average Weighted Mean Patch Fractal Dimension | 1.30 | 1.34 | 1.33 | 1.37 |

*Table 3*

**Changes in selected connectivity metrics describing Rome's urban landscape between 1949 and 2008***

| Class | 1949 | | | 1974 | | | 1999 | | | 2008 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % class | % occur. | | % class | % occur. | | % class | % occur. | | % class | % occur. |
| Core | 34.9 | 4.6 | | 42.3 | 9.5 | | 36.9 | 7.0 | | 35.6 | 7.3 |
| Islet | 22.6 | 63.5 | | 8.4 | 13.7 | | 11.6 | 28.5 | | 11.0 | 25.7 |
| Perforation | 1.6 | 0.7 | | 1.3 | 0.8 | | 0.8 | 0.5 | | 0.8 | 0.4 |
| Edge | 25.1 | 7.3 | | 28.1 | 17.3 | | 23.6 | 17.1 | | 23.6 | 18.9 |
| Loop | 1.4 | 0.8 | | 1.9 | 1.9 | | 4.2 | 2.4 | | 3.6 | 2.2 |
| Bridge | 5.6 | 2.2 | | 7.1 | 4.7 | | 11.6 | 4.0 | | 14.9 | 4.4 |
| Branch | 8.8 | 21.0 | | 11.0 | 52.1 | | 11.2 | 40.5 | | 10.6 | 41.0 |

*) *% class* indicates the proportion of surface area occupied by each landscape class; *% occur.* indicates the proportion of patches classified in each landscape class (see 'Methodology' for further details)

The two subsequent expansion phases featured diverging trends with the decline of 'core' urban patches and a moderate increase of 'islet' patches. The 'medium-density' phase was characterized by decreased 'edge' surfaces and growing 'loop' and 'bridge' urban elements. The 'low-density' expansion phase was characterized by stable 'edge' surface with slightly decreasing 'loop', 'islet' and 'branch' urban elements, and an overall increase in 'bridge' urban patches.

These trends indicate that different phases of urban expansion can be identified using a landscape metrics analysis integrated with a morphological spatial approach (Ioannidis et al. 2009). Taken together, results suggest that the three expansion phases in Rome were characterized by specific morphological traits in terms of compactness, fragmentation and spatial complexity.

## Conclusions

Monitoring landscape structure and dynamics on a country, regional and local scale provides an increasingly detailed picture on the relationship between urban expansion and settlement form (Hasse and Lathrop 2003, Kasanko et al. 2006, Schneider and Woodcock 2008, Ioannidis et al. 2009). Using diachronic, high-resolution land-use maps, the present study contributes to urban studies by illustrating a long-term investigation on Rome's morphology based on landscape metrics.

The study assesses the impact of different socioeconomic and territorial contexts on the city's morphology as reflected in three phases of the recent Rome's expansion. Results suggest that landscape metrics and spatial approaches such as MSPA can effectively illustrate changes in urban morphology that reflect different territorial contexts on a local scale. The selected indicators represent an effective tool to monitor changes towards settlement scattering and to inform policies promoting urban containment in peri-urban regions. It is widely known that informality and planning ‘deregulation’, two elements of the past growth of several Mediterranean cities (Leontidou 1990, Couch et al. 2007, Turok and Mykhnenko 2007), negatively impact landscape structure and composition (Paul and Tonts 2005, Chorianopoulos et al. 2010, Salvati et al. 2012). Policies containing the most recent suburbanization trends should be developed with the objective of preserving sustainable (*e.g.* compact and land-saving) urban forms through the adoption of ‘holistic’ planning frameworks that recognize the socioeconomic peculiarity and the environmental advantages of compact and semi-dense forms (Alphan 2003, Gemmiti et al. 2012, Salvati 2013), considered as the prevailing urban morphology in the Mediterranean region.

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*Correspondence:* Consiglio per la Ricerca e la sperimentazione in Agricoltura, Centro per lo Studio delle Relazioni Pianta-Suolo (CRA-RPS), Via della Navicella 2-4, I-00184 Rome, Italy

E-mail: luca.salvati@entecra.it

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# THE ASSOCIATION BETWEEN LAND-USE DISTRIBUTION AND RESIDENTIAL PATTERNS: THE CASE OF MIXED ARAB-JEWISH CITIES IN ISRAEL

*Ran* **GOLDBLATT**, *Itzhak* **OMER**
Tel-Aviv University, Israel

**Abstract**: The emergence of GIS and the availability of high resolution geographic data have improved our ability to investigate the residential segregation in cities and to identify the temporal changes of the spatial phenomena. Using GIS, we have quantitatively and visually analyzed the correspondence between land-use distribution and Arab residential patterns and their changes in the period between 1983 and 2008 in five mixed Arab-Jewish Israeli cities. Results show a correspondence between the dynamics of Arab/ Jewish residential patterns and the spatial distribution of various land-uses. Arab residential patterns diffused faster towards areas with relatively inferior land-uses than towards areas with more attractive land-uses, in which a gentrification process occurred. Moreover, large-scale non-residential land-uses act as spatial partitions that divide between Arab and Jewish residential areas. Understanding the association between the urban environment and residential patterns can help in formulating an appropriate social and spatial policy concerning planning of land-uses and design of the built environment in mixed cities.

**Key Words:** *ethnic residential segregation, land-uses, spatial continuity, residential dynamics, mixed cities*

## Introduction

The term mixed city is often used in the Israeli context to describe cities in which an Arab minority lives alongside a Jewish majority. Several studies have investigated the characteristics and development of the Israeli Arab-Jewish mixed cities, including planning and architectural aspects (Ben Artzi 1980,Yacobi 2002, Tamari 2004, Khamaisi 2008), segregation and residential patterns (Falah 1996, Omer 2005, Kipnis and Schnell 1978), as well as various social aspects like ethnicity and national narratives (Yiftachel and Yacobi 2003, Monterescu 2011) and interactions between Arabs and Jews in various life domains (Hadas and Gonen 1994, Falah et al. 2000).

However, the potential influence of the built environment on the formation of residential patterns, particularly in mixed cities, has not yet been fully explored. More specifically, while it is well known that the urban built environment and its various land-uses are related to the constitution of urban social areas and socio-spatial processes (Giddens 1984, Lefebvre 1991, Polednak 1993, Amin and Thrift 2002, Bolt et al. 2002) – including the formation of ethnic residential patterns (Rabin 1987, Boal 2002, Omer 2010) – to best of our knowledge, no extensive research has yet been conducted for exploring this relation in the context of Arab/ Jewish residential patterns in mixed Israeli cities.

Moreover, the development of GIS (Geographic Information Systems) technology and the increasing availability of high resolution and good quality geographic data has encouraged research aimed to identify the spatial distribution of population groups, with a consideration given to their relative spatial location within the urban context (Omer 2010). The spatial analysis capabilities of GIS enable to use, in addition to population data, geometrical and topological information encoded in spatial data structure (Wong 2003, Wu and Sui 2001). Thus, GIS technology has the potential to enhance segregation studies by providing analytical mapping with high-resolution geo-referenced databases (e.g. census data). Previous GIS-based residential segregation studies have mainly concentrated on evaluating changes in segregation of residential patterns (Lesger and Van Leeuwen 2012, Lloyd et al. 2012, Gilliland et al. 2011) as well as in implementing spatial segregation measures at different geographic scales (as opposed to the traditional non-spatial structural measures such as the commonly used *Dissimilarity index*) (Wu and Sui 2001). However, little attention has been given to the correspondence between changes in social or ethnic residential patterns and the functional and physical attributes of the urban environment, such as the spatial structure and distribution of land-uses in the city.

Though several studies have investigated the characteristics and development of Israeli Arab-Jewish mixed cities, including the Arab-Jewish residential patterns (Yacobi 2002, Khamaisi 2008, Falah 1996), the correspondence between land-use distribution and Arab-Jewish residential patterns in the Israeli context, has not yet been fully explored.

In this paper we use GIS tools and analysis methods to investigate the correspondence between land-use distribution and the physical attributes of the built environment and the formation of Arab-Jewish residential patterns in five Israeli mixed cities. We explore the land-use characteristics of Arab and Jewish residential areas and we identify those land-uses that create spatial partitions between them. In the following section we discuss concepts of spatial segregation, as well as social and spatial factors that potentially facilitate residential distribution, followed by a description of the Israeli Arab-Jewish context. In the third section, we present the methodology followed by the research results. Conclusions and implications appear in the final paragraph.

## Land-use Distribution and Ethnic Residential Patterns

Residential segregation refers to the residential location of various population groups in the urban space and reflects the relation between social differences and physical location in urban residential areas (Massey and Denton 1988). Residential segregation of minority groups results from internal group cohesiveness and own-group preferences as well as from majority-group attitudes of tolerance and institutional discrimination (Clark 2002, Johnston et al. 2007).

The relation between space and society goes back to the assumptions of Emile Durkheim, who treated space as socially in origin and spatial-physical divisions as corresponding with social divisions. Based on this perspective, the Chicago school (Burgess 1925) was among the first theories to deal with the relationship between spatial and social structures of cities. This school referred to the residential differentiation in ecological terms of segregation and assimilation, suggesting a correspondence between social assimilation of minority groups and a degree of spatial assimilation (Peach 2000, Hiebert and Ley 2003).

According to the "self-segregation" theory, social groups choose where to live partially by prejudices they hold about other groups, which lead them to favor living with others similar to them (Clark 1996) and to desire to strengthen their self-identity and political power (Boal 2002), or even to control residential and public space by creating “landscapes of exclusion” within a strongly classified environment (Sibley 1995). The "discrimination" theory claims that while the income and preferences of minority groups may allow them to move into "stronger" residential areas, other discriminatory housing market barriers sometimes prevent them from doing so (Peach 2000). Such market barriers may also be structurally inherent due to legislation by institutional authorities (Giddens 1984), which, by state laws and various regulations, can affect the accessibility of various population groups to housing resources (Smith 1987). The resulting segregation frequently has significant consequences on accessibility to essential public services, such as educational, social and medical services, and cultural amenities (Polednak 1993, Collins and Williams 1999).

However, residential segregation is often a matter of choice. Minority enclaves frequently represent destinations for incoming immigrants preferring specific residential locations, at least partially due to their contribution to internal group cohesiveness and opportunities (Johnston et al. 2007). At the same time, other factors also affect residential choices. These factors include socio-economic status and ethnic diversity within minority groups (Omer 2005, Bolt and Van Kempen 2010), dwelling prices (Owusu 1999), geographical distribution of housing types (Omer 2011), life cycle and the desire to improve living conditions (Hamadan 2006), as well as job opportunities and community infrastructure, such as the presence of communal educational and religious institutions (Boal 2002).

According to the “sentiment and symbolism” theory (Firey 1945), cultural properties of the built environment play an important role in residential choices of social groups. Communities tend to ascribe physical places in the city with collective sentimental associations (historic, cultural etc.), which may constitute a genuine, attractive force for certain cultural groups that, in turn, preserve these associations within their community (Scaff 1948). Sentimental associations sometimes generate an environment that maintains community conflict and group stereotyping (Boal 2002). On the other hand, “neutral” elements in the built environment sometimes moderate or even lessen residential segregation (Omer 2011). These characteristics play a role in the identification of places and neighborhoods in the city (Golledge and Stimson 1997) and in the identities that people establish (i.e. national identity), which allow them to differentiate themselves from others (Yacobi 2008).

The physical environment also affects dynamics of minority residential patterns through human experience, behavior, and individual preferences regarding residential choices. It allows, facilitates, or prevents various mental and behavioral acts, mainly through three distinct physical and spatial characteristics of the urban built environment (Weisman 1981, Montello 2007): *differentiation* (i.e. the degree to which different parts of the built environment have a unique layout, such as size, color, and shape); *complexity* (i.e. the composition and organization of spaces and street networks), and *visibility* (i.e. the degree to which different places and features in an environment are visually connected).

Since the Chicago School, many studies have investigated the association between the spatial distribution of social groups and the characteristics of the physical urban environment, including the distribution of land-uses (Boal 2002, Galster and Cutsinger 2007, Omer 2011) and the spatial configuration of the urban street network (Grannis 1998, 2005; Vaughan 2007, Omer and Goldblatt 2012). Generally, these studies suggest that less accessible and isolated neighborhoods surrounded by physical obstacles tend to differ from their surrounding area in their socio-economic and ethnic characteristics. While pedestrian streets connecting neighborhoods were found to be a moderating feature of segregation (Grannis 2005, Omer and Goldblatt 2012), other spatial features sometimes function as obstacles that prevent social groups from expanding and from being within walking distance with one another. For example, according to an economic survey conducted in London in the 19th century, poverty areas in the city tended to be "literally walled-off from the rest of the city by barrier-like boundaries that isolated their inhabitants, minimizing their normal participation in the life of the city about them…" (Pfautz 1967: 120). In another research conducted in 50 American cities, Rabin (1987) found that black and white residential neighborhoods were often divided by the discontinuous system of residential streets with access between the neighborhoods primarily through nonresidential streets. Similar conditions have been reported by Dupont (2004) who found that the Yamuna River, with its large bed of agricultural land, and the natural forest of the Aravalli Hills act as demarcation lines between urban sectors in Delhi, India.

## The Israeli Context: Arab-Jewish Mixed Cities

In 2010, Palestinian Arab citizens constituted approximately 16.5% of the state's population (Smoocha 2010) with roughly 1.25 million residents. While the majority of Israeli Arabs are Muslims (82%), they also include Christians and Druze (9% and 9%, respectively). The vast majority of Jews and Arabs live in well-defined, homogenous and separated Jewish or Arab villages, townships and cities, while approximately 10% of Israeli Arab citizens reside, as a minority, in seven mixed cities (not including Jerusalem): five old cities (established before 1948) – Haifa, Jaffa, Acre, Lod, Ramle; and two new cities – Natzrat Illit and Ma'alot-Tarshiha[1)] (Fig. 1). Though these cities differ in their ethnic composition and demographic characteristics (Table 1), their residential patterns evolved relatively similarly.

*Table 1*

**Characteristics of the mixed Israeli Cities, 2008**

| City | Pop* | Jews (%) | Arabs (%) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Total | Muslim | Christian | Druze | Area (sq km) |
| Acre | 46,3 | 66.4 | 28.3 | 90.9 | 8.5 | 0.6 | 13.5 |
| Haifa | 264,8 | 80.9 | 10.2 | 46.1 | 51.9 | 0.98 | 68.9 |
| Jaffa[a] | 45,9 | 63.8 | 33.3 | 79.4 | 20.4 | 0.0 | 4.83 |
| Lod | 67,5 | 67.5 | 24.9 | 95.3 | 4.6 | 0.0 | 12.2 |
| Ramle | 65.5 | 73.4 | 23.0 | 80.0 | 19.7 | 0.2 | 11.9 |

[a]= Estimated number on the basis of the 2008 Population and Housing Census and the 2009 Tel-Aviv-Jaffa Municipality Annual Survey; *= numbers in thousands; Source: The Israeli Local Authorities 2008, publication No. 1414, The 2008 Population Housing Census, Israeli Central Bureau of Statistics.

Two main residential patterns characterize these cities: *mixed* (where Jews and Arabs reside in the same neighborhoods), and *separated* (homogenous Arab and Jewish neighborhoods), as shown in Figure 2. In general, the Arab population of these cities resides in homogenous Arab neighborhoods, while a small minority resides in adjacent mixed areas.

1) In this research we concentrate only on the old "typical" mixed cities. The development and characteristics of the "new" mixed cities are different than the "old" cities. Namely, the majority of the Arab population in Maalot-Tarshiha and NatzratIllit are not natives at the cities. Arabs did not reside in NatzratIllit when it was established in 1957 as a Jewish city and Maalot-Tarshiha was established by the union of two cities: the Jewish Maalot and the Arab Tarshiha, to one unified municipality, which was declared as a city in 1996. Generally, the majority of the Arab population in this city resides in the former Tarshiha while the Jewish population resides in the former Maalot.

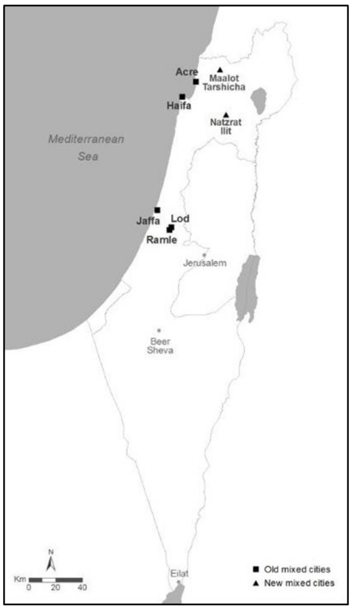


*Fig. 1* **– The mixed Israeli cities**

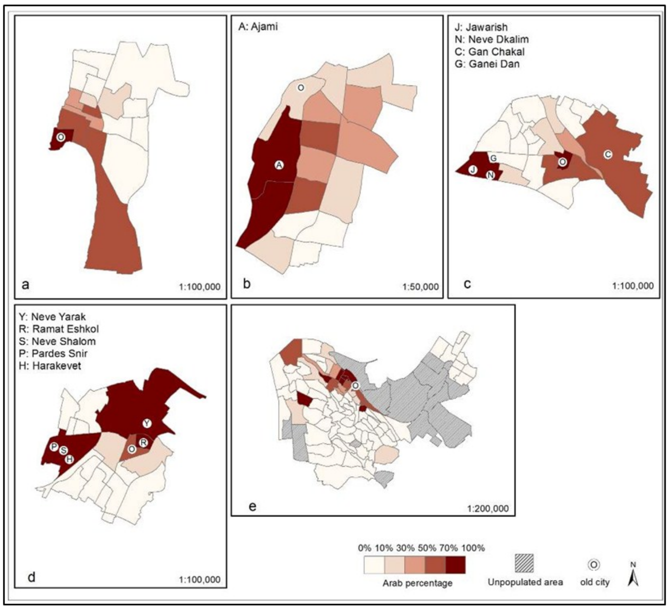


*Fig. 2* **– The Arab population distribution in the mixed cities in 2008: a. Acre, b. Jaffa, c. Ramle, d. Lod, e. Haifa**

However, these residential patterns are not static and they are constantly evolving. Arabs initially settled in homogenous Arab neighborhoods and gradually expanded into neighboring Jewish areas due to the lack of residential solutions, progressively changing them into mixed or Arab neighborhoods (Khamaisi 2008).

## Materials and Methods

The analysis of the association between the built environment's attributes and the residential patterns was conducted in several stages. First, the analysis of the correspondence between land-use distribution with (1) Arab residential patterns in 2008[2)], and (2) ethnic composition change in the period between 1983 and 2008. Second, the analysis of land-uses that function as spatial partitions in the interface zones dividing Arab and Jewish residential areas.

Analysis of Arab residential distribution was based on the ICBS's 1983 and 2008 *Population and Housing Census*, using the statistical area geographical unit scale, within a GIS framework[3),4)]. Intensity of ethnic composition changes and the subsequent dynamics of Arab

2) Detailed demographic data at the statistical area geographical unit scale is published by the ICBS as part of the *Population and Housing Census* approximately every 12 years. The latest census was published in 2008.

3) The data, obtained from the 1983 and 2008 ICBS (Israel Central Bureau of Statistics) *Population and Housing Census,* includes information about each statistical area`s demographic and ethnic characteristics. Changes in size and pattern of Arab residential distribution were analyzed for the period between 1983 and 2008 by comparing the data on Arab residential distribution, per statistical area, between both years. Major changes in the statistical area`s distribution and boundaries did not allow a reliable comparison with surveys prior to 1983.

4) The statistical unit is the smallest unit that the ICBS makes available to the public. Census tracts are defined by ICBS as "small and homogenous units that enable analysis of statistical data in small geographical units. Each unit is comprised of between 3000-4000 persons".

and Jewish residential patterns were revealed by computing the annual rate of change of the Arab population for each statistical area, as follows: ($Pt2_x$ - $Pt1_x$)/T, where *P* is the percentage of the Arab population in statistical area *x* in 2008 [*t2*] and in 1983 [*t1*]; T denotes the difference between years of the censuses[5)]. Such analysis enabled us not only to visually compare between the Arab spatial distributions in the two time frames, but also to quantitatively define various change-paces and to compare between the cities.

Land-use distribution data was obtained as GIS layers from the *Survey of Israel* (MAPI) and the "Mapa" company[6)]. The data, obtained as a point layer[7)], includes the spatial location and usage of all residential and non-residential land-uses. The land-uses were classified into eight categories: (i) commerce, (ii) education and research, (iii) public services (including health and welfare), (iv) industry and agriculture, (v) Jewish worship institutes, (vi) mixed residential buildings (combining residence with another land-use), (vii) Muslim and Christian worship institutes, and (viii) sports and culture land-uses. Examples of land-uses included in each land-use category appear in appendix 1.

In order to take into account the varying sizes of the examined statistical areas, we computed for each statistical area the number of buildings belonging to each of the eight categories as a percentage of the total number of buildings in the area (including residential buildings).

*Appendix 1*

**Examples of land-uses included in each land-use category**

| | |
|---|---|
| **Commerce** | Commercial center, mall, market, store, bank, event hall. |
| **Education, research** | University, school (e.g. high school, junior high school, elementary school), academic institute, kindergarten, Talmudic college, religious school. |
| **Health, public services** | Retirement home, geriatric center, hospital, detention center, court (e.g. magistrates court, district court), pharmacy, cemetery, municipality, medical institute, first aid station, police station. |
| **Industry, Agriculture** | Industrial area, production plant, packing house, nursery, dairy farming, pen. |
| **Jewish worship institutes** | Synagogue, Jewish religious institute (excluding synagogue and cemetery). |
| **Muslim & Christian Worship** | Waqf, church, other Christian religious institute, mosque |
| **Sports, Culture** | Sport center, opera, archeological site, historic site, public swimming pool, stadium, memorial site. |

5) Due to differences in the divisions of some statistical areas for the two time periods (areas had been merged, split or added), some adjustments were made in order to facilitate the comparison between the two time periods. We computed the Arab proportion for statistical areas that had merged by 2008 by combining the 1983 census data for these areas. Areas that split in 2008 were excluded from the comparison.

6) The Survey of Israel is the official Israeli government agency for Mapping, Geodesy, Cadastre and Geoinformatics. "Mapa - Mapping and Publishing Ltd." is a private company. All data is updated to 2011.

7) The data does not include the area of the built structure. However, for the purpose of this research, the data is sufficient enough and reflects the use and meaning associated with the land-uses.

The analysis of the relation between the 2008 Arab residential distribution and the land-use distribution was done using a *Two-tailed Pearson correlation test,* in which we compared the Arab population percentage with the percentage of the various land-use categories in each statistical area. In addition, to better understand the correspondence between land-use distribution and residential patterns, the statistical areas in each city were classified into 3 residential patterns: Jewish, mixed and Arab (as will be described below). Each area was then analyzed to identify its land-use characteristics.

Analysis of the relation between the annual change in Arab residential patterns and land-use distribution between 1983 and 2008 was done by classifying each city`s statistical areas according to three trends in the Arab population change rate during that period: (a) a decrease, (b) a slow increase, and (c) a rapid increase, as will be described below. We then computed the number of buildings belonging to the eight land-use categories as a percentage of the total number of buildings for each area.

The analysis of the characteristics of the land-uses located in the interface zones between Arab and Jewish residential areas was done by identifying the adjacent statistical areas that exhibit the greatest differences in the percentage of Arab population. This was done by converting the polygonal layer of the statistical areas into a polyline layer, with the lines` values representing the difference between each pair of adjacent statistical areas. We then analyzed the land-use characteristics of these dividing zones. This allowed us to identify the type and characteristics of the spatial partitions dividing between Arab and Jewish residential areas. The data was analyzed using SPSS v.16.00 and it was analyzed and presented in ArcGIS v.10.00.

## Results

### Land-Use Distribution and Arab Residential Patterns

Examination of the correspondence between the Arab residential patterns in 2008 (reflected by the percentage of Arabs in each statistical area) and the land-use distribution in all cites (Table 2) shows a significant positive correlation in several land-use categories: Muslim and Christian worship institutes ($r=0.54$, $p<0.00$), mixed residential buildings ($r=0.35$, $p<0.00$), commercial land-use ($r=0.33$, $p<0.00$), and industry and agriculture land-use ($r=0.23$, $p<0.05$). A high ratio of Arab population is also associated with areas with a relatively high percentage of commercial land-use and Muslim and Christian worship institutes, when investigating each city separately. In the case of Jaffa, only sports and culture land-uses were found to be (negatively) correlated ($r=-0.56$, $p<0.05$) with the Arab population distribution. In Acre, for example, this correlation is significantly positive ($r=0.64$, $p<0.01$), mainly due to the relatively high number of culture land-use buildings located in the older Arab areas, as compared to the city`s northern Jewish neighborhoods. The differences in correlations between the cities result from the unique distribution of the physical and social attributes in each city and from the unique history and temporal changes of each city`s Arab population. For example, in Acre, Lod and Ramle commercial land-uses are located in or around the core area of the Arab population, and hence, these cities are characterized by a positive significant correlation between the presence of Arab population and commercial land-uses. Against that, in Jaffa, commercial land-uses are located relatively far from the Arab historic core area, which leads to a negative correlation between these two variables. Interestingly, none of the investigated cities demonstrated a significant correlation between Arab-Jewish distribution and the presence of Jewish worship institutes. The same tendency was found concerning the presence of public services and education and research institutes, i.e. the correspondence with the Arab-Jewish residential distribution is weak.

*Table 2*

**Correlation between land-use category percentages and the ratio of the Arab population at the statistical area level**

| | Commerce | Education, Research | Health, Public Services | Industry, Agriculture | Jewish worship institutes | Mixed Residential Building | Muslim & Christian Worship | Sports, Culture |
|---|---|---|---|---|---|---|---|---|
| Acre (n[a]=16) | r*** = 0.77 | r = -0.18 | r = 0.23 | r = 0.34 | r = -0.13 | r*** = 0.68 | r***= 0.67 | r***= 0.64 |
| | p = 0.00 | p = 0.51 | p = 0.40 | r = 0.20 | p = 0.62 | p = 0.00 | p = 0.01 | p = 0.01 |
| Haifa (n[a]=90) | r* = 0.19 | r = 0.02 | r = 0.04 | r** = 0.24 | r* = -0.18 | r***= 0.49 | r***= 0.61 | r = 0.02 |
| | p = 0.08 | p = 0.86 | p = 0.70 | p = 0.02 | p = 0.09 | p = 0.00 | p = 0.00 | p = 0.88 |
| Jaffa (n[a]=16) | r = -0.27 | r = -0.27 | r = -0.10 | r = -0.52 | r = -0.26 | r = -0.15 | r = 0.01 | r**= -0.56 |
| | p = 0.32 | p = 0.31 | p = 0.71 | p = 0.85 | p = 0.34 | p = 0.58 | p = 0.97 | p = 0.02 |
| Lod (n[a]=19) | r**= 0.51 | r = -0.23 | r = -0.03 | r** = 0.47 | r = -0.26 | r = 0.23 | r***= 0.79 | r = -0.23 |
| | p = 0.03 | p = 0.35 | p = 0.91 | p = 0.04 | p = 0.28 | p = 0.33 | p = 0.00 | p = 0.35 |
| Ramle (n[a]=21) | r*** = 0.58 | r* = -0.39 | r = 0.26 | r = 0.31 | r = -0.33 | n.a. | r***= 0.80 | r = -0.33 |
| | p = 0.01 | p = 0.08 | p = 0.27 | p = 0.17 | p = 0.14 | n.a. | p = 0.00 | p = 0.14 |
| All cities (n[a]=162) | r*** = 0.33 | r = -0.04 | r = 0.10 | r** = 0.23 | r = -0.12 | r***= 0.35 | r***= 0.54 | r = 0.00 |
| | p = 0.00 | p = 0.64 | p = 0.21 | p = 0.04 | p = 0.13 | p = 0.00 | p = 0.00 | p = 0.98 |

[a] n= number of statistical areas; * p<.1, **p<.05, ***p<.01

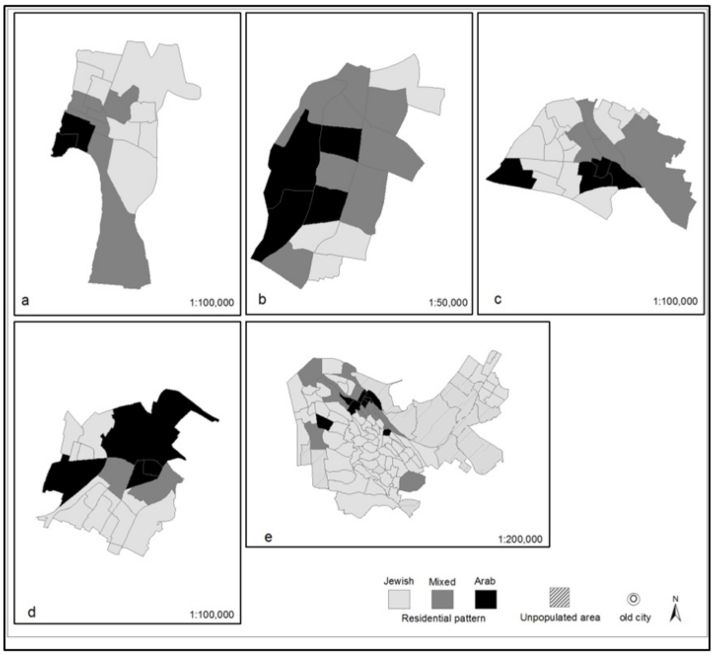


*Fig. 3* – **Distribution of Jewish (Arab percent < 15%), Arab (Arab percent > 60.1%) and Mixed (Arab percent between 15.1% and 60%) areas (per statistical area, 2008), in a. Acre, b. Jaffa, c. Ramle, d. Lod, e. Haifa**

These results can be understood when examining the spatial distribution of the cities` various public land-uses in three categories of Arab-Jewish population composition: Arab (higher than 60.1% Arabs), Jewish (less than 15% Arabs), and mixed (between 15.1% and 60% Arabs). Figure 3 presents the spatial distribution of these areas and Table 3 presents the percentage of buildings per land-use category in each residential pattern.

*Table 3*

**Percentage of buildings per land-use category in A: Arab (Higher than 30.1% Arabs), M: Mixed (15.1%-60% Arabs) and J: Jewish (less than 15% Arabs)**

| | | Commerce | Education, Research | Health, Public Services | Industry, Agriculture | Jewish worship institutes | Mixed Residential Building | Muslim & Christian Worship | Sports, Culture |
|---|---|---|---|---|---|---|---|---|---|
| Acre (n[a]=3,501) | A | 19.85% | 2.54% | 6.05% | 0.36% | 0.73% | 9.08% | 1.21% | 2.30% |
| | J | 4.78% | 3.52% | 4.57% | 0.00% | 1.21% | 0.95% | 0.11% | 0.95% |
| | M | 20.77 | 4.66% | 6.60% | 7.50% | 1.94% | 1.68% | 0.00% | 3.62% |
| Haifa (n[a]=26,892) | A | 9.39% | 0.96% | 2.02% | 0.39% | 0.09% | 6.27% | 0.66% | 0.44% |
| | J | 3.87% | 1.11% | 1.28% | 0.06% | 0.48% | 1.94% | 0.01% | 0.67% |
| | M | 11.41% | 2.38% | 3.17% | 0.68% | 0.41% | 8.52% | 0.03% | 1.20% |
| Jaffa (n[a]=4,710) | A | 0.86% | 1.04% | 1.11% | 0.00% | 0.12% | 0.58% | 0.52% | 0.52% |
| | J | 0.90% | 1.41% | 1.92% | 0.00% | 0.30% | 0.40% | 0.00% | 2.21% |
| | M | 1.77% | 1.21% | 1.38% | 0.20% | 0.40% | 1.11% | 0.30% | 1.16% |
| Lod (n[a]=3,777) | A | 11.93% | 3.43% | 3.20% | 2.98% | 2.25% | 2.87% | 0.88% | 0.88% |
| | J | 3.50% | 5.08% | 2.49% | 0.10% | 0.99% | 0.91% | 0.00% | 1.63% |
| | M | 5.72% | 3.43% | 5.08% | 0.76% | 1.14% | 1.78% | 0.13% | 0.64% |
| Ramle (n[a]=4,186) | A | 12.0% | 4.2% | 3.0% | 1.0% | 1.7% | n.a. | 0.9% | 0.9% |
| | J | 3.9% | 2.1% | 2.1% | 0.0% | 1.8% | n.a. | 0.0% | 1.6% |
| | M | 9.9% | 2.4% | 6.3% | 2.1% | 1.0% | n.a. | 0.3% | 0.8% |

[a] n= number of residential and non-residential buildings

### *Changes in the Ethnic Residential Patterns between 1983 and 2008 and Public Land-Use Distribution*

According to the ICBS, between 1983 and 2008, the five investigated cities experienced a moderate but consistent increase of the Arab population rate, while a decrease of the Jewish one (Table 4). A detailed examination of changes in Arab population distribution for this period (expressed by the annual change rate in each statistical area) (Fig. 4) reveals that the Arab residential pattern in all cities has generally been characterized by a diffusion form. Because the changes are presented for the period between 1983 and 2008, the Arab population rate did not significantly change in the cities` historic areas but mostly in the cities` peripheral parts. This diffusion form of the Arab's residential patterns can be explained primarily by two processes: *invasion-succession* (Berry and Kasarda 1977) and *spatial diffusion* (Morrill 1970), in which minority populations expand into contiguous neighborhoods occupied by the majority group, resulting in a spatial diffusion process.

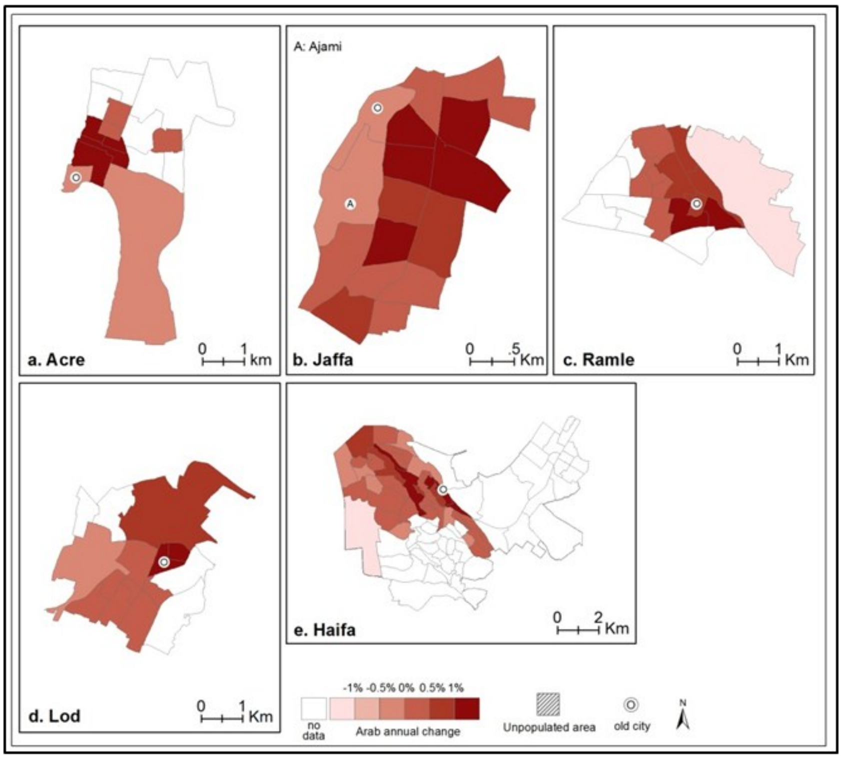


*Fig. 4* – **Annual change rate of the Arab population between 1983 and 2008, in: a. Acre, b. Jaffa, c. Ramle, d. Lod, e. Haifa**

*Table 4*

**Changes in the cities' Arab and Jewish Populations between 1983 and 2008**

| | 1983 | | | 2008 | | | Change between 1983-2008 |
|---|---|---|---|---|---|---|---|
| | Arabs* | Jews* | Arab% | Arabs* | Jews* | Arab% | Arab% |
| Acre | 7.7 | 27.6 | 21.2% | 13.1 | 30.7 | 28.3% | +7.1% |
| Haifa | 17.4 | 208.2 | 7.7% | 27.0 | 214.2 | 10.2% | +2.5% |
| Jaffa | 8.0 | 28.9 | 21.8% | 12.9 | 21.5 | 34.3% | +12.5% |
| Lod | 6.7 | 33.8 | 16.5% | 16.8 | 45.6 | 24.9% | +8.4% |
| Ramle | 6.2 | 36.0 | 14.8% | 15.1 | 48.1 | 23.0% | +8.2% |

*numbers in thousands

As demonstrated in Figure 4, the level of change in Arab residential distribution is not uniform throughout the cities. The question that now arises is what are the land-use characteristics of the different residential areas and how do they correspond with Arab residential change.

Table 5 presents the percentage of buildings belonging to each land-use category in areas characterized by a decrease of Arab population (i.e., a negative annual change rate), a slow increase (annual change rate between 0.1% and 1% per year), and a rapid increase (annual change rate higher than 1% per year). When looking at all cities (see bottom of Table 5), results show that areas in which the Arab population decreased (and the Jewish population increased) are characterized by the highest percentage of commercial land-uses, as well as by the highest percentage of sports and culture and public services (9.66%, 1.17%, and 3.20% of all buildings, respectively). At the same time, areas that experienced a rapid increase of the Arab population are characterized by the lowest percentage of positive and attractive land-uses, such as education and research and sports and culture land-uses (1.72% and 0.79%, respectively).

*Table 5*

**Percent of buildings per land-use category for each annual change rate pace[a]**

| | Change rate | N[b] | Com-merce | Education, Research | Industry, Agriculture | Muslim & Christian Worship | Jewish Worship | Mixed Residential Building | Sports, Culture | Public Ser-vices |
|---|---|---|---|---|---|---|---|---|---|---|
| Acre | < 0% | 522 | 32.95 | 2.11 | 11.30 | 1.72 | 0.19 | 4.21 | 5.17 | 6.13 |
| | 0%-1% | 537 | 7.08 | 6.33 | 0.00 | 0.19 | 2.79 | 0.19 | 1.86 | 6.52 |
| | >1% | 958 | 15.76 | 2.82 | 0.21 | 0.10 | 1.15 | 6.58 | 1.57 | 6.58 |
| Jaffa | < 0% | 941 | 1.49 | 0.96 | 0.11 | 1.17 | 0.11 | 0.74 | 1.06 | 1.17 |
| | 0%-1% | 2393 | 1.50 | 1.30 | 0.00 | 0.04 | 0.33 | 0.79 | 1.59 | 1.38 |
| | >1% | 1376 | 0.65 | 1.16 | 0.22 | 0.22 | 0.29 | 0.73 | 0.44 | 2.11 |
| Lod | < 0% | 338 | 7.10 | 5.92 | 0.59 | 0.59 | 1.18 | 2.37 | 0.89 | 4.44 |
| | 0%-1%< | 2452 | 5.34 | 4.32 | 1.26 | 0.04 | 1.96 | 1.18 | 1.35 | 3.10 |
| | >1% | 369 | 15.45 | 4.34 | 0.54 | 1.36 | 2.44 | 5.15 | 1.36 | 3.25 |
| Ramle | < 0% | 395 | 13.67 | 3.54 | 5.06 | 0.25 | 1.01 | n.a. | 1.52 | 5.82 |
| | 0%-1% | 2273 | 6.82 | 3.43 | 0.22 | 0.31 | 1.76 | n.a. | 1.10 | 3.12 |
| | >1% | 657 | 8.83 | 1.67 | 0.91 | 0.15 | 1.98 | n.a. | 0.76 | 3.50 |
| Haifa | < 0% | 3437 | 8.15 | 1.54 | 0.20 | 0.32 | 0.35 | 4.16 | 0.58 | 2.88 |
| | 0%-1% | 9330 | 6.61 | 1.01 | 0.04 | 0.06 | 0.51 | 5.40 | 0.75 | 1.88 |
| | >1% | 1937 | 5.73 | 1.08 | 1.19 | 0.00 | 0.26 | 4.54 | 0.57 | 1.14 |
| All cities | < 0% | 5633 | 9.66 | 1.90 | 1.58 | 0.60 | 0.39 | 3.20 | 1.17 | 3.20 |
| | 0%-1% | 16985 | 5.75 | 2.03 | 0.24 | 0.09 | 0.94 | 3.26 | 1.04 | 2.30 |
| | >1% | 5297 | 7.29 | 1.72 | 0.68 | 0.19 | 0.79 | 3.40 | 0.79 | 2.81 |

[a]change rate = the annual change rate of the Arab population at each statistical area.
[b]N= number of residential and non-residential buildings

A detailed examination of the cities` land-use distribution (see Fig. 5 with selected cases) shows that in three cities (Acre, Ramle and Haifa) areas that experienced a decrease of the Arab population are characterized by the highest percentage of commercial land-uses. Only in

Lod the highest percentage of commercial land-uses is found in areas in which the Arab population had rapidly increased (see Fig. 5b). Lod is also an exception in regard to sports and culture land-uses; in all cities but Lod, areas that showed a rapid increase of the Arab population are characterized by the lowest percentage of these land-uses. Moreover, in three of the cities (Lod, Ramle and Haifa), the highest percentage of education and research land-uses is found in areas in which the Arab population had decreased (namely, areas into which Jews moved into).

Unexpectedly, the highest percentage of Muslim and Christian worship institutes was found in areas that showed a decrease of Arab population. This is demonstrated in the case of Acre, Jaffa and Haifa, where the highest percentage of Muslim and Christian worship institutes is found in areas into which Jewish population has entered (see, for example, Fig. 5a and Fig. 5c with selected areas in Haifa and Jaffa). This implies that religious institutes do not play a significant role in residential decisions among the population. Thus, the results supports the notion that the gentrification process, whereby the Jewish majority penetrates the Arab minority's residential areas and pushes out the minority residents, is associated with relatively more positive and attractive land-uses (e.g. sports and culture and education and research land -uses) while areas into which the Arab population has entered are characterized by a much lower percentage of these positive land-uses.

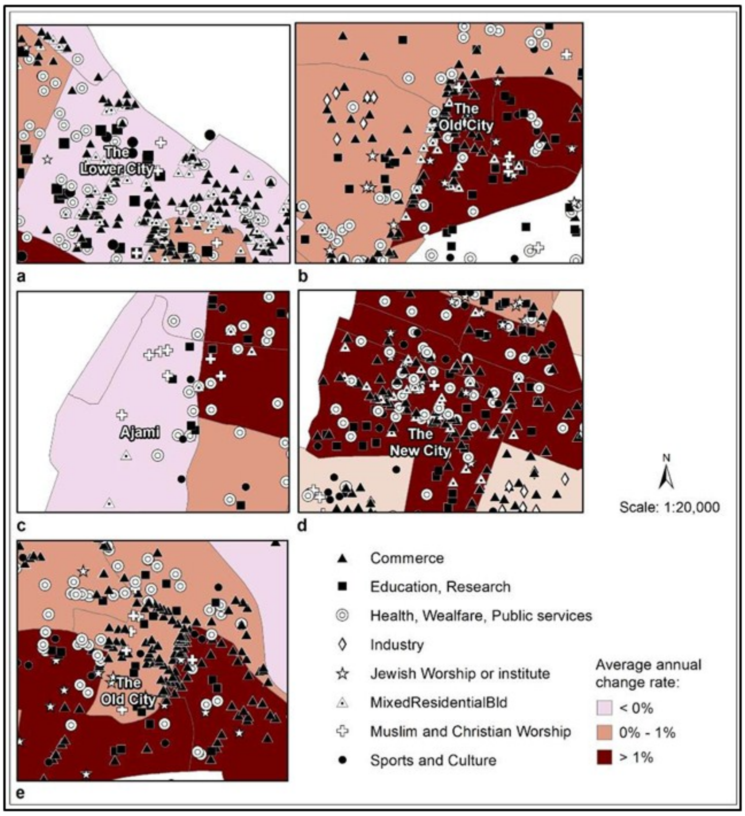


*Fig. 5* – **Distribution of the Arab population and of public land-uses (selected areas), in a. Haifa, b. Lod, c. Jaffa, d. Acre, e. Ramle**

### Spatial Partitions as Social Boundaries

While various land-uses may affect the evolvement of ethnic residential patterns in mixed areas due to their functional and symbolic meaning, certain land-uses also serve as spatial partitions due to their physical and spatial characteristics that provide conditions facilitating separation, or segregation, between ethnic and social groups (Rabin 1987, Grannis 2005, Omer and Goldblatt 2012). Large-scale land-uses often act as physical barriers, or spatial partitions, separating between residential areas of ethnic groups.

In order to explore the potential function of land-uses as spatial partitions dividing Arab and Jewish residential areas, we analyzed the land-use characteristics of the dividing areas in each city, that constitute the division between statistical areas characterized by Arab and Jewish populations. This analysis revealed five types of large-scale spatial partitions dividing between Arab and Jewish neighborhoods: (a) major paths (e.g. main roads, streets and railroads); (b) open spaces (e.g. public open spaces, groves and orchards); (c) public land-use complexes (e.g. sports, culture and education institutes); (d) industrial areas; and (e) artificial barriers (e.g. walls and fences). While some of these spatial partitions (e.g. railroads, several open spaces and walls) are fully impenetrable, that is – do not allow access between their two sides, other partitions (e.g. main streets) do not act as a full barrier, but rather they make difficult the access between the two sides and they increase the visual and physical distance between the residents living in their two sides.

To illustrate these types of spatial partitions, for each city we identified the five adjacent statistical areas that exhibit the greatest differences in Arab population percentage, and analyzed the land-uses that are located in the dividing area between each adjacent statistical areas and that serve as spatial partitions. Table 6 presents the land-use characteristics of these dividing areas and Fig. 6 demonstrates selected cases of these spatial partition types.

In all cities, with the exception of Haifa, main roads, streets, and railroads were found to serve as barriers between Arab and Jewish areas. These long shaped features differ in size and functionality and vary from main urban streets (like Yefet streets in Jaffa), to major thoroughfares (like road No. 40 in Ramle – Fig. 6a) and railroads (like in Lod – Fig. 6b). In addition, large open spaces were also found to serve as partitions between Arab and Jewish areas. These open spaces vary from agriculture fields (in Acre, Ramle and Lod) and groves and orchards (in Lod and Ramle) to a large natural forest and mountain landscape in Haifa that create a natural barrier between Kababir neighborhood (with 72.3% Arabs) and the surrounding Jewish neighborhoods (with 0.1% to 1% Arabs) (Fig. 6c). In Ramle, agriculture fields create conditions for a difference of nearly 78% in the Arab population percentage on either side. In addition, in all cities complexes of public land-uses (i.e. educational institutes, sports and culture, and other public services including cemeteries) tend to act as spatial partitions (see for example Fig. 6d. with the case of Jaffa). In other cases, artificial physical barriers appear to emphasize the boundaries between Arab and Jewish neighborhoods, for example, the old city wall in Acre which combine with various public land-uses to divide the Arab old city (with 98.9% Arabs) and the newer city (with 60.4% Arabs), and two concrete fences in Ramle that divide between Jewish and Arab neighborhoods (see Fig. 6e).

*Table 6*

**Land-use characteristics of the division areas between Arab and Jewish residential areas**

| | Land-use of spatial partition | Difference in Arab population percentage(with percentage of Arab population in the two adjacent statistical areas) |
|---|---|---|
| Acre | Railroad, 4-digit thoroughfare | 54% (59% / 5%) |
| | Railroad, cemetery, agriculture fields, open | 49.9% (59% / 9.1%) |
| | Railroad, open space | 45.3% (50.3% / 5%) |
| | Acre`s old city wall, public open space, education institutes, public services, sports and culture land-uses | 38.5% (98.9% / 60.4%) |
| | Railroad, 4-digit road, open space | 36.3% (41.3% / 5%) |
| Lod | Agriculture fields, groves and orchards, | 98.5% (98.8% / 0.3%) |
| | Open space | 98.1% (98.8% / 0.7%) |
| | Open space, cemetery, groves and orchards | 97.6% (97.9% / 0.3%) |
| | Regular urban street | 95.2% (98.8% / 3.6%) |
| | Railroad, industry, open space | 94.3% (98.8% / 4.5%) |
| Ramle | Agriculture fields, groves and orchards, | 77.7% (78.4% / 0.7%) |
| | Open space, concrete fence | 74.2% (78.4% / 4.2%) |
| | Groves | 65.4% (78.4% / 13%) |
| | 2-digit areal road, open space, agriculture | 63.7% (68.5% / 4.8%) |
| | City stadium, tennis courts, city swimming pool, cemetery, education institutes | 60.8% (63.9% / 3.1%) |
| Jaffa | Cemetery, public services, education | 64.2% (79.5% / 15.3%) |
| | Main street (Yefetst.) | 61% (70.3% / 9.3%) |
| | Sports and culture, education institutes, | 54.2% (63.5% / 9.3%) |
| | Main street (Yefetst.) | 52.6% (70.3% / 17.7%) |
| | Main street (Yefetst.), public services, educational institutes, commercial area | 41% (79.5% / 38.5%) |
| Haifa | Forest and groves, valley | 72.2% (72.3% / 0.1%) |
| | Forest and groves | 71.8% (72.3% / 0.5%) |
| | Forest and groves | 71.5% (72.3% / 0.8%) |
| | Forest and groves, valley | 71.3% (72.3% / 1%) |
| | Forest and groves, open space, industry | 71.1% (72.3% / 1.2%) |

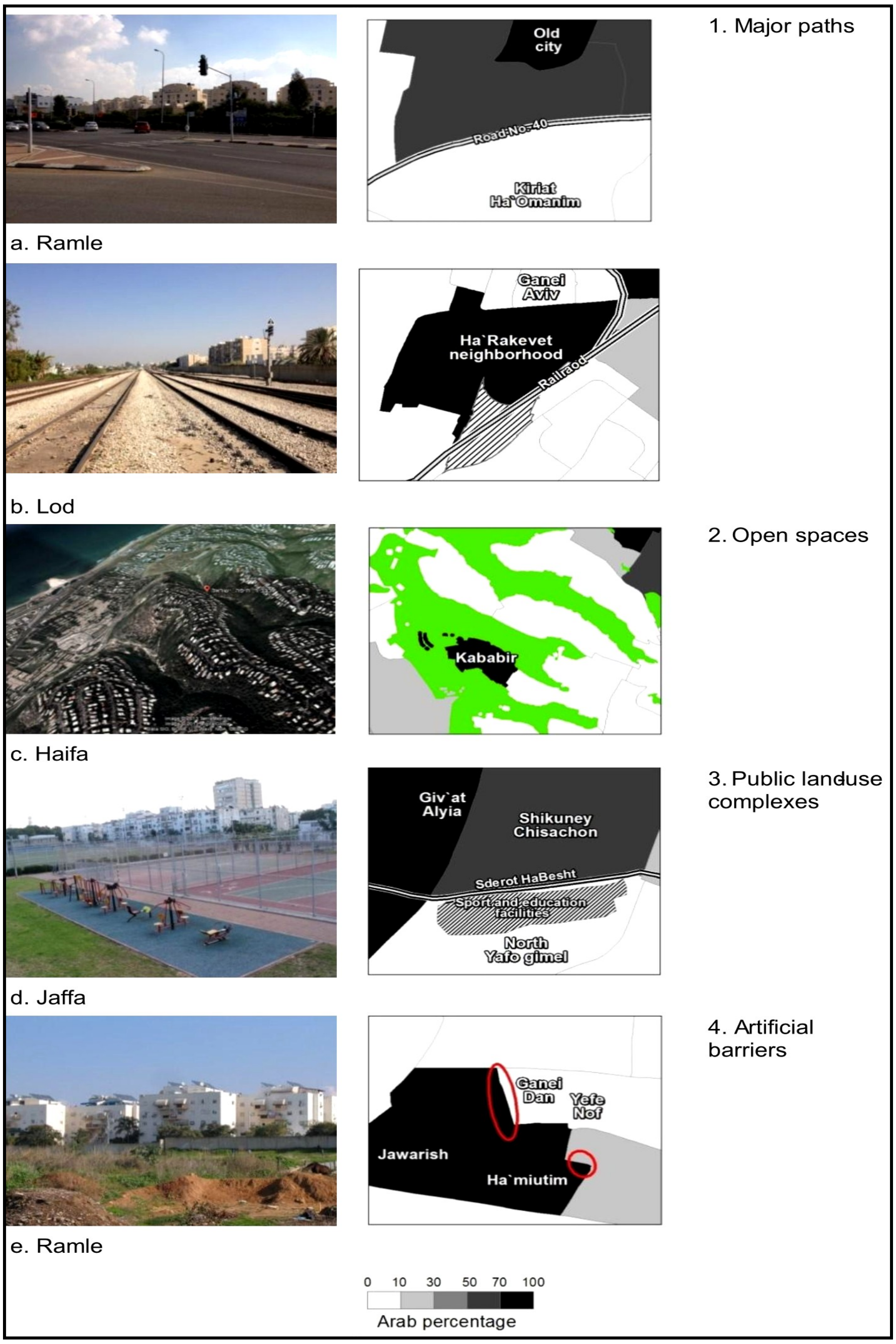


*Fig. 6* – **Cases of spatial partitions separating ethnic areas, by type**

## Discussion and Conclusions

In this paper we examined the Arab-Jewish residential patterns in five Israeli mixed cities in order to evaluate the influence of land-use distribution and spatial partitioning on dynamics of Arab-Jewish residential distribution patterns and the exposure between these population groups in urban areas. The use of GIS enabled us to quantitatively and visually integrate spatial, physical and social databases and analyze the association between these dimensions in the context of Arab-Jewish residential segregation.

Various factors have previously been found to potentially affect residential decisions, and in turn, residential segregation. Though ethnic preferences and attitudes to neighborhood diversity play a role in residential decisions, the built environment *per se* can also contribute to urban segregation due its own characteristics and spatial configuration (Omer 2011). For example, the physical distinctiveness of residential buildings, public spaces and other non-residential land-uses contributes to the formation and preservation of segregation between neighborhoods and residential areas populated by different social and ethnic groups (Brower 1996, Campbell et al. 2009). But at the same time, the functional and symbolic meanings ascribed to different places in the city also affect the everyday life routines of the residents and their residential choices. The results of this study have shown a positive significant correlation between the Arab population's residential pattern and the distribution of several types of land-uses, both functional and symbolic: mainly Muslim and Christian worship institutes, mixed residential buildings, and commercial land-uses. Against that, Arab-Jewish mixed residential areas are characterized by a relatively high percentage of various types of public land-uses (e.g. public services and commercial land-uses) – which potentially provide opportunities for encounters between Arabs and Jews and, as previously found, potentially affect inter-group contacts, and in turn, even decrease prejudice and social distance (Young 1990, Semyonov and Glikman 2009). Moreover, this finding also means that while the Arab population in the mixed cities suffers from lack of accessibility to various public spaces and services (e.g. cultural services) (Khamaisi 2008), the residence of Arabs in the mixed neighborhoods provides Arabs in these neighborhoods an "advantage" gained from the economic and political power of the majority group (i.e. the Jewish population), including access to public, educational and leisure services.

In addition, the results correspond with previous studies indicating that \`neutral\` elements in the built environment (such as the presence of public institutions) tend to appear in cities\` mixed areas (Omer 2011). Interestingly, this study has shown that areas that experienced a gentrification process and a decrease of the Arab population are characterized by a high percentage of symbolic land-uses (e.g. worship institutes), implementing that, similarly to the findings of Ben-Artzi (1980), the existence of worship land-uses are less important in Arab residential decisions.

Different land-use configurations also have an effect on the Arab-Jewish composition change in different areas of the cities. Results show that high rates of Arab-Jewish composition change characterize areas associated with commercial land-uses. However, a gentrification process, i.e. the increase of the Jewish population rate in these cities, had generally occurred in areas with more positive and attractive land-uses e.g., sports and culture, and public services.

The research had also revealed a correspondence between the Arab population distribution and the spatial continuity of the urban area, as defined by the distribution of land-uses. While various land-uses potentially affect the evolvement of ethnic residential patterns in mixed areas due to their functional and symbolic meaning, some of the land-uses serve as spatial partitions due to their physical and spatial characteristics that provide conditions that facilitate separation or segregation between the Arab and the Jewish populations. These partitions were shown to include main roads, streets, and railroads, as well as large open spaces and complexes of public service land-uses. The important consequences of these partitions are their effect on the physical and visual access between neighboring residential areas, and the resulting discontinuity of urban street systems. This finding also means that similarly to the argument of Grannis (1998, 2005), the segregated networks of residential streets may be more important for understanding urban racial composition/segregation than the Euclidean geographic indices traditionally used in the segregation research. Such physical elements create patterns of segregated street networks that lessen the visual access between neighborhoods and enhance the differentiation between Arab and Jewish neighborhoods – both, physically and symbolically.

The findings of this study support the notion that dynamics of ethnic residential distribution are bound up with the spatial distribution of non-residential land-uses that have different functional and symbolic meaning and with the physical dimensions of the land-uses. These functional, symbolic and physical attributes create conditions for the expansion of the Arab minority' residential pattern and have the potential to moderate, or in other cases to increase, exposure between Arabs and Jews.

A deeper understanding of the association between the urban built environment and the residential distribution can provide important input to urban spatial policymaking. Firstly, awareness of public land-uses that correspond with Arab residential change can assist the urban planners' response to the needs of the Arab population moving to other areas, and to plan the spatial distribution of public land-uses in a more equitable and appropriate way. Secondly, understanding the significance of the built environment`s spatial continuity has major implications in policymaking aiming to moderate spatial segregation, for example, through improving spatial (visual and physical) access between residential Arab and Jewish areas.

In closing, it should be noted that in this paper we only illustrated the relation between the distribution of land-use and spatial partitions and the distribution of the Arab population, with no concern to the actual attitudes, feelings or perceptions of the Arab and Jewish populations. In addition, correlations, by nature, do not always imply causality; therefore, further research is still needed to examine the relationship between the built and the social environment, with respect to differential perceptions of various types of land-uses among the two populations, as well as to structural aspects such as urban economic processes.

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*Correspondence:* Department of Geography and Human Environment, Tel Aviv University, Tel Aviv-Yafo, 6997801, Israel

E-mail: ran@eslab.tau.ac.il

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# RURAL AND REGIONAL DEVELOPMENT POLICIES IN EUROPE: SOCIAL FARMING IN THE COMMON STRATEGIC FRAMEWORK (HORIZON 2020)

*Antoni Francesc* **TULLA,** *Ana* **VERA,** *Anna* **BADIA,** *Carles* **GUIRADO,**
*Natàlia* **VALLDEPERAS**
Department of Geography, Universitat Autònoma de Barcelona, Catalonia, Spain

**Abstract:** Social Farming (SF) is an emerging sector in the rural European context, but the European Economic and Social Committee (2013/C 44/07) emphasizes that SF should be planned and implemented under the new 2014-20 rural development policy because of the positive results obtained. The SF concept can be associated with agriculture as a multifunctional activity, giving agricultural practice new meanings and functions and incorporating social services, medical treatment and rehabilitation, and educational training and support. In addition, agriculture must be considered as a means of employment and social integration for groups as diverse as individuals who are unemployed or living with mental retardation, mental disorders, or addictions, among others. As a result, innovative SF activities are contributing to the social economy, rural and regional development, and support for a new agro-social paradigm. These are mainly activities linked with the endogenous resources of the territory that generate new enterprises, together with complementary activities that consolidate an economic network as the basis for regional development.

**Key Words:** *social farming, regional development, European structural funds, rural areas, Catalonia.*

## Introduction

This article aims to show that Social Farming (SF) is an activity that can support sustainable regional development and alleviate the growing inequalities between rural and urban areas. Regional development has often been based on urban systems because industries and services replaced agrarian activities as the economic engine of the 20$^{th}$ century. The core-periphery model shows that areas where agrarian activity predominates have a survival economy while urban areas modernize, giving way to a dual economy (Lipton 1977) that leads to uneven regional development. This is due to an imbalance in the distribution of power, not only to the resources available in the territory (Wallerstein 1979). Economic development can be defined as the modification of human and natural factors to produce growth in a particular area of specific economic variables, such as productivity or Gross National Product (GNP). However, this requires political willpower in territorial planning and regulations that protect and promote less economically dynamic areas.

The value that is currently placed on the natural environment and quality of life of a population requires that we work towards sustainable development involving alternatives that take into account the renewal capacity of an area’s natural and human resources (Pearce 1976). Regional development requires an economic balance between the various areas of a country; otherwise, excessive movements of human and material resources can preclude a minimum level of sustainability or quality of life in some territories (Tălângă et al. 2011). In this scenario, supportive measures are most needed in rural areas, where local development can be due to endogenous or exogenous factors. The former may include the arrival on the economic and social scene of innovative individuals whose activities produce gains that can be reinvested in the same area. The most important exogenous factors are derived from advantages in transportation, communications, and other facilities that, together with external investments, allow the creation or renewal of economically competitive activities. The key element in regional development is the continuous growth in technological innovation, which implies greater capital needs and may bring with it dependency on external investors or taking advantage of the territory itself for tourism or value-added agrarian activities (Tulla et al. 2009).

In the western nations, rural spaces are undergoing profound changes. Shaping a new postindustrial society (Bell 1999), in which the industrial sector is no longer dominant, leads to the expansion of services and the disappearance of the fordist division of labour. In this new scenario, new information technologies occupy a prominent position, and they develop in parallel fashion, with less differentiation between rural and urban spaces (Pahl 1966, Sempere and Tulla 2008). The industrialization of agriculture after the Second World War, which some authors have called the "Green Revolution" (Lockwood 1999), brought major changes to the productive function of rural areas, converting traditional production to competitive products adapted to market demands. The mechanization of fieldwork and need for increasingly large extensions of land brought about a significant decline in workforce, the disappearance of many small farms, and finally, a major reduction in agrarian sector employment (Van der Ploeg 2006). This restructuring caused the commodification of the countryside – a shift from landscapes of production to landscapes of consumption, in the words of Cloke (2006). The agrarian productive function has given way to tourism and counterurbanization as tools for structuring rural areas, even with respect to social and territorial organization (Clout 1972, Woods 2005).

In the capitalist concept of agriculture, nature has a subsidiary role and there are major environmental impacts due to intensive use of the territory, excessive pressure on natural resources, and the use of chemicals and genetic modifications that have damaging effects on human health. This tendency worsens with the promotion of monocultures instead of multicrop diversity, land erosion when fields and traditional land management methods are abandoned, especially in the mountain areas (Barrachina and Tulla 2010), and other factors. In the 1980s, organized efforts began to implement rural multifunctionality as a process of integration with rural development efforts, where agrarian activity is considered economically residual (Armesto 2005). These initiatives emphasize rural tourism, ecotourism or adventure sports, complemented by cultural values related to natural or monumental heritage and the artisan activities related to a specific territory (food products) or new settlers (textile and other artists).

Agrarian activity is considered an opportunity to construct alternative economic models not based exclusively on tourism. This new concept has produced a change in the role of farms and farmers in modern society, giving rise to a new farm culture, with a new consciousness, new values and new means of production, as studied by Neus Monllor (2011) in Catalonia and Ontario (Canada). The emerging farmer has a series of new values, including ecological "farm-to-table" production[1)] using local and sometimes heritage varietals, and responds to the new expectations of certain consumer groups that look for food products with characteristics related to a healthier lifestyle with environmental awareness and social responsibility (Carbone and Senni 2010). In this context, the SF appears to offer a new activity that can, of itself, assist in

1) Also named "farm-to-fork" or "proximity agriculture". It's a new trend of local farms selling products in their surrounding area. There is a new group of restaurants, called "kilometer zero" or "slow food", which uses a percentage of products from less than a hundred kilometers distance.

local development and, if networks of cooperation are established between the various advocates, at the regional level as well. In Catalonia, there are diverse networks that help with product distribution, support entrepreneurs, and provide training and advice in the search for financing, among other things. The most important of these is the Social Farm Network *(*Xarxa CX Agrosocial 2011), a group of 15 enterprises providing more than 1400 jobs, 1100 of them filled by people with a disability or at risk of social exclusion.

Regional development refers to funding policies and internal or external actions taken to improve areas in need of economic development (Foster and Sen 1997). This often means a combination of regional and agricultural sector policies. In the European Union (EU), the Common Agricultural Policy (CAP) includes SF in the Common Strategic Framework (Willems 2013). The idea is that SF can add value by affecting not only agrarian activity but also health care, services, the environment, research and employment. This is why EU governments, and therefore common EU policy, must promote activities that support and promote SF. In recent years, this has included EU grants based on economic diversification policies, social inclusion, and rural development, such as the Leader programmes, to encourage these activities. If SF is recognized as an important element of rural economic development in the next Horizon 2020 framework as programmed (2014-2020), this should provide access to new funding sources and an opportunity to present proposals for European Structural Funds (EAFRD, ESF and ERDF)[2).].

Without a doubt, SF could become a key element in the regional development of many rural areas of Europe. Therefore, it seems important to analyze the possibilities for SF development, taking as our guide the European SoFar network (2005 and 2008) and the specific experience in Catalonia (Xarxa CX Agrosocial 2011).

## Methodology

This study applied two scales of analysis, the first being a general overview of the context for the SF concept and the European examples and the second one is a more local analysis of the experience to date in Catalonia (Fig. 1). The methodology was three-pronged: a literature review, including websites; in-depth interviews and survey research; and analysis of statistical data. In broad strokes, the structure of the bibliographic research was as follows: the transformation of agriculture and rural areas in the past 30 years, the application of regional and local development policies, and SF and a new social and economic environment that combines health and cultural services with activities that help to provide employment and social integration for at-risk groups.

In Catalonia, 105 entities were identified and can be considered SF because the workers who benefit have a disability or belong to at-risk groups. Garden stores constitute about 50% of these entities, and a process of diversification or changes in activity were observed; the other 50% are related to farming, greenhouses, forestry, lumbering, vineyards, olive groves, the production of wine and olive oil, cattle, the food industry (primarily dairy and beef production) or other farm products. There are two areas of specialization that, like the garden stores, have their own particular dynamics: environmental education and catering or restaurant food preparation. The statistical sources used to calculate the presence of groups with disabilities or at risk of social exclusion were from the Catalan Statistical Institute (IDESCAT 2013) and union groups (UGT 2012).

2) EAFRD (European Actions for Rural Development), ESF (European Social Fund), and ERDF (European Rural Development Fund).

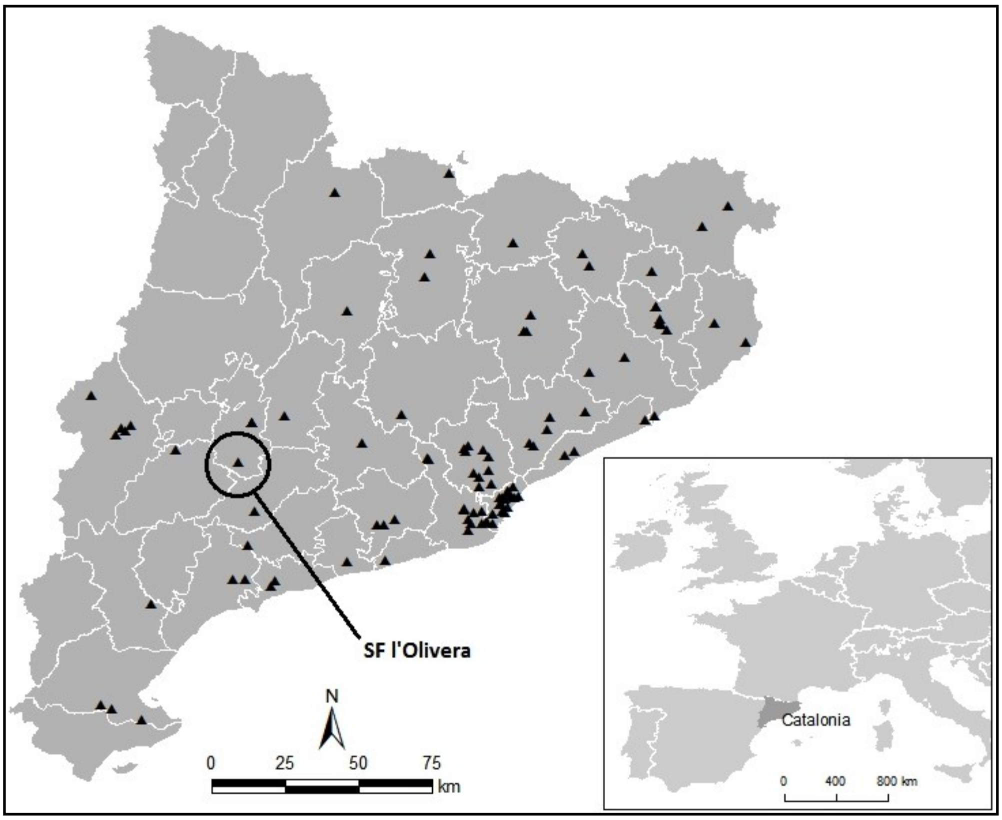


*Fig. 1* – **Localization of SF in Catalonia**
Source: RecerCaixa 2011 ACUP023

In-depth interviews and surveys provided a picture of the SF activity in Catalonia. The 22 interviews were conducted with two types of individuals: (a) advocates of a particular entity who were members of a foundation that supported it or of an administrative council for a nonprofit business; and (b) key informants responsible for particular networks. In addition, 65 questionnaires were administered. The interviews were intended to reveal the characteristics and operations of the SF entities and the 25 survey questions requested basic information about the entities' work. In Catalonia, approximately 25% of the staff and advocates are women; therefore, we explored the gender balance in other European countries (Berenguer 2013): the proportion is similar in The Netherlands (Bock 2004) and it exceeds 60% in Italy (Di Iacovo 2003). However, 50% of the population served in Catalonia is female (IDESCAT 2013, UGT 2012).

Basically, we were interested in determining the environments in which SF can develop, based on the agents involved, the type of activities and the profile of those who benefit. It is necessary to know the legal framework related to the inclusion of individuals with a disability in employment and social engagement, because it affects the possibilities for expanding the SF activity.

3) The TSS consists of legally recognized organizations inscribed in the public register as nonprofits, i.e., which reinvest their benefits in their own activity and which are private rather than public (Anuari TSS a Catalunya 2009). The social cooperatives in Italy can also be considered TSS.

In Catalonia, the third social sector (TSS)[3)] is very important and, under the Spanish law that requires hiring workers with a disability (LISMI) and the Catalan legislation[4)], SF is compatible with legal entities such as Special Employment Centres (SEC). The SEC has a variety of legal options for business status, from a cooperative to an anonymous society, but it must register as a business[5)]. The main requirement to be considered a SEC is that at least 70% of the workforce under standard contract must have a disability or be a member of an at-risk group. The subsidy for investments and to support labour costs can reach 50% if the entity offers a service plan that includes rehabilitation, therapy, and social, cultural and sport integration.

The body of information obtained from the literature search, interviews and surveys provided sufficient knowledge to describe the SF experience in Europe in general and in Catalonia in particular. The most difficult part, because this activity is relatively new, was to determine the links between regional and local development policies and the SF experiences. In this sense, the study of networks such as SoFar (2005 and 2008) and COST Action 866 (2006-2010) in Europe, CX AgroSocial (2011) in Catalonia, or Réseau Cocagne (2007) and Réseau Astra (2009) in France have been more important. The creation of networks strengthens the relationship between SF objectives and regional development because they help to better determine the needs of each place and population.

**A general overview on Social Farming**

There are three potential areas of SF contribution to regional development policy: (1) the need to deliver services to population groups at risk of social marginality (Di Iacovo and O'Connor 2009); (2) the new strategies for rural entrepreneurship that seek out new activities of interest to a certain segment of society and generate income (O'Connor et al. 2010); and (3) the new Common Agricultural Policy (CAP), which considers rural development to be important[6)], increasing environmental action through programmes such as the green checque "greening" (Katsarova 2013). This last relationship will be strengthened by the measures proposed in the Common Strategic Framework (Willems 2013). It is evident that SF, even in its early phase as a strategic development tool, can be beneficial for rural areas. First of all, we must understand SF and the process that has been followed to date.

Social Farming consists of a broad range of activities that have certain things in common: farm production and direct services to empower groups of individuals, such as people with a physical or mental disability; people seeking recovery from drug addiction, imprisonment, or failure in school; the elderly; abused women; and at present, the unemployed and farms that are failing (Di Iacovo 2011, Guirado et al. 2013b). In other European countries, numerous models exist that combine voluntary and public social services initiatives, public and private funding, and regulations concerning employment, social outreach and economic support for at-risk groups and individuals (Di Iacovo 2010), as we discuss below.

With the creation of the SoFar network (2005-08) and the attention received from the EU (Willems 2013), SF has achieved greater recognition. Although the traditional concept had been the more restrictive "Green care", SF is now becoming more generalized and it includes different lenses. Green care was limited to activities and practices unified by the idea of using nature to improve mental and physical human health, albeit in a variety of different ways.

4) Special Employment Centers are qualified by the Catalan government, the Generalitat de Catalunya (*Centres Especials de Treball de Catalunya*, 2012) Under the April 7, 1982, *Spanish* Law on social integration of people with disabilities (LISMI, Ley 13/1982).

5) *Registre d'Entitats, Serveis i Establiments Socials* (RESES).

6) This concerns the second pillar of the CAP, with the 25% of the budget.

Sempik et al. (2010) grouped these activities into two large categories: on one hand, experiencing the natural environment through the senses ("looking at nature") or outdoor physical activity ("being active in nature"), a category that encompasses curative and therapeutic properties; on the other hand, working in the natural environment ("shaping nature") includes planting, gardening, or therapies involving interaction with the animal world.

Another concept is "Care farming", which uses commercial farming and the agricultural landscape as the basis for promoting physical and mental health, establishing a cooperative triangle involving farmers, health and human services professionals, and care receivers (Hine et al. 2008). Another related concept, "Farming for health", refers to the combination of agricultural labour and care for individuals that emphasizes both the agricultural sector (including farming and the social environment) and the health and human services system of institutions, care providers and care receivers (Dessein 2008).

In contrast to these other concepts, SF always takes into consideration the social and territorial context, seeking diversification of economic activity, better access to services, and improved quality of life for all inhabitants of the territory (Di Iacovo and O'Connor 2009). The SF territorial framework becomes a useful instrument for local and regional development, as the European Economic and Social Committee (Willems 2013) has recognized in the current framework programme (2014-2020).

At present, SF can be considered an agrarian or generically rural activity with two major vectors: impact on a broad range of at-risk groups and the capacity to generate economic activities that contribute to local and regional progress. There are six basic areas of SF activity that cover the diverse experiences to date in European countries (SoFar 2005, 2008; COST Action 866 2006-10, Guirado et al. 2013b):

- *Therapy,* including activities involving horticulture and animal care that benefit individuals with a mental disability, disease or disorder, with special education needs, etc. Rehabilitation takes place in residential treatment facilities and penitentiary centres, treating persons with alcohol and/or drug addiction, traumatic experiences (physical or mental abuse, rape), or recovering from illness, as well as problem youth and those with eating disorders, treated in centres for minors.

- *Workforce readiness* prepares individuals with physical and/or mental disability to participate in the production and distribution cycle, to the best of their abilities. It also includes training in new marketable skills for those being released from penitentiary centres, young people who failed in school, and others needing to enter the workforce. We must highlight that professional training is provided for groups that had no previous opportunity to learn or who left school. Since the services are for groups that are disadvantaged in obtaining employment, the public administration provides certain subsidies.

- *Inclusion in mainstream schools* of students with various problems requires activities that facilitate learning in general and job skills or the trades in particular. Many of these students have special needs or adjustment problems. These training activities are based in learning about farm life and production cycles (farm-school, school garden plots, etc.). There are also cultural activities that reassess and communicate rural values and customs as part of the social integration of at-risk groups.

- *Work with individuals and groups at high risk of social exclusion* (due to homelessness, immigration, abuse, unemployment, age [children and the elderly], etc.) to facilitate their inclusion, which can empower these groups. Social cohesion is the goal of community projects that engage different social groups to benefit interpersonal relationships (community gardens, consumer cooperatives, etc.).

- *Promotion of small farms and artisans* (not particularly viable in a competitive economy), by means of organic production, diversification and a commitment to groups at risk of social exclusion. The intersection of two problematic situations (farmers at economic risk and groups at social risk), together with structural assistance policies of the CAP and other institutions, can lead to a rural recovery that will help to shape regional development.

- *Social-recreation activities* with the objective of improving quality of life and personal or social engagement, directed at persons with special needs (people with disabilities, children, families, the elderly). Examples are socially conscious agrotourism or educational activities on farms, whether paid for by the participants or partially subsidized by private or public entities.

The types of SF economic activities can be classified using two criteria (Di Iacovo and O'Connor 2009): the uses made of nature and the degree of personnel specialization. Types of use range from primarily therapeutic (T) to the production (P) of foods or artisanal items. Types of personnel training range from health professions (HP) to the agrarian sector (AS), related to rural transformation or tourism.

When we cross these criteria (2X2 matrix), the classification generates four broad groups of activities:

1) Treatment units in hospitals and specialized centres that use contact with nature as part of a cure. Personnel have more training in health care than in economics. The care provided in this environment is very formal. These centres may be part of the public health system or private foundations (T – HP).

2) Social economy projects, with the objective of producing foods or artisanal craft items, taking into account the therapeutic functions that can improve the social participation of individuals with physical or mental disabilities. Personnel have training in both health-related and economic fields. The entities that take on these projects are nonprofit organizations or "social entrepreneurship" businesses that receive public or private funding (T – AS).

3) Farms specializing in health and human services. The primary function is agricultural production, with personnel who are farmers but also take therapeutic and health-related aspects into account. There may be personnel with some type of health-care training, but the centres provide an informal environment. The priority is not to achieve economic profit; family members and charities often provide private subsidy for the operation. The main objective is better health through agrarian activity (P – HP).

4) Inclusive farming sites, where the activity is agrarian or rural tourism. Within a framework of publicly or privately funded structured programs, employees are drawn from groups at risk of social exclusion. Personnel have training in farming and/or rural tourism. The operations seek economic benefit, often achieved by public subsidy or private contributions from foundations or

family members of the employees from at-risk groups (P – AS).
At the larger scale, the initial results of the bibliographic analysis showed that the majority of the studies have been done at the beginning of the 21st century, although some European studies are available from the latter decades of the 20th century. The experience in Catalonia is more recent and there is not much documentation from which to study them.

The judicial and financial system related to SF varies by country. In Italy, one of the pioneers, where SF began in the 1970s, we found three general types: nonprofit organizations, such as social cooperatives; private initiatives that attempt to make a profit, and volunteer organizations that actively support public or private initiatives. The situation is similar in Catalonia. However, SF could be considered a mature concept in Italy, where there were 6000 social cooperatives and 190,000 employees in 2003 (Istat 2006), but in 2011 there were only a hundred entities and 3,000 employees in Catalonia (Fig. 1) (Xarxa CX Agrosocial 2011). Our research identified only 5 sites in the rest of Spain.

In Europe, SF has adapted to the diverse public approaches to health services, to the harms caused by unemployment, to the policies on social integration about at-risk groups and, very importantly, to the capacity for initiative among the advocates for public or private entities with an interest in resolving the issues. The different models take into account at least the following five elements: 1) the systems that regulate health and human services, 2) the society's state of well-being, 3) funding, 4) the typology of the actors, and finally, 5) how SF is managed. These five elements and the unique composition of each territory have given way to very different systems of SF organization. In Europe, four major models have been described (Esping 1995, Haugan et al. 2006, SoFar 2005, 2008, Guirado et al. 2013b):

- *Social democrat*. In northern Europe (Denmark, Finland, Norway, Sweden), this model is based on the fundamental right of all citizens to access health and social services through a national health system, and it is sustained by high taxes on the inhabitants. These services have been decentralized, and more than 60% are offered by a city or county, which guarantees ongoing training for those who participate in the farm projects. Instead of creating specific institutions, the farms are subsidized when the owner acts as a supervisor, taking responsibility for a few at-risk individuals. Therefore, there is a dual objective: policies of social integration and policies that provide economic support for the farms.

- *Corporate*. This model exists in central Europe (Germany, Austria, Belgium, France, The Netherlands, and Luxemburg). It also guarantees everyone's access to public health services by paying into the social security system, but it allows the establishment of private systems that act in parallel with the public system and they can become providers of health and social services under public contract. There is a public interest in promoting "care farms" and, thanks to the subsidization policies, many training courses are organized. As a result, SF is considered by the concerned stakeholders as an action of solidarity rather than as a profitable business. Nonetheless, there is high pressure from funding agencies to increase the production of food or services, to be more self-sufficient and less dependent upon public subsidies.

- *(Neo)Liberal*. Primarily present in Ireland and the United Kingdom, this model is based mainly on assistance to families and individuals with specific needs and difficulties, provided through the TSS (associations, foundations, etc.), volunteers, and public or church-related charities work. The public system does not guarantee universal coverage. Access to health care depends in large part on private insurance contracts. The actors are outside of public institutions and the management is the responsibility of civil society with private or foundation funding, or partial support from the public sector.

- *Mixed*. This model, present in Mediterranean countries (Italy, Spain), is a combination of the social democratic and corporate models: the private and public sectors coexist as service providers. At the same time, the TSS is especially valuable in this model, working directly with families to care for individuals. In this case, we find ourselves with a fragmented system, in which the existence of a public health system, increasingly weakened, is complemented by a private system that is expanding because of government policies. The strong presence of the TSS means that some services are no longer offered by the public system; they are delegated to nonprofit organizations. At the same time, families have an active role in promoting many of these nonprofit service providers that provide individualized support depending on the framework of SF activities.

The abyss that has been created between the needs in the population and the state's capacity to provide services was evident during the periods of economic growth at the end of the 20th century, but it is even more noticeable in the current crisis. In many countries, the tradition of associations has spontaneously generated new types of organization of the civil society[7)] and bottom-up social practices. It is often easier in agricultural and rural areas to incorporate workers with various kinds of disabilities or at risk of social marginalization. Many initiatives have sprung from the traditions of solidarity and volunteerism, whether of religious origin or community-based or from some other mutual-benefit organization. Without a doubt, the fabric of each country affects the implementation of SF-oriented entities.

One of the most remarkable changes in Europe over the past 25 years has been legal reform that transformed the traditional welfare state from a public system to a mixed public-private system. The most extreme examples in Italy and Catalonia are social cooperatives and not-for-profit enterprises, both of which are in the TSS (SoFar 2005, 2008, Guirado et al. 2013b). Interest in strengthening SF in some countries must also be associated with new opportunities in multifunctional agriculture to contribute to rural development (Van der Ploeg 2006). In a wider sense, rurality includes both existing farm operations and those that are created as part of urban migration to the countryside (Woods 2005). What must be noted in both cases is the orientation towards projects that favour the rehabilitation and workplace integration of people with special needs. The first efforts were more focused on individuals with physical or mental disability, but over time this has become generalized to include all at-risk groups. Altogether, the diverse initiatives that have strengthened SF have helped to consolidate regional development policies, especially when networks are created between SF entities that also reinforce the structure of available services in a particular area.

**Regional development and local rural projects in Catalonia**

Social Farming projects provide a strong boost to economic and social development at the local level. In rural areas, activities linked to the territory and products from the land have greater repercussion for endogenous development, social cohesion and the fabric of the business environment (Tulla et al. 2009). These are more socially responsible initiatives and also more

7) Civil society, in contrast to the TSS, does not necessarily require legal recognition of the entity, and can embrace very diverse organizational structures (neighborhood associations, church groups, nongovernmental organizations, etc.).

respectful of the land and environment, strengthening the values that make positive contributions to the construction of new models of development. There is a reassessment of agrarian activities and of the new multifunctional pattern in rural areas. At the same time, resources from the local territory of each SF installation are more valued, generating both new and older forms of economically productive activity and helping to achieve social gains through their services, facilities, and infrastructure. We could say, then, that these initiatives help to energize rural areas, generating new places of employment that help to stabilize the population with a more attractive level of services and reinforcing the networks of small cities in the countryside (Zamfir et al. 2009). Apart from the specific benefits of SF for some at-risk groups, it also helps to construct a more egalitarian and cohesive society that reinforces loyalty to place and an established basis for territorial development (Pallarès-Barberà et al. 2004).

Many SF initiatives, either due to the ideology of their sponsors or the advantages of CAP policies (Katsarova 2013), choose to focus on ecological, organic or biodynamic agriculture (Lockwood 1999), or at least to ensure that integrated or conventional production minimizes the use of chemical and transgenic products. At the same time, this sensitivity on the part of those who initiate or direct SF operations makes the farms an exponent, not only of social and economic development of a place but also of the reassessment of local culture and customs (Guirado et al. 2013a). They perceive the local cultural heritage as an active element that not only gives them singularity, with unique products in a very competitive market, but also allows them to adapt to their environment and plan for its exploitation based on local characteristics and natural cycles. In this sense, we must assess the return to particular varieties of local products, traditional farming techniques, and abandoned fields that can be recovered. Many traditional practices that were effective instruments for the conservation of the territory and landscape have been progressively lost, as in the case of today's large extensions of crops and cattle.

The SF projects also represent the emergence of a new farm community that opts for local production to support "proximity agriculture" that allows a direct connection with consumers. This new focus is supported among both traditional farmers and newcomers from urban areas (Monllor 2011). The intent is to reconfigure the current food system, working toward food autonomy by focusing on foods produced ethically, locally, and with social justice (Carbone and Senni 2010). Parallel to the emergence of this new farm paradigm, there are the new patterns of consumption in the postindustrial nations. In these countries, society is increasingly sensitized and it has acquired food consumption habits that also focus on ecology, ethics, quality, proximity, healthfulness, and respect for the environment (Verbeke 2005). In recent years, the consumption of ecological agricultural products in Spain has increased significantly: a 7% rise in 2011, achieving a market share of about 2%. The amount of agricultural land dedicated to ecological farming is constantly increasing in Spain[8)].

The products of SF operations in Catalonia (Table 1) are perfectly suited to these consumer habits, meeting the needs of these emerging market segments as they continue to grow in importance. Consumption patterns combining quality and ethical considerations offer a clear commercial opportunity for business and economic viability. The products are sold on-site at the farm, through cooperatives or consumer groups and specialized establishments as "proximity agriculture", shortening the commercial cycle and guaranteeing total traceability of product origin, which adds even more value.

8) Data source: Ministerio de Agricultura, Alimentación y Medio Ambiente, Anuario 2011.

*Table 1*

**Main characteristics of Catalan Social Farming experiences in a SWOT analysis**

| | |
|---|---|
| **[STRENGTHS]**<br>*AGRICULTURE*<br>- Strategic sector in current economic crisis<br>- Multifunctionality and crop diversification<br>- Local food movement ("farm-to-table") and improved profile of agricultural practices<br>- Implementation of sustainable agriculture standards and social values<br><br>*TERRITORY*<br>- Contribution to local development and social fabric<br>- Creation of services to take care of people<br>- New relationships between producers, consumers and society in general<br><br>*SOCIAL INNOVATION AND ENTREPRE-NEURSHIP*<br>- Return-on-investment for public funding<br>- Initiatives with a civic origin<br>- Strengthening of public-private cooperation<br><br>*BENEFICIARIES*<br>- Special-needs groups gain appropriate employment opportunities<br>- Individuals at risk of social exclusion gain support<br>- User groups (producers, consumers and society in general) | **[OPPORTUNITIES]**<br>*CURRENT CONTEXT*<br>- Socioeconomic scenario demands innovation and projects with social merits<br>- Changes in consumption patterns (e.g. interest in production with ethics and justice, Fair Trade) and eating habits (preference for organic products)<br><br>*EMPLOYMENT AND SOCIAL EQUALITY*<br>- New employment opportunities in agriculture and related sectors<br>- Need to create initiatives that provide employ-ment and reduce the impact of economic crisis<br><br>*SOCIETY*<br>- Alternative financing pathways<br>- Use of new technologies<br>- Broad network of Third Sector initiatives in Catalonia<br><br>*INSTITUTIONS*<br>Programs that encourage a social economy<br>Assistance for entrepreneurship and innovation |
| **[WEAKNESSES]**<br>*MANAGEMENT/ORGANIZATION*<br>- Dependence on public funding<br>- Low productivity outcomes<br>- Delay of non-payment of subsidies<br><br>*CONTEXT*<br>- Emerging sector with a limited track record<br>- Practices are not well codified<br>- Networks are not well structured<br><br>*BENEFICIARIES*<br>- Under representation of certain groups<br>- Difficulties in meeting the special needs of certain groups/individuals | **[THREATS]**<br>*CONTEXT*<br>- Uncertainty and hesitance about entrepre-neurship<br>- Lack of social awareness and recognition<br>- Neoliberal model of business objectives vs economics based on ethics and solidarity<br><br>*SOCIAL FARMING SITUATION*<br>Limited appreciation of the social contributions of SF (e.g., at-risk groups)<br>Limited awareness of SF in Catalonia, compared to elsewhere in the EU<br><br>*POLITICS/INSTITUTIONS*<br>- Cutbacks in social welfare funding<br>- Socialization and privatization of health care and social services<br>- Excessive bureaucracy and administrative limitations<br>- Lack of a regulatory framework and a lack of political will |

Source: Own elaboration from RecerCaixa project

More specifically, we can consider the various groups of activities that rely on SF in Catalonia, and they may contribute to local and regional development. Among others, these include the following:

- Greenhouses and garden centres have been, and remain, among the most common activities used to provide jobs for those with physical and mental disabilities. In some cases, these workers' families have established foundations to create cooperatives or not-for-profit businesses. They are normally located in rural areas close to cities.

- Vegetable and flower production, at small- and mid-scale, is among the activities that employ the greatest diversity of at-risk groups. In Catalonia, local governments and the Caritas Foundation of the Catholic Church have provided the most land for use by socially marginalized groups (unemployed, the elderly, ex-drug addicts, etc.). The production is often for local sale or for consumption by the group working the land. There are also gardens located at prisons near Martorell and in the City of Mallorca.

- Ecological production of eggs and small animals (rabbits, chickens, partridges, etc.) is an emerging activity in response to the growing demand for these affordable foods in a period of economic crisis. These installations are mid-sized but very modern and equipped with technology.

- Farms with sheep and goats, both for meat and milk products, are difficult to establish. They require special training in pasturing, sanitation, and production techniques, along with a large investment in land, animals, and workers. Most of these initiatives are located in rural mountain areas or far from the cities.

- Beef and dairy cattle are among the most adaptable to ecological standards. In the SF context, these are normally mid-sized operations that hire at-risk individuals. However, in Catalonia there is an example of a large dairy products company, "*La Fageda*" (Xarxa CX AgroSocial 2011), with a 5% market share for yoghurt sales. The company's operations range from caring for the dairy cows to selling the final products. Its success comes from its niche in the ethical products market, its cooperative business structure, being part of a network, and the public SEC benefits available to it.

- The cultivation of mid-sized vineyards and olive groves is expanding because of the diversity of jobs that can be learned relatively easily by at-risk groups. Added value is achieved by making wine and oil, normally produced ecologically and marketable as a high-quality product. *L'Olivera*[9], described in the next section, exemplifies this type of operation.

- Food production industries, restaurants and catering businesses that employ at-risk groups require increased organization. For this reason, SF involves foundations, cooperatives and businesses, and there is an important commitment to providing advance training for these workers.

- Rural tourism can be readily combined with agrarian projects, and can have very diverse functions. It provides jobs for individuals with disabilities but also to those at risk

9) Information obtained from the in-depth interview and the cooperative's website: http://www.olivera.org [last update 01-04-2014]

of social exclusion. This is also the modality that best incorporates environmental education.

Finally, it is important to discuss the legal aspects of the entities involved in SF, which vary by country. Spain passed its legislation on hiring individuals with a disability, LISMI[10)], in 1982. In Catalonia, the alternative option is the SEC[11)], described in the methodology section, and inclusive or sheltered work environments, businesses that have more flexibility in the type of at-risk groups from which they contract employees.

**A Catalan Social Farming experience: *L'Olivera* cooperative as a case study.** L'Olivera is a social integration cooperative established in 1978 in Vallbona de les Monges, a small village in Catalonia's Urgell County. It was an initiative by a young urban group that decided to move to a rural area with a deep structural crisis. They were motivated by the possibility of building an alternative lifestyle model, and arrived in the village at a time when the local population was abandoning their fields and closing up their houses to move to the city. This project was closely linked to the land and built around two main pillars: agrarian production and living in the community, with the objective of working alongside people with disabilities.

The origin of this project was an effort to promote endogenous local development based on the agrarian sector, attempting innovative production and supporting cooperative work with at-risk individuals. They worked cooperatively, rather than each person for himself or herself. After various attempts, in 1985 they decided to create a bodega and begin wine production, from the vine to the sale to consumers. In 1986, this became a Special Job Centre, under the provisions of Spain's LISMI.

In the early 1990s, annual wine production reached 14,000 bottles, and it has since increased to 100,000. At the same time, the group began to cultivate olive trees – recovering abandoned groves – and to produce ecological oil. The increased production has required them to expand their facilities, including an olive press on site and space for the machinery to bottle and store their products. This has resulted in a greater commercial presence, increasing the sales volume and export quotas. At present, the cooperative has 50 employees, of whom 50% have some type of psychological disability or mental disorder. Their decision to work in the social and collaborative economy has led to an organizational model that fully integrates all of the employees, giving individuals with disabilities the opportunity to be full members of the cooperative, if they so choose. This has led to greater confidence in the project and more involvement by all of the participating groups. Their work helps them feel valued by the cooperative, integrated into the community, and able to live a more normal life.

In terms of local development, the work done at *l'Olivera* is multifunctional because it is not only the production of wine and oil and the integration of people with disabilities into the organization, but it also includes new activities in the realm of social economy. These activities establish socially valuable links with other economic initiatives, such as the creation of

10) Article 49 of the 1976 Spanish Constitution (1976) requires that policies be established to provide for, treat, rehabilitate and integrate into society those with physical, sensory and psychic disabilities. The 1982 law for social integration of people with disabilities (LISMI, *Ley 13/1982,* 7 April), established norms by which public and private businesses with more than 50 employees, of which at least 2% have a disability, receive fiscal incentives.

11) Special Employment Centers were created by the Department of Labor and Department of Social Welfare of the Generalitat de Catalunya in 2009. There are specific agreements between the Administration and the various types of businesses, cooperatives or foundations, which provide economic benefits in exchange for hiring at-risk individuals and providing care and treatment services.

networks of joint commercialization. Those efforts have been complemented with wine tourism activities and visits to the bodega, which bring visitors to the area who combine their stay in the village with visits to the Cistercian convent of the same name (*Vallbona de les Monges* means Good Valley of the Nuns).

In this sense, *l'Olivera* is among the SF successes in Catalonia, incorporating at-risk individuals into a successful rural development project. It is economically viable, socially just and environmentally sustainable, demonstrating that it is possible to create regional development strategies that combine social economy and agroecology promotion. In addition, SF is a growing trend in Catalonia, with a symbiosis between social action and agriculture, despite the current economic crisis. The 15 members of the CX AgroSocial network (2011) provide the basic structure for rural development in Catalonia, but there are others who could choose to join.

## Conclusions

It is evident that activities related to SF have increased over the past 25 years in Europe; in some countries the number of farms, businesses or cooperatives has multiplied by a factor of 20 or more. The origins of these entities can be categorized into four main types, which in one way or another converge when SF activity becomes standardized: first, public or religious organizations have adapted SF to therapies used in health care centres, to redirect young people who have not done well in school, or to support the reintegration of recovering drug addicts or those who have been incarcerated; second, associations and foundations created by families to provide work and better living conditions for individuals with physical or mental disability; third, private initiatives through cooperatives or businesses, often not-for-profit, that provide therapeutic services and attempt to combine the incorporation of at-risk groups into the working world with income generating activities; and finally, the legislation in each country related to at-risk groups and also specific laws permitting SF entities that guarantee funding in exchange for particular provisions.

At a mature phase of SF implementation, networks emerge to bring together and coordinate the efforts of diverse agents and businesses. Local governments and later national governments as well, are becoming aware of the importance of this new activity to the development of rural areas, with the double objective of creating needed services and generating additional income for the served population. This new social function for agriculture is strengthened by the ecological orientation of its production methods and by its respect for the land and the environment. The current priority attached to food autonomy and local agriculture strengthens SF by attracting consumers who prefer to purchase these healthier products from producers who share their ethics.

Recently, due to the efforts of various networks of scientists, the EU has included SF in the funding objectives for rural development (2014-2020). This activity therefore becomes one of the elements to be considered in proposing policies for regional development, especially when these are not isolated activities but rather incorporated into various types of networks.

Finally, we could conclude that there are a series of social and economic benefits for rural areas, which could increase as SF becomes more widespread: (a) the creation of employment opportunities for current and future at-risk groups; (b) diversification in farm products; (c) new agrarian and rural initiatives, beyond the tourism sector, that strengthen multifunctionality and create added value; (d) consolidation of sustainable ecological agriculture and support for both quality and proximity in systems of product distribution; (e) increased social services for at-risk individuals in rural contexts, where resources are scarce and it is difficult to meet their needs; (f) the arrival of new families in small villages, attracted by new employment opportunities related to SF and by services adapted to their needs; (g) expansion of the types of entities and initiatives that combine agrarian and other, more urban, activities that require a high-quality natural environment; (i) the empowerment of at-risk groups; and, among others, (j) the possibilities for social and employment integration that can result in a decreased probability of recurrence (e.g., former inmates), and greater self-confidence for members of these groups.

In the development arena, SF offers a clear example of economic and social innovation, closely related to collective action and to active, participative and ongoing interaction between individuals, agents and territorial resources. These facilitate the creation of networks of collaboration and cooperation at the local level that promote social cohesion and help to stabilize the population of a territory, while increasing the feeling of belonging to a community and encouraging cooperation.

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*Correspondence:* Department of Geography, Universitat Autònoma de Barcelona, Catalonia, Plaça Cívica, Campus de la UAB, 08193 Sardañola del Vallés, Barcelona, Spain

E-mail: antoni.tulla@uab.cat

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# HOUSEHOLD/ZONAL SOCIOECONOMIC CHARACTERISTICS AND TOUR MAKING: CASE OF RICHMOND/TRI-CITIES MODEL REGION IN VIRGINIA

*Xueming* **CHEN**
Virginia Commonwealth University, United States

**Abstract:** This paper statistically assesses the impacts of household/zonal socio economic characteristics on tour making within the Richmond/Tri-Cities Model Region, Virginia, United States, based on the dataset made available through the 2009 Virginia National Household Travel Survey (NHTS) Add-On Program. The tour analysis distinguishes nine tour types (three simple tours and six complex tours) stratified by aggregate tour purposes of work (including school and other subsistence activities), maintenance and discretionary. A series of regression model runs have yielded the following conclusions: First, at aggregate level, the number of drivers, median household income, household size, number of workers, and zonal walking modal share are statistically significant and positively impact tour frequency. Tour length and complexity are positively related to household income and number of vehicles, but negatively related to zonal walking modal share. Second, at an individual tour type level, each tour type's frequency/length/complexity is impacted by a different set of household/zonal socioeconomic characteristics. Zonal socioeconomic characteristics have little or no impacts on household tour making. It is recognized that many unknown factors may also have impacted tour activities, which require further in-depth studies in order to better explain complex tours.

**Key Words:** *tour, Richmond/Tri-Cities model region, household and zonal socio-economic characteristics, regression model*

## Introduction

In 2007, the Transportation Research Board (TRB) published a Special Report 288: *Metropolitan Travel Forecasting, Current Practice and Future Directions*, which recommends that Metropolitan Planning Organizations (MPOs) and other agencies in the United States using travel demand models begin to transition from the prevailing four-step modeling paradigm to more advanced model forms (for example, improved land use modeling, tour-based models, activity-based models, discrete-choice modeling, supply-side models, TRANSIMS, and others) in order to more effectively respond to new policy and planning requirements (TRB 2007).

In 2009, in response to this TRB Special Report 288, the Virginia Department of Transportation (VDOT) put out a Virginia Transportation Modeling (VTM) research report entitled "*Implementing Activity-Based Models in Virginia*." Based on its thorough and objective analysis, the VDOT report recommends an incremental approach to advanced model development, including activity-based models (ABMs). VDOT (2009) recognizes that many challenging requirements (e.g., data, forecast, software, staffing) must be met in order to develop an ABM in Virginia. The development of a fully operational statewide ABM will probably take many years and cost several million dollars before its completion.

In line with the long-term goal of ABM development in Virginia, this paper intends to conduct a tour making analysis based on the empirical data provided by the 2009 Virginia National Household Travel Survey (NHTS) Add-On Program. Due to space limitation, this paper only concentrates on the Richmond/Tri-Cities Model Region in Virginia ("the study area") and limits its scope of work to statistically examining the relationship between household/zonal socioeconomic characteristics and tour making (tour frequency, length, and complexity). Since this is a demand-side analysis and the basic unit of analysis for NHTS is the household, household socioeconomic characteristics are thus critically important. Meanwhile, it may also be worth testing the impacts of zonal-level socioeconomic characteristics on household tour-making as well, since nobody has ever done this test before. This study intends to set a preliminary stage for more in-depth disaggregated tour- and activity-based analyses in the future.

Following this introduction, the rest of this paper is divided into six sections. First, Section 2 provides a literature review. After that, Section 3 presents a research methodology. Subsequently, Section 4 provides an overview of the Richmond/Tri-Cities Model Region, with an emphasis on its socioeconomic and travel characteristics. Section 5 examines the statistical relationship between tour frequency/distance/complexity and household/zonal socioeconomic characteristics. Based on empirical analysis, Section 6 discusses the research results and remaining limitations. Finally, Section 7 summarizes research findings and it draws conclusions.

## Literature Review

Activity-based travel demand analysis is believed to have two major advantages over the existing four-step models by providing a better understanding of travelers' responses to transportation policies and programs and an explicit analysis of complex travel patterns such as trip-chaining behavior (Lee et al. 2007). According to VHB (2006), ABMs, by definition, use the tour (rather than the trip) as the basic unit of travel and they are therefore also called tour-based models. It is the tour-based analysis that lays the foundation for ABM development.

Over the past four decades, many ABM models have been developed with various degrees of application successes. The earliest ABMs have been developed within the context of European national models in countries such as the Netherlands (Hague Consulting Group 1992), Italy (Cascetta et. al. 1993), Sweden (Algers et. al. 1997) and Denmark (Fosgerau 2002).

In Canada, Miller et. al. (2005) uses the 1996 Transportation Tomorrow Survey (TTS) data in the Greater Toronto Area (GTA) to develop the tour-based model of travel mode choice. A key organizing principle in the model is that if a car is to be used on a tour, it must be used for the entire chain, since the car must be returned home at the end of the tour. No such constraint, however, exists with respect to other modes, such as walk and transit.

In their review of models of Australian capital cities, SKM (2009) found that the Sydney Strategic Travel Model (STM) was the only Australian capital city model which was tour-based (the others being trip-based). Milthorpe and Daly (2010) take travel data from the Sydney Household Travel Survey and analyze it using both trip and tour methodologies. Comparisons are then made on the results from this analysis. Major differences include insights into non-home based travel, the proportion of journeys which involve deviations (intermediate stops) and the resulting additional kilometrage. Also, as most people start and finish the day at home, it is possible to examine the symmetry, or otherwise, for outward (away from home) and return (towards home) tour legs. They also find that the travel purposes have different duration and time of day profiles.

The most important U.S. based ABM applications include Simulation-based Applications; Computational Process Models (CPM); Hazard-Based Duration Models; Econometric-based

Applications; Mathematical Programming Approaches; TRansportation ANalysis and SIMulation System (TRANSIMS); Discrete and Discrete-Continuous Choice Models; Structural Equation Models; and others (Bhat 1997, Bowman and Ben-Akiva 1997, Gärling et. al. 1994, Golob and McNally 1995, Kitamura 1996, McNally 2007, Pas 1997, Recker 1995, USDOT 1997).

Sometimes called stop-making behavior, trip-chaining behavior in activity-based modeling describes the importance of multi-purpose trip-making rather than single trip-making. Numerous studies have examined trip-chaining or stop-making models using the frequency of stops on the way home and/or on the way to work as dependent variables (Bhat 1999, Bhat and Singh 2000, Chu 2003, Shiftan 1998, Wallace et al. 2000). In these studies, the stop-making behavior is derived from the activity-based concept and it is used to describe stopping behavior made by a traveler, in particular a commuter, on the way to home or work. With the assumption that a commuter has a regularly followed route, stopping at a location away from home or work during commuting in order to participate in an activity is treated as a deviation from the commute trip. Therefore, in prior research, stop-making models were usually applied with respect to linking non-work activities with work activities, including the morning commute, midday trips, evening commute, and trips before or after the commute (Bhat 1999, Bhat and Singh 2000, Wallace et al. 2000). In addition to work trips, non-workers' trip-chaining as a series of out-of-home activity episodes (or stops) of different types interspersed with periods of in-home stays have also been investigated (Bhat and Misra 2001, Misra et al. 2003).

In spite of its conceptual novelty and model development progresses, the inherent complexity of activity behavior, data availability and collection cost, compatibility with existing full-step model (FSM) results and the risks it causes, existing agencies' modeling capability and ABM's lack of solid theoretical framework have prevented the widespread applications of ABMs in the U.S. and elsewhere. In the U.S., the following planning agencies have taken the lead in developing and applying the activity-/tour-based models: San Francisco County Transportation Authority (SFCTA), Metropolitan Transportation Commission (MTC), Denver Regional Council of Governments (DRCOG), New York Metropolitan Transportation Commission (NYTMC), Mid-Ohio Regional Planning Commission (MORPC), Tahoe Regional Planning Agency (TRPA), Sacramento Area Council of Governments (SACOG), Atlanta Regional Commission (ARC), and New Hampshire Department of Transportation (Statewide), and others. In addition, Portland Metro and Texas Department of Transportation are actively experimenting with and testing the tour-based models.

It is noticed that ABM concepts have recently been applied not only to model development, but also to planning research. For example, Krizek (2003) offers a typology of travel tours to account for different travel purposes and analyzes the relationships between tour type and neighbourhood access using detailed travel data from the Central Puget Sound Region. This paper takes a similar approach for the Richmond/Tri-Cities Model Region by examining the impacts of household/zonal socioeconomic characteristics on local tour making.

## Research Methodology

### *Data Sources*

The primary data source of this study is the 2009 Virginia NHTS Add-On Program. The add-on sample size for the entire Virginia is 15,231 households and 117,544 trips, which includes 2,273 households and 17,075 trips for the Richmond/Tri-Cities Model Region.

The data set for the study area includes household, person, vehicle, and trip/location tables.

This study primarily uses trip/location table, which already includes each traveler's most important household information. The paper uses household tour as the unit of analysis, which is aggregated from individual trip information.

The secondary data source is the 2008 socioeconomic data for all traffic analysis zones (TAZ) within the study area. TAZ-level population, household, automobile and employment densities may impact individual trips and household tours, which remain to be tested.

### *Tour Definitions*

Activities in a household used for satisfying human needs are classified into three categories: subsistence (work or work-related business), maintenance (grocery shopping, personal and household business, and pick-up/drop-off passengers), and leisure (social and recreational purposes). Subsistence and maintenance are household needs, and leisure is formed by the need of the individual (Reichman 1976).

Following the tour type classification and terms used by Krizek (2003), this paper also assumes nine home-anchored tour types for the study area (Note: H=Home; W=Work; M=Maintenance; D=Discretionary):

- Type 1: Simple Work (H-W-H);
- Type 2: Simple Maintenance (H-M-H);
- Type 3: Simple Discretionary (H-D-H);
- Type 4: Complex Work Only (H-W-W-…-H);
- Type 5: Complex Maintenance Only or Complex Discretionary Only (H-M-M-…-H or H-D -D-…-H);
- Type 6: Complex Work + Maintenance Only (H-W-M-…-H). Note: Tripmaking could take place in any order;
- Type 7: Complex Work + Discretionary Only (H-W-D-…-H). Note: Tripmaking could take place in any order;
- Type 8: Complex Maintenance + Discretionary Only (H-M-D-…-H). Note: Tripmaking could take place in any order;
- Type 9: Complex Work + Maintenance + Discretionary (H-W-M-D-…-H). Note: Tripmaking could take place in any order.

In the above tour type classification, the term "Work" is a subsistence activity including income-producing or paid time like work or school (Lee et al. 2007).

### *Research Hypotheses*

This study makes the following hypotheses regarding the impacts of household/zonal socioeconomic characteristics on aggregate household-level tour-making (combining all tour purposes):

First, tour frequency is negatively related to tour length. Shorter tours are more frequent than longer-tours;

Second, tour length is positively related to tour complexity. In other words, longer tours are more likely to have intermediate stops or trips for each tour;
Third, the household socioeconomic characteristics have much more significant impacts on aggregate household-level tour-making than zonal socioeconomic characteristics.

In the meantime, it should be pointed out that at the disaggregated levels, the impacts of socio-economic characteristics on household-level tour-making vary by tour purposes.

*Analytical Approaches*

For each tour type, including aggregate type (combining all tour purposes), this study uses Poisson regression (for count data) to estimate the impacts of household/zonal socioeconomic characteristics on tour frequency (measured by number of tours per household), and applies Ordinary Least Squares (OLS, for continuous data) regression models in the estimation of the impacts of household/zonal socioeconomic characteristics on tour length (measured by miles per tour) and tour complexity (measured by trips per tour). Table 1 shows the list of variables used in these regression models. Each regression model, though with a different dependent variable, has the same set of independent variables.

*Table 1*

**List of Variables**

| Regression Model | Dependent Variables (DVs) | Independent variables (IVs) |
|---|---|---|
| Poisson Regression | AGGHHFREQ (Tour frequency) | *Household Socioeconomic Characteristics*<br><br>DRVRCNT (Number of drivers in a household);<br>HHFAMINC (Median household income);<br>HHSIZE (Household size);<br>HHVEHCNT (Number of vehicles in a household);<br>NUMADLT (Number of adults in a household);<br>WRKCOUNT (Number of workers in a household);<br>CARRATIO (Average automobile modal share of a tour);<br>WALKRATIO (Average walking modal share of a tour);<br>AVGAUTO (Autos per household);<br><br>*Zonal Socioeconomic Characteristics*<br><br>POPDEN (Population/square mile);<br>HHDEN (Households/square mile);<br>AUTODEN (Autos/square mile);<br>TEMPDEN (Total employment/square mile). |
| OLS Regression | AVGHHMIL (Tour length) | |
| OLS Regression | AVGHHTRIP1TOUR (Tour complexity) | |

For Poisson Regression, AIC (Akaike Information Criterion) and Wald ChiSq are used to test model and parameter significance, respectively, whereas for OLS Regression, R-Square and t value are used to test model and parameter significance, respectively.

**Richmond/Tri-Cities Model Region: Facts at a Glance**

*Geographic Setting*

As the capital city of the Commonwealth of Virginia, Richmond City is the central city of the Richmond/Tri-Cities Model Region, or the greater Richmond area. At present, the Richmond/Tri -Cities Model Region (1,792 square miles; 1.2 million existing residents; 980 internal traffic analysis zones, or TAZs) contains the two urban regions: Richmond City and the Tri-Cities (Petersburg, Hopewell and Colonial Heights), plus other surrounding counties. It is bounded by the Fredericksburg Model Region to the north and extends into New Kent and Charles City counties, but does not border the Hampton Roads Model Region. The James River bisects the study area. Major interstates crossing the region are Interstates 64 and 95 (intersecting in Richmond) and Interstate 85 (intersecting I-95 near Petersburg). Figure 1 shows the map of Richmond/Tri-Cities Model Region.

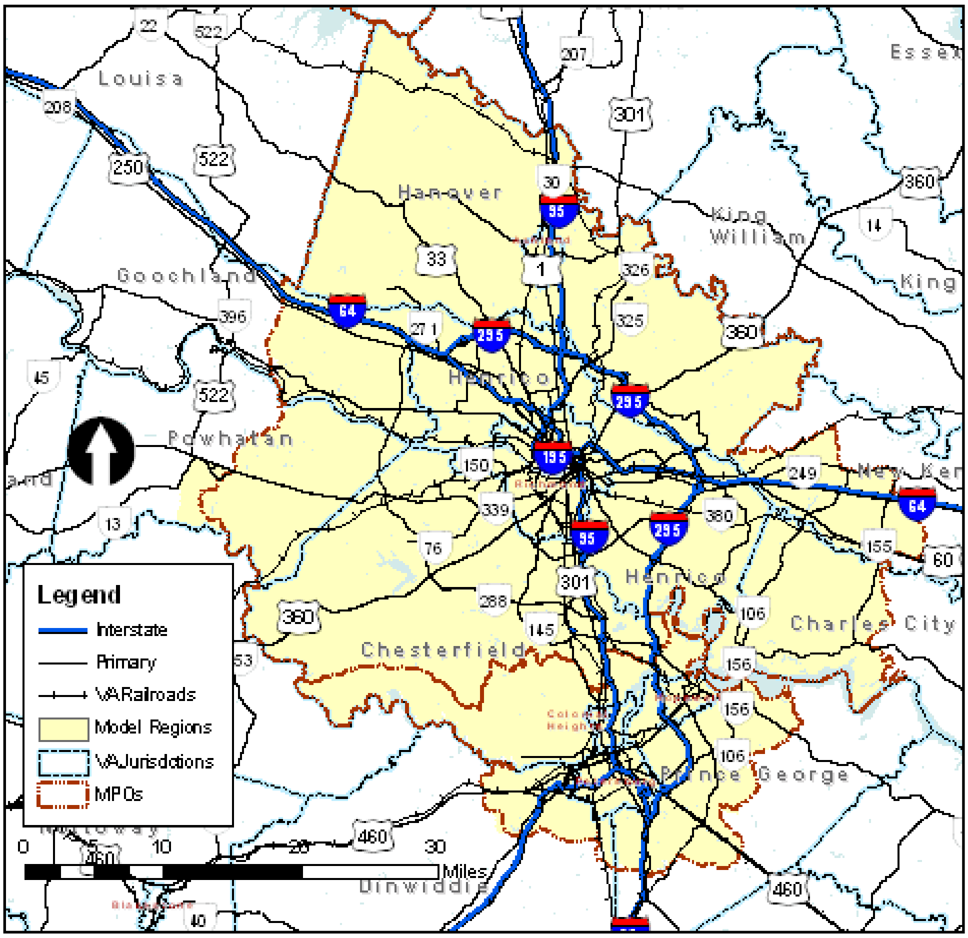


*Fig. 1* **– Map of Richmond/Tri-Cities Model Region**

## Impacts of Socioeconomic Characteristics on Tours

*Tour Descriptive Statistics*

In this paper, a tour is defined as a set of trip segments that begin and end at an individual's home, irrespective of dwell time at each stop. The correspondence between the tour codes assigned (TOURCODE) and summary trip purposes (WHYTRP1S) is shown in Table 2.

*Table 2*

**Correspondence between TOURCODE and WHYTRP1S**

| TOURCODE | WHYTRP1S |
|---|---|
| H (Home) | 01 (Home) |
| W (Work) | 10 (Work) |
| M (Maintenance) | 20 (School/Daycare/Religious activity)<br>30 (Medical/Dental services)<br>40 (Shopping/Errands)<br>60 (Family personal business/Obligations) |
| D (Discretionary) | 50 (Social/Recreational)<br>70 (Transport someone)<br>80 (Meals)<br>97 (Other reason) |
| NA (Not Applicable) | -7 (Refused)<br>-8 (Do not know) |

This study examines three simple tours (2 trips per tour) and six complex tours (>2 trips per tour). As shown in Table 3, the total number of home-anchored sample tours in the study area amounted to 5,368 tours with the following breakdown:

- Almost 60% of these tours were simple tours with the following tour purposes: Simple Maintenance (24.91%), Simple Discretionary (24.59%), and Simple Work (9.58%). Note: Simple Work used here is a generic term, including work, school, and other subsistence activities;
- For the remaining complex tour types, the most important tour purposes were: Complex Maintenance + Discretionary Only (15.03%), Complex Maintenance Only or Complex Discretionary only (14.08%). All other tour purposes were relatively less important.

Complex tours had a longer mean travel distance than simple tours. Within simple tours, Simple Work tours had a much longer mean travel distance than Simple Maintenance tours and Discretionary tours. Complex Work + Maintenance + Discretionary had the longest mean travel length due to its complicated trip chains. Generally speaking, work tours more likely use freeway system due to its longer commuting distance, whereas short-distanced maintenance tours may use local arterial streets to access neighborhood/community stores. As a result, mean speed for work-related tours is faster than that for maintenance-/discretionary-related tours. By definition, simple tours (work, maintenance, discretionary) only have two trips per tour (origin-destination and destination-origin). The most complex Type 9 tour has most trips per tour (6.26). All other complex tours have mean trips per tour ranging from 3.57 to 4.55.

*Table 3*

**Tour Classification and Descriptive Statistics for the Study Area**

| Type # | Tour type | Coding | # of tours | % of tours | Mean travel distance (miles) | Mean travel time (minutes) | Mean Speed (miles / hour) | Mean trips per tour |
|---|---|---|---|---|---|---|---|---|
| 1 | Simple Work | H-W-H | 514 | 9.58 | 25.98 | 45.84 | 34.01 | 2.00 |
| 2 | Simple Maintenance | H-M-H | 1,337 | 24.91 | 11.92 | 31.98 | 22.37 | 2.00 |
| 3 | Simple Discretionary | H-D-H | 1,320 | 24.59 | 14.22 | 33.63 | 25.37 | 2.00 |
| 4 | Complex Work Only | H-W-W-…-H | 47 | 0.88 | 74.95 | 123.40 | 36.44 | 4.55 |
| 5 | Complex Maintenance Only or Complex Discretionary Only | H-M-M-…-H or H-D-D-…-H | 756 | 14.08 | 25.48 | 57.74 | 26.48 | 3.57 |
| 6 | Complex Work + Maintenance Only | H-W-M-…-H* | 227 | 4.23 | 37.11 | 73.72 | 30.20 | 3.97 |
| 7 | Complex Work + Discretionary Only | H-W-D-…-H* | 200 | 3.73 | 41.21 | 77.37 | 31.96 | 4.00 |
| 8 | Complex Maintenance + Discretionary Only | H-M-D-…-H* | 807 | 15.03 | 57.71 | 91.62 | 37.79 | 4.43 |
| 9 | Complex Work + Maintenance + Discretionary | H-W-M-D-…-H* | 160 | 2.98 | 90.93 | 129.66 | 42.08 | 6.26 |
| Total | | | 5,368 | 100 | | | | |

Note: *Tripmaking could take place in any order

### *Tour Regression Analysis Results*

This section reports two sets of regression analysis results: aggregate level (combining all tour purposes) and tour type level. The aggregate level results combine the results of all nine tour types together, whereas tour type level results show each individual tour results one by one. Appendices 1 through 3 show the modeling results for tour frequency, tour length, and tour complexity, respectively. All significant results are bolded.

#### Aggregate Level Analysis Results

Appendix 1 indicates that variables representing household characteristics [number of drivers (DRVRCNT), median household income (HHFAMINC), household size (HHSIZE), and number of workers (WRKCOUNT)], walking modal share (WALKRATIO), and TAZ automobile density (AUTODEN) have p-values less than 0.05, therefore they are statistically significant at 0.05 levels. All of these variables positively impact tour frequency. This finding is reasonable because a household with more people, higher income level and walking modal share will take more tours. The TAZs with higher automobile density are typically located in the suburban areas with more tours.

With respect to aggregate level tour length, Appendix 2 suggests that tour length is positively related to HHFAMINC and HHVEHCNT, but negatively related to WALKRATIO, meaning higher walking modal shares are associated with shorter tour length.

High-income households tend to live in suburban areas, which will have longer commuting distance. As illustrated in Figure 2, in the Richmond/Tri-Cities Model Region, the TAZs with the longer trip times (greater than 1.3 Standard Deviations from mean travel time) are located in the outlying suburban areas, especially in the southeast corner areas, such as Prince George County, and Charles City County. Most job opportunities are concentrated in Richmond City, which is located in the central part of the study area. The closer the commuters live near Richmond City, the shorter the commuting distance, and vice versa. In the United States, due to the suburbanization movement, high-income households tend to live in suburban areas, whereas low-income households tend to live in central city areas.

As stated earlier, tour complexity is measured by trips per tour. The more trips a tour includes, the more complicated it is. High-income and more-vehicle households tend to make more stops in a tour. Households with higher automobile or walking modal shares tend to make more tours as well, but each tour is less complicated with fewer trips. HHDEN reflects land use density.

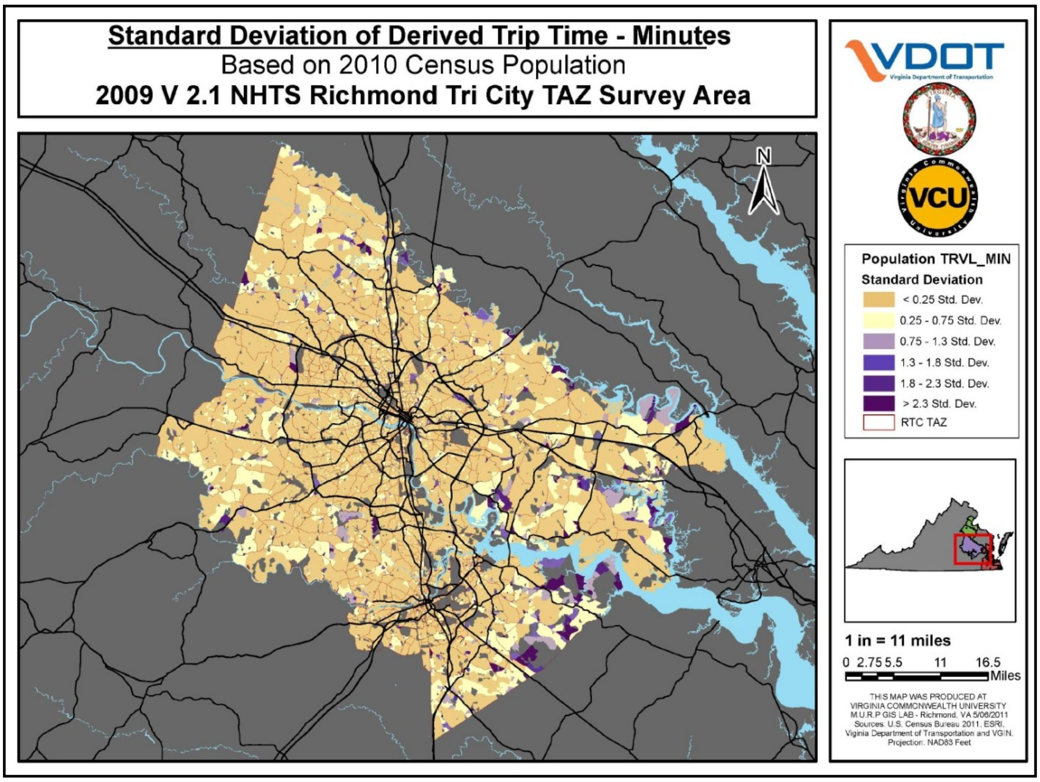


*Fig. 2* **– Standard Deviation of Derived Trip Time in the Study Area**

Higher land use density typically reduces the number of tours, but each tour has more chained trips. See Appendix 3 for details.

Zonal socioeconomic characteristics have virtually no impacts at all on aggregate level household tour-making, regardless of whether it is measured by tour frequency, tour length, or tour complexity.

## Tour Type Level Analysis Results

Having analyzed tours at an aggregate level, it is necessary to conduct a more detailed tour type level analysis, through which the relationship between each tour type's tour frequency/ length/complexity and its associated household/zonal socioeconomic characteristics can be more quantitatively estimated. See Appendices 1-3 for details. For all tour types, zonal socioeconomic characteristics also have low or no impacts on household tour-making, regardless of whether it is measured by tour frequency, tour length, or tour complexity.

### Tour Type 1: Simple Work

For Type 1 tours, no independent variable is statistically significant at 0.05 level for tour frequency. However, number of workers has a much larger impact than other variables. Therefore, there is a direct and positive linkage between number of workers and number of Simple Work tours.

With respect to its tour length, the statistically significant variables at 0.05 level are HHFAMINC (positively related) and WALKRATIO (negatively related). Those households with a higher HHFAMINC are typically located in suburban areas with longer commuting distance or tour length. A higher WALKRATIO figure implies either a lower vehicle ownership rate or a lower automobile modal share, which is typically associated with shorter tour length.

Since a Simple Work tour only has 2 constant trips for all households, no regression is run for dependent variable AVGHHTRIP1TOUR (measuring tour complexity).

### Tour Type 2: Simple Maintenance

For Type 2 tours, the only statistically significant variable at 0.05 level impacting tour frequency is household size (HHSIZE). Household size positively impacts the number of Simple Maintenance tours made. A larger household needs more shopping and other maintenance trips to meet everyone's needs.

Type 2 tour length is negatively impacted by WALKRATIO for the similar reasons as those of Type 1 tour. Since a Simple Maintenance tour only has 2 constant trips for all households, no regression is run for dependent variable AVGHHTRIP1TOUR (measuring tour complexity).

### Tour Type 3: Simple Discretionary

Type 3 tour frequency is significantly impacted by HHFAMINC (positively related), HHSIZE (positively related), and WRKCOUNT (negatively related). It is reasonable for a higher-income and larger-sized household to make more discretionary trips (e.g. leisure and entertainment). In contrast, a household with more workers tends to make more commuting trips and thus less discretionary trips.

Type 3 tour length is negatively impacted by WALKRATIO, which is similar to both Type 1 and Type 2 tours. Since a Simple Discretionary tour only has 2 constant trips for all households, no regression is run for dependent variable AVGHHTRIP1TOUR (measuring tour complexity).

Tour Type 4: Complex Work Only

It is worth noting that no variables significantly impact Type 4 tour frequency and tour length. Only household density (HHDEN) negatively impacts tour complexity. This suggests that Complex Work Only tours are perhaps impacted by other unknown variables yet to be included in future regression model runs with expanded IVs.

Tour Type 5: Complex Maintenance Only or Complex Discretionary Only

Similarly, no variables significantly impact Type 5 tour frequency for unknown reasons. But number of adults and total employment density significantly affect its tour length. Household size negatively impacts tour complexity.

Tour Type 6: Complex Work + Maintenance Only

For Tour Type 6, no variables significantly impact its tour frequency for unknown reasons. However, household size positively impacts its tour length, and number of vehicles positively impacts its tour complexity.

Tour Type 7: Complex Work + Discretionary Only

For Tour Type 7, only walking modal share significantly impacts its tour complexity in a positive way.

Tour Type 8: Complex Maintenance + Discretionary Only

For Tour Type 8, household size positively impacts its tour frequency. The number of vehicles positively affects its tour complexity.

Tour Type 9: Complex Work + Maintenance + Discretionary

For the most complicated Tour Type 9, its tour frequency is significantly impacted by number of workers in a negative way.

## Discussion

This study conducts a preliminary statistical analysis to examine the relationship between household/zonal socioeconomic characteristics (Note: TAZ-level household automobile and walking modal shares are included as independent variables) and tour making.

It is appropriate to use Poisson regression for modeling tour frequency and use OLS regression for modeling tour length and tour complexity. Independent variables adequately describe both household and zonal socioeconomic characteristics. This treatment is based on the assumption that a household's tour making should be directly impacted by household socioeconomic characteristics, but may also be impacted by its surrounding neighborhood's land use patterns. Higher land use densities tend to lower a household's trip rates (Leinbach 2004). Therefore, it is worthwhile to test the validity of this assumption.

The completed regression model runs have yielded pretty reasonable results for all simple tours (work, maintenance, and discretionary). However, their validity in explaining complex tours seems relatively limited. It is very likely that many unknown yet important variables are yet to be included in regression equations.

## Conclusions

This paper documents the research results from the 2009 Virginia NHTS Add-On Program for the Richmond/Tri-Cities Model Region. It statistically assesses the impacts of household/zonal socioeconomic characteristics on tour making within the study area. Overall, household socio-economic characteristics have direct and large impacts on household tour-making, through the direction and degree of these impacts that vary by tour types. However, zonal socioeconomic characteristics have very low or no impacts on household tour-making.

Through this empirical study, it has also been found that:

- Almost 60% of the sampled tours in the study area were simple tours, especially maintenance and discretionary tours. Other important complex tour types include Complex Maintenance + Discretionary Only, Complex Maintenance Only or Complex Discretionary Only tours;

- For simple tours, work purpose had a much longer mean travel distance than maintenance and discretionary purposes. Complex tours had a much longer mean travel distance than simple tours. The Complex Work + Maintenance + Discretionary had the longest travel distance due to its complicated trip chains;

- At aggregate level, number of drivers, median household income, household size, and number of workers and walking modal share are statistically significant and positively impact tour frequency. Tour length is positively related to household income and number of vehicles;

- At tour type level, for Tour Type 1, no independent variable is statistically significant for its frequency, even though number of workers seems to have a larger impact. With respect to Type 1 tour length, statistically significant variables are HHFAMINC (positively related) and WALKRATIO (negatively related);

- For Tour Type 2, the only statistically significant variable impacting tour frequency is household size (HHSIZE). Household size positively impacts the number of Simple Maintenance tours made. Its tour length is significantly impacted by WALKRATIO in a negative way;

- Tour Type 3 frequency is significantly impacted by HHFAMINC (positively related), HHSIZE (positively related), and WRKCOUNT (negatively related). A household with more workers tends to make more commuting tours and less discretionary (recreational or entertainment) tours. Type 3 tour length is negatively impacted by walking modal share.

In spite of the above useful findings, it should also be pointed out that this study still has several limitations due to data scarcity and other reasons. For example, this statistical analysis has not taken a look at survey respondents' activity schedules, activity coordination among household members, time and space constraints, in-home activities, and others. Using a statistical tool also has its inherent weakness: correlation does not mean causality. Those IVs may not definitely have causal relationships with DVs. Therefore, there is still room for further modelling improvement to better simulating travelers' activities and tours.

**Appendix 1**

**Regression Model Results for Tour Frequency (AGGHHFREQ)**

| Parameter | Aggregate Tour: n=1751, AIC=6386.0131 | | | Tour Type 1: Simple Work: n=430, AIC=988.7826 | | | Tour Type 2: Simple Maintenance: n=787, AIC=2216.3955 | | | Tour Type 3: Simple Discretionary: n=709, , AIC=2150.0097 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | Wald ChiSq | Pr > ChiSq | Estimate | Wald ChiSq | Pr > ChiSq | Estimate | Wald ChiSq | Pr > ChiSq | Estimate | Wald ChiSq | Pr > ChiSq |
| Intercept | -0.0420 | 0.16 | 0.6869 | -0.0616 | 0.03 | 0.8595 | -0.0427 | 0.04 | 0.8327 | -0.2142 | 0.94 | 0.3322 |
| DRVRCNT | **0.0952** | **7.60** | **0.0058** | -0.0331 | 0.07 | 0.7892 | 0.0055 | 0.01 | 0.9327 | -0.028 | 0.17 | 0.6845 |
| HHFAMINC | **0.0143** | **20.10** | **<.0001** | -0.0006 | 0 | 0.9567 | -0.0014 | 0.05 | 0.8211 | **0.0165** | **6.16** | **0.013** |
| HHSIZE | **0.2698** | **423.60** | **<.0001** | -0.0281 | 0.26 | 0.6127 | **0.1746** | **44.96** | **<.0001** | **0.1961** | **66.21** | **<.0001** |
| HHVEHCNT | -0.0215 | 1.77 | 0.1839 | -0.0029 | 0 | 0.9491 | -0.0419 | 1.46 | 0.2277 | -0.0047 | 0.02 | 0.8969 |
| NUMADLT | -0.0566 | 2.70 | 0.1004 | 0.062 | 0.29 | 0.5933 | 0.0371 | 0.35 | 0.5566 | -0.0273 | 0.16 | 0.6925 |
| WRKCOUNT | **0.0463** | **6.10** | **0.0135** | 0.1492 | 3.38 | 0.0662 | -0.017 | 0.21 | 0.6489 | **-0.0781** | **4.27** | **0.0389** |
| CARRATIO | 0.0125 | 0.12 | 0.7336 | -0.0532 | 0.3 | 0.5811 | 0.0833 | 1.65 | 0.1985 | 0.0206 | 0.09 | 0.7651 |
| WALKRATIO | **0.1914** | **6.08** | **0.0137** | -0.1114 | 0.09 | 0.7615 | 0.1065 | 0.97 | 0.3242 | -0.1417 | 2.91 | 0.088 |
| AVGAUTO | 0.0278 | 0.68 | 0.4100 | 0.0173 | 0.02 | 0.8751 | 0.0219 | 0.11 | 0.7426 | 0.0838 | 1.34 | 0.247 |
| POPDEN | -0.0000 | 0.52 | 0.4698 | 0 | 0.07 | 0.793 | 0 | 0.18 | 0.6738 | 0 | 0 | 0.9683 |
| HHDEN | -0.0000 | 0.12 | 0.7308 | -0.0001 | 0.08 | 0.7723 | 0 | 0.04 | 0.8429 | 0 | 0.03 | 0.8705 |
| AUTODEN | **0.0001** | **10.91** | **0.0010** | 0 | 0 | 0.9639 | 0.0001 | 1.24 | 0.2645 | 0.0001 | 1.23 | 0.2675 |
| TEMPDEN | 0.0000 | 0.05 | 0.8210 | 0 | 0.59 | 0.444 | 0 | 0.02 | 0.894 | 0 | 0 | 0.9472 |

**Appendix 1**

**Regression Model Results for Tour Frequency (AGGHHFREQ)**

| Parameter | Aggregate Tour: n=1751, AIC=6386.0131 | | | Tour Type 1: Simple Work: n=430, AIC=988.7826 | | | Tour Type 2: Simple Maintenance: n=787, AIC=2216.3955 | | | Tour Type 3: Simple Discretionary: n=709, , AIC=2150.0097 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | Wald ChiSq | Pr > ChiSq | Estimate | Wald ChiSq | Pr > ChiSq | Estimate | Wald ChiSq | Pr > ChiSq | Estimate | Wald ChiSq | Pr > ChiSq |
| Intercept | -0.0420 | 0.16 | 0.6869 | -0.0616 | 0.03 | 0.8595 | -0.0427 | 0.04 | 0.8327 | -0.2142 | 0.94 | 0.3322 |
| DRVRCNT | **0.0952** | **7.60** | **0.0058** | -0.0331 | 0.07 | 0.7892 | 0.0055 | 0.01 | 0.9327 | -0.028 | 0.17 | 0.6845 |
| HHFAMINC | **0.0143** | **20.10** | **<.0001** | -0.0006 | 0 | 0.9567 | -0.0014 | 0.05 | 0.8211 | **0.0165** | **6.16** | **0.013** |
| HHSIZE | **0.2698** | **423.60** | **<.0001** | -0.0281 | 0.26 | 0.6127 | **0.1746** | **44.96** | **<.0001** | **0.1961** | **66.21** | **<.0001** |
| HHVEHCNT | -0.0215 | 1.77 | 0.1839 | -0.0029 | 0 | 0.9491 | -0.0419 | 1.46 | 0.2277 | -0.0047 | 0.02 | 0.8969 |
| NUMADLT | -0.0566 | 2.70 | 0.1004 | 0.062 | 0.29 | 0.5933 | 0.0371 | 0.35 | 0.5566 | -0.0273 | 0.16 | 0.6925 |
| WRKCOUNT | **0.0463** | **6.10** | **0.0135** | 0.1492 | 3.38 | 0.0662 | -0.017 | 0.21 | 0.6489 | **-0.0781** | **4.27** | **0.0389** |
| CARRATIO | 0.0125 | 0.12 | 0.7336 | -0.0532 | 0.3 | 0.5811 | 0.0833 | 1.65 | 0.1985 | 0.0206 | 0.09 | 0.7651 |
| WALKRATIO | **0.1914** | **6.08** | **0.0137** | -0.1114 | 0.09 | 0.7615 | 0.1065 | 0.97 | 0.3242 | -0.1417 | 2.91 | 0.088 |
| AVGAUTO | 0.0278 | 0.68 | 0.4100 | 0.0173 | 0.02 | 0.8751 | 0.0219 | 0.11 | 0.7426 | 0.0838 | 1.34 | 0.247 |
| POPDEN | -0.0000 | 0.52 | 0.4698 | 0 | 0.07 | 0.793 | 0 | 0.18 | 0.6738 | 0 | 0 | 0.9683 |
| HHDEN | -0.0000 | 0.12 | 0.7308 | -0.0001 | 0.08 | 0.7723 | 0 | 0.04 | 0.8429 | 0 | 0.03 | 0.8705 |
| AUTODEN | **0.0001** | **10.91** | **0.0010** | 0 | 0 | 0.9639 | 0.0001 | 1.24 | 0.2645 | 0.0001 | 1.23 | 0.2675 |
| TEMPDEN | 0.0000 | 0.05 | 0.8210 | 0 | 0.59 | 0.444 | 0 | 0.02 | 0.894 | 0 | 0 | 0.9472 |

## Appendix 2

### Regression Model Results for Tour Length (AVGHHMIL)

| Parameter | Aggregate Tour: n=1751, R-Square= 0.0220 | | | Tour Type 1: Simple Work: n=430, R-Square=0.0825 | | | Tour Type 2: Simple Maintenance: n=787, R-Square=0.0820 | | | Tour Type 3: Simple Discretionary: n=709, R-Square=0.1052 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| |
| Intercept | 33.58632 | 2.56 | 0.0105 | 11.40361 | 1.16 | 0.2482 | 9.24135 | 2.35 | 0.0191 | **14.81022** | **1.99** | **0.0471** |
| DRVRCNT | -7.06202 | -1.39 | 0.1659 | -6.72375 | -1.89 | 0.0589 | 0.22572 | 0.17 | 0.8681 | -4.23501 | -1.65 | 0.0992 |
| HHFAMINC | **1.01089** | **2.41** | **0.0159** | **0.78375** | **2.55** | **0.0112** | -0.00547 | -0.04 | 0.9652 | -0.04038 | -0.18 | 0.8597 |
| HHSIZE | 1.17675 | 0.52 | 0.6034 | 2.93739 | 1.84 | 0.066 | -0.03425 | -0.06 | 0.9542 | -0.48317 | -0.48 | 0.6321 |
| HHVEHCNT | **4.51158** | **2.09** | **0.0364** | 0.39208 | 0.29 | 0.7705 | 0.29241 | 0.44 | 0.6632 | -0.0674 | -0.05 | 0.9583 |
| NUMADLT | 2.16702 | 0.42 | 0.6739 | 0.06005 | 0.02 | 0.9858 | 1.18491 | 0.88 | 0.3808 | 4.97233 | 1.95 | 0.0513 |
| WRKCOUNT | 0.95162 | 0.36 | 0.7156 | 0.86416 | 0.37 | 0.71 | -0.0119 | -0.02 | 0.9875 | 1.30089 | 0.95 | 0.3421 |
| CARRATIO | -7.20070 | -1.51 | 0.1304 | 0.03137 | 0.01 | 0.991 | 1.02537 | 0.81 | 0.4197 | 0.3386 | 0.14 | 0.8903 |
| WALKRATIO | **-34.08735** | **-3.24** | **0.0012** | **-21.1185** | **-2.12** | **0.0347** | **-9.87843** | **-4.58** | **<.0001** | **-18.0808** | **-6.3** | **<.0001** |
| AVGAUTO | -4.03921 | -0.92 | 0.3551 | 5.29112 | 1.68 | 0.0935 | 1.49347 | 1.14 | 0.2534 | 3.49921 | 1.41 | 0.16 |
| POPDEN | -0.00336 | -0.85 | 0.3961 | 0.00077 | 0.25 | 0.8005 | -0.0013 | -1.13 | 0.258 | 0.000826 | 0.39 | 0.6988 |
| HHDEN | 0.00709 | 1.02 | 0.3065 | 0.00261 | 0.53 | 0.5949 | **0.00515** | **2.06** | **0.0393** | 0.0022 | 0.56 | 0.5769 |
| AUTODEN | -0.00169 | -0.53 | 0.5944 | -0.00431 | -1.62 | 0.1068 | **-0.003** | **-2.94** | **0.0033** | **-0.00382** | **-2.07** | **0.0386** |
| TEMPDEN | -0.00199 | -1.53 | 0.1254 | -0.00159 | -1.34 | 0.1812 | -0.00071 | -1.89 | 0.0596 | **-0.00139** | **-2.01** | **0.045** |

## Appendix 2

### Regression Model Results for Tour Length (AVGHHMIL), Continuation

| Parameter | Tour Type 4: Complex Work Only: n=46, R-Square=0.2645 | | | Tour Type 5: Complex Maintenance Only or Complex Discretionary Only: n=519, R-Square=0.0381 | | | Tour Type 6: Complex Work + Maintenance Only: n=206, R-Square=0.1189 | | | Tour Type 7: Complex Work + Discretionary Only: n=180, R-Square=0.1008 | | | Tour Type 8: Complex Maintenance + Discretionary Only: n=526, R-Square=0.0225 | | | Tour Type 9: Complex Work + Maintenance + Discretionary: n=142, R-Square=0.1009 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| |
| Intercept | 174.5045 | 1.58 | 0.1241 | 23.75173 | 1.93 | 0.0545 | 26.86737 | 1.46 | 0.1465 | 59.39362 | 2.3 | 0.0226 | 32.41398 | 0.82 | 0.4099 | 185.81409 | 1.6 | 0.1119 |
| DRVRCNT | 33.63847 | 0.98 | 0.3328 | -3.28275 | -0.8 | 0.4232 | -7.0280 | -0.9 | 0.3668 | 1.5516 | 0.2 | 0.8413 | -5.6070 | -0.38 | 0.7077 | 21.97799 | 0.5400 | 0.5893 |
| HHFAMINC | -2.73375 | -1.03 | 0.3119 | 0.25672 | 0.65 | 0.5128 | 0.5707 | 0.95 | 0.3418 | -0.0243 | -0.03 | 0.9777 | 1.3062 | 1.06 | 0.2909 | 6.38636 | 1.5100 | 0.1324 |
| HHSIZE | 14.68228 | 1.16 | 0.2528 | -1.04981 | -0.57 | 0.5708 | **10.0830** | **3.19** | **0.0017** | 2.5408 | 0.77 | 0.4406 | -1.0087 | -0.16 | 0.8736 | 16.78404 | 0.9100 | 0.3667 |
| HHVEHCNT | 8.43845 | 0.7 | 0.4881 | -2.50985 | -1.22 | 0.2222 | 1.0840 | 0.3 | 0.7635 | 2.2094 | 0.65 | 0.5175 | **12.4521** | **2.27** | **0.0235** | -13.22037 | -0.7600 | 0.447 |
| NUMADLT | -50.0034 | -1.8 | 0.0815 | **10.2948** | **2.44** | **0.015** | -4.5946 | -0.67 | 0.5017 | -8.1816 | -0.99 | 0.326 | -0.8819 | -0.06 | 0.9543 | 26.60249 | 0.6000 | 0.5517 |
| WRKCOUNT | -12.8596 | -0.65 | 0.52 | 3.48898 | 1.53 | 0.1264 | -2.1798 | -0.45 | 0.6514 | -6.1048 | -1.25 | 0.2146 | -2.2601 | -0.3 | 0.7655 | **-55.64586** | **-1.9800** | **0.0497** |
| CARRATIO | 25.4572 | 1.11 | 0.2736 | 0.20393 | 0.05 | 0.9569 | -5.5645 | -1.03 | 0.3039 | -0.7014 | -0.11 | 0.9148 | -18.6078 | -1.51 | 0.1324 | -49.86878 | -1.2600 | 0.2103 |
| WALKRATIO | 0 | n/a | n/a | -10.1942 | -0.75 | 0.4547 | -14.5219 | -0.66 | 0.5091 | 6.6285 | 0.37 | 0.7127 | -20.0410 | -0.35 | 0.7275 | -176.60795 | -1.5800 | 0.1166 |
| AVGAUTO | -24.7752 | -0.66 | 0.5117 | -3.10404 | -0.77 | 0.4437 | 5.2091 | 0.89 | 0.3759 | 2.0713 | 0.27 | 0.7877 | -1.9494 | -0.15 | 0.8788 | -54.10520 | -1.2900 | 0.2011 |
| POPDEN | -0.01511 | -0.18 | 0.861 | -0.00291 | -0.68 | 0.4961 | **0.0020** | 0.32 | 0.7478 | -0.0058 | -0.62 | 0.5339 | -0.0045 | -0.39 | 0.6933 | -0.02975 | -0.7700 | 0.4437 |
| HHDEN | -0.01696 | -0.15 | 0.8852 | 0.00239 | 0.36 | 0.7175 | **-0.0014** | -0.15 | 0.8814 | 0.0082 | 0.6 | 0.548 | 0.0087 | 0.45 | 0.6536 | 0.06276 | 0.9300 | 0.3541 |
| AUTODEN | 0.01466 | 0.22 | 0.8303 | 0.0015 | 0.57 | 0.5679 | **-0.0049** | -1.41 | 0.1604 | -0.0025 | -0.35 | 0.7276 | 0.0011 | 0.14 | 0.8908 | -0.02206 | -0.5700 | 0.568 |
| TEMPDEN | -0.01407 | -0.55 | 0.5892 | **-0.00284** | **-2.2** | **0.0286** | **-0.0009** | -0.64 | 0.5238 | -0.0026 | -1.55 | 0.1239 | -0.0004 | -0.1 | 0.9204 | -0.00563 | -0.5200 | 0.6062 |

**Appendix 3**

**Regression Model Results for Tour Complexity (AVGHHTRIP1TOUR)**

| Parameter | Aggregate Tour: n=1751, R-Square= 0.0352 | | | Tour Type 1: Simple Work: n=430, R-Square=n/a | | | Tour Type 2: Simple Maintenance: n=787, R-Square=n/a | | | Tour Type 3: Simple Discretionary: n=709, R-Square=n/a | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| |
| Intercept | 3.40887 | 15.56 | <.0001 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| DRVRCNT | -0.13184 | -1.55 | 0.1215 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| HHFAMINC | **0.02273** | **3.25** | **0.0012** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| HHSIZE | -0.07237 | -1.91 | 0.0559 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| HHVEHCNT | **0.10232** | **2.84** | **0.0045** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| NUMADLT | -0.05163 | -0.60 | 0.5484 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| WRKCOUNT | 0.01590 | 0.36 | 0.7156 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| CARRATIO | **-0.16526** | **-2.08** | **0.0378** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| WALKRATIO | **-0.77038** | **-4.38** | **<.0001** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| AVGAUTO | -0.06629 | -0.91 | 0.3636 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| POPDEN | -0.00012635 | -1.91 | 0.0561 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| HHDEN | **0.00028704** | **2.48** | **0.0133** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| AUTODEN | -0.00004032 | -0.76 | 0.4457 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| TEMPDEN | -0.00002298 | -1.06 | 0.2903 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

**Appendix 3**

**Regression Model Results for Tour Complexity (AVGHHTRIP1TOUR), Continuation**

| Parameter | Tour Type 4: Complex Work Only: n=46, R-Square=0.3167 | | | Tour Type 5: Complex Maintenance Only or Complex Discretionary Only: n=519, R-Square=0.0384 | | | Tour Type 6: Complex Work + Maintenance Only: n=206, R-Square=0.0859 | | | Tour Type 7: Complex Work + Discretionary Only: n=180, R-Square=0.1239 | | | Tour Type 8: Complex Maintenance + Discretionary Only: n=526, R-Square=0.0416 | | | Tour Type 9: Complex Work + Maintenance + Discretionary: n=142, R-Square=0.0998 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| | Estimate | t value | Pr > \|t\| |
| Intercept | 2.32371 | 0.85 | 0.3998 | 3.6463 | 11.88 | <.0001 | 4.21267 | 6.52 | <.0001 | 4.14517 | 5.49 | <.0001 | 4.8582 | 9.58 | <.0001 | 7.76178 | 6.5 | <.0001 |
| DRVRCNT | 1.02286 | 1.21 | 0.2337 | -0.0903 | -0.89 | 0.3764 | -0.4127 | -1.51 | 0.1314 | -0.2997 | -1.32 | 0.1874 | -0.2249 | -1.17 | 0.2443 | -0.43175 | -1.0300 | 0.3031 |
| HHFAMINC | 0.04074 | 0.62 | 0.5387 | -0.0026 | -0.27 | 0.7868 | 0.0324 | 1.54 | 0.1244 | 0.0358 | 1.4 | 0.1622 | 0.0183 | 1.15 | 0.2508 | 0.00793 | 0.1800 | 0.8552 |
| HHSIZE | -0.4304 | -1.38 | 0.1754 | **-0.0908** | **-1.97** | **0.0496** | 0.0119 | 0.11 | 0.9145 | -0.1074 | -1.12 | 0.2656 | 0.0084 | 0.1 | 0.9182 | 0.20906 | 1.1000 | 0.2745 |
| HHVEHCNT | 0.09442 | 0.32 | 0.7521 | -0.0603 | -1.18 | 0.2392 | **0.3734** | **2.96** | **0.0035** | 0.1267 | 1.27 | 0.2054 | 0.1238 | 1.75 | 0.0806 | 0.14661 | 0.8200 | 0.4122 |
| NUMADLT | -0.8273 | -1.21 | 0.2361 | 0.1602 | 1.53 | 0.1277 | -0.0768 | -0.32 | 0.7488 | 0.3076 | 1.27 | 0.2074 | 0.0236 | 0.12 | 0.9057 | 0.06925 | 0.1500 | 0.8801 |
| WRKCOUNT | -0.14504 | -0.3 | 0.7678 | 0.1078 | 1.9 | 0.0583 | -0.0317 | -0.19 | 0.8512 | -0.2521 | -1.76 | 0.0805 | -0.1503 | -1.54 | 0.1248 | -0.28617 | -0.9900 | 0.3235 |
| CARRATIO | 0.27108 | 0.48 | 0.6336 | 0.1592 | 1.7 | 0.0905 | -0.0376 | -0.2 | 0.8428 | -0.0513 | -0.27 | 0.7891 | -0.2354 | -1.48 | 0.1404 | -0.20511 | -0.5000 | 0.6153 |
| WALKRATIO | 0 | n/a | n/a | 0.1539 | 0.45 | 0.6505 | 0.7915 | 1.03 | 0.3052 | **1.5434** | **2.94** | **0.0038** | 1.0847 | 1.46 | 0.1444 | 0.98720 | 0.8600 | 0.392 |
| AVGAUTO | 0.76569 | 0.83 | 0.4113 | 0.0432 | 0.43 | 0.6688 | -0.2318 | -1.13 | 0.2614 | -0.1226 | -0.55 | 0.5862 | -0.0738 | -0.45 | 0.6548 | -0.31769 | -0.7300 | 0.4643 |
| POPDEN | 0.00359 | 1.7 | 0.0985 | -0.0002 | -1.95 | 0.0522 | -0.0002 | -0.99 | 0.3252 | -0.0004 | -1.6 | 0.1119 | -0.0002 | -1.63 | 0.1044 | -0.00001 | -0.0200 | 0.9801 |
| HHDEN | **-0.00635** | **-2.21** | **0.0342** | 0.0002 | 1.39 | 0.1655 | 0.0002 | 0.66 | 0.5111 | 0.0005 | 1.27 | 0.2058 | 0.0004 | 1.6 | 0.111 | 0.00044 | 0.6300 | 0.5267 |
| AUTODEN | -0.00089 | -0.53 | 0.5994 | 0.0001 | 1.59 | 0.1124 | 0.0001 | 1.19 | 0.2357 | 0.0002 | 1.07 | 0.2844 | 0.0000 | 0.17 | 0.8631 | -0.00059 | -1.4800 | 0.1419 |
| TEMPDEN | -0.00056 | -0.88 | 0.3859 | 0.0000 | 0.01 | 0.9919 | 0.0000 | -0.51 | 0.6092 | 0.0000 | 0.52 | 0.6033 | -0.0001 | -1.96 | 0.0501 | -0.00009 | -0.8400 | 0.4051 |

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*Correspondence:* Virginia Commonwealth University, 821 West Franklin Street, Richmond, VA 23284, United States

E-mail: xchen2@vcu.edu

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# URBAN FOOTPRINT OF MUMBAI - THE COMMERCIAL CAPITAL OF INDIA

*T. V.* **RAMACHANDRA**[1,2,3], *H. A.* **BHARATH**[1,2], *M. V.* **SOWMYASHREE**[1]
[1]Energy & Wetlands Research Group, Center for Ecological Sciences (CES)
[2]Centre for Sustainable Technologies (Astra)
[3]Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP) Indian Institute of Science, Bangalore, Karnataka, India

**Abstract:** Urban footprint refers to the proportion of paved surface (built up, roads, etc.) with the reduction of other land use types in a region. Rapid increase in the urban areas is the major driver in landscape dynamics with the significant erosion in the quality and quantity of the natural ecosystems. The urban expansion process hence needs to be monitored, quantified and understood for effective planning and the sustainable management of natural resources. Cities and towns have been experiencing considerable growth in urban area, population size, social aspects, negative environmental and geographical influence, and complexity. Mumbai, the commercial capital of India, has experienced a spurt in infrastructural and industrial activities with globalization and opening up of Indian markets. Unplanned urbanization has resulted in dispersed growth in peri-urban pockets due to socio-economic aspects with the burgeoning population of the city. Consequent to this, there has been an uneven growth pattern apart from the increase in slums in and around the city. This has necessitated the understanding of the urbanization pattern and process focusing especially on the expanding geographical area, its geometry and the spatial pattern of its development. This communication discusses the urban footprint dynamics of Mumbai using multi-temporal remote sensing data with spatial metrics. Land use analysis indicated a decrease of vegetation by 20% with an increase in urban extent by 155% during the last three decades. Landscape metrics aided in assessing the spatial structure and composition of the urban footprints through the zonal analysis by dividing the region into four zones with concentric circles of 1 km incrementing radius from the city centre. The study reveals a significant variation in the composition of the urban patch dynamics with increasing complexity and aggregation of urban area at the centre and sprawl at the outskirts. Shannon's entropy further confirms of sprawl with time. Further zoning with the circular gradients aided in understanding the transition process of land use categories into urban patch.

**Key Words:** *urbanization, urban sprawl, urban pattern, remote sensing, spatial metrics, Mumbai*

## Introduction

Urbanization involves transformation of various land uses into urban areas. Unplanned and uncontrolled urban expansion leads to environmental degradation causing shortages of housing, worsening water quality, excessive air pollution, improper waste management etc. (Ramachandra et al. 2012, Uttara et al. 2012). The process of urbanization has a major impact on the land use patterns, affecting functional aspects of the landscape (Hara et al. 2005, Frohn and Hao 2006), including the process of waste assimilation. This necessitates mapping and monitoring of urban footprint through quantification of paved surface (built up, roads, etc.). The proportion of paved surface (built up, roads, etc.) with the reduction of other land use types in a region is referred as urban footprint. A concentrated growth of urban footprint often leads to the dispersed growth or urban sprawl at outskirts. Urban sprawl is often referred to as uncontrolled, scattered sub-urban development which lacks basic amenities such as treated water supply, sanitation, infrastructure, etc. with serious implications on local ecology and environment (Peiser 2001, Yedla 2003, Sudhira et al. 2004, Huang et al. 2008, Ramachandra et al. 2012, Bharath et al. 2012). Advanced understanding and visualization of sprawl helps in better regional planning with appropriate basic infrastructure and amenities (like supply of treated water, electricity, sanitation facilities). These regions are often left out of most of the governmental surveys (ex: national population census) as these pockets are not grouped under either urban or rural areas. The understanding of sprawl dynamics is very crucial to provide better governance with basic amenities and it also balances the provision of natural resources and human needs through visualized and orderly regional planning. Urban sprawl was evaluated and characterized exclusively based on major socio-economic indicators such as population growth, commuting costs, employment shifts, city revenue change, and number of commercial establishments (Han and He 1999, Brueckner 2000, Lucy and Phillips 2000, Lin and Ho 2003, Lichtenberg and Ding 2008). However, these approaches do not identify and quantify the impacts of urban sprawl in a spatial context that is required for local area planning.

Availability of temporal remotely sensed data acquired through space-borne sensors helps detecting the urban landscape dynamics in relation to urbanization (Chen et al. 2000, Epstein et al. 2002, Lo and Yang 2002, Ji et al. 2001, Lo and Yang 2002, Yeh and Li 2001, Sudhira et al. 2003, Ramachandra et al. 2012). This aids in characterizing the spatiotemporal trends of urbanization process and sprawl (Zerah 2008). Computation of metrics and modelling based on multi temporal spatial data provides a basis for predicting urbanization processes. This information supports policy making for an effective urban planning with natural resources conservation. Further temporal dynamics information with spatial metrics provides insights to the urbanization pattern (i.e., property, complexity and size of the existing urban area), which helps the sustainable regional development (Hill et al. 2004, DeFries 2008, Bhatta 2009a, 2009b, Ramachandra et al. 2012).

Urban pattern analysis provides the spatial properties and configuration of the area at a particular time (Galster et al. 2001) as urban patterns deal with the physical structure and the spatial characteristics of the urban processes that vary over time (Aguilera et al. 2011). Urban patterns have been analysed using spatial metrics (Jiang et al. 2007, Angel et al. 2007, Bharath et al. 2012, Ramachandra et al. 2012). Spatial metrics are useful in detecting the evolution of the urban sprawl pattern with time. These metrics, developed for thematic categorical maps, are applicable to a particular scale and resolution (Herold et al. 2003). Spatial metrics concepts are mostly used in the landscape ecology, but recently, it is being applied in the urban environments for mapping the urban process and structure (Alberti and Waddell 2000, Herold et al. 2002). Further, to understand, to locate and to quantify the specific areas of sprawl, density gradients (Ramachandra et al. 2012) are potentially useful in quantifying the urban development. The combination of remote sensing, density gradients and spatial metrics techniques provides an accurate and detailed mapping of the data which are immensely useful in urban applications (Ji et al. 2006, Ramachandra et al. 2012, Weng 2012). This communication is based on the potential of remote sensing, density gradients and spatial metrics for understanding the urban sprawl including the direction of growth. This paper is subdivided into four sections. The first section outlines the study area and data, the second section focuses on the methods used for understanding urban dynamics and the final section presents the results and conclusion.

## Study area

Mumbai is the capital of the Indian state of Maharashtra. It is located at 18°55'N and 72°50' E and it is bounded by the Arabian Sea in the west. It is the most populous city in India, and the sixth most populous city in the world and it is also considered as the commercial capital of India that serves as an economic hub of India. In the last three decades, the city saw tremendous growth in the infrastructure development and urban expansion. Mumbai has a population density of 4583 persons per square kilometre (Census of India 2001). Mumbai urban agglomeration is ranked third after Tokyo and Mexico City. The city started experiencing urbanization and industrial expansion during the 1860s, which gradually led to the rise of more urban areas. Mumbai is formed of seven islands and the expansion of Mumbai resulted in the bulging of the islands causing a scarcity of land. The study has been carried out for Mumbai city considering a 10 km buffer (Fig. 1).

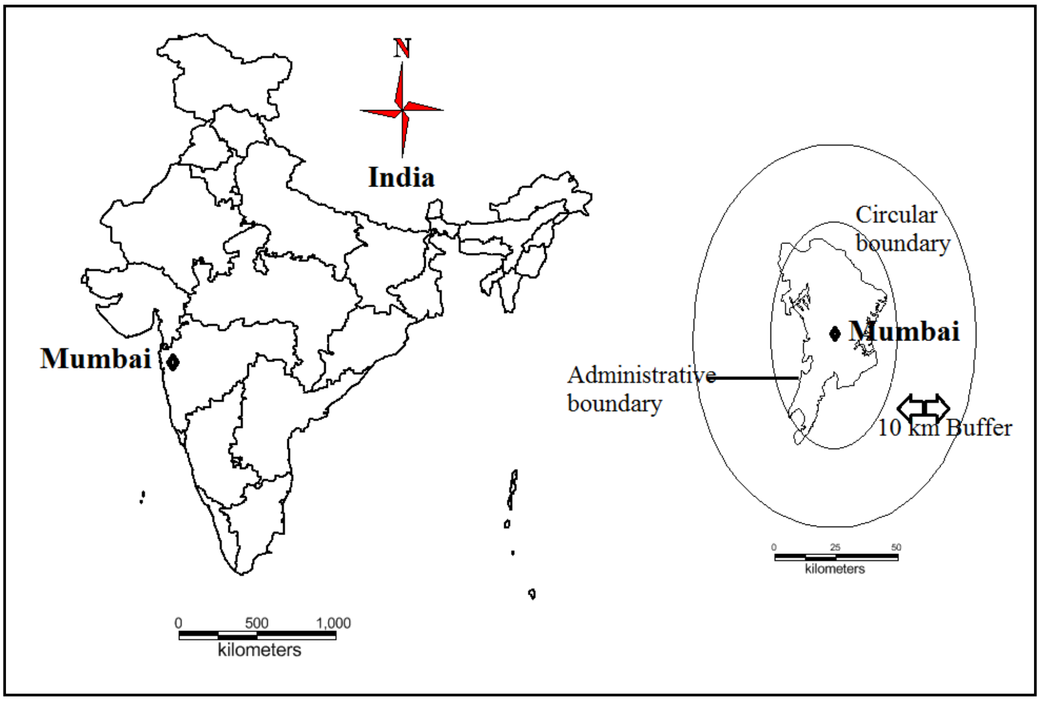


*Fig. 1* – **Study area: Mumbai with 10 km buffer**

*Demography and Economy*

Mumbai is the most populous city and a cosmopolitan megacity of India. It is also considered the business capital of India because of its large trading activities. According to the 2011 census, Mumbai's population was about 12 million. Figure 2 depicts the temporal decadal population since 1901. Table 1 lists the geographical area, population and population density during the past four decades. In the beginning of 1990, the city experienced a major growth in the development of manufacturing industries and service sector industries, such finance, mass

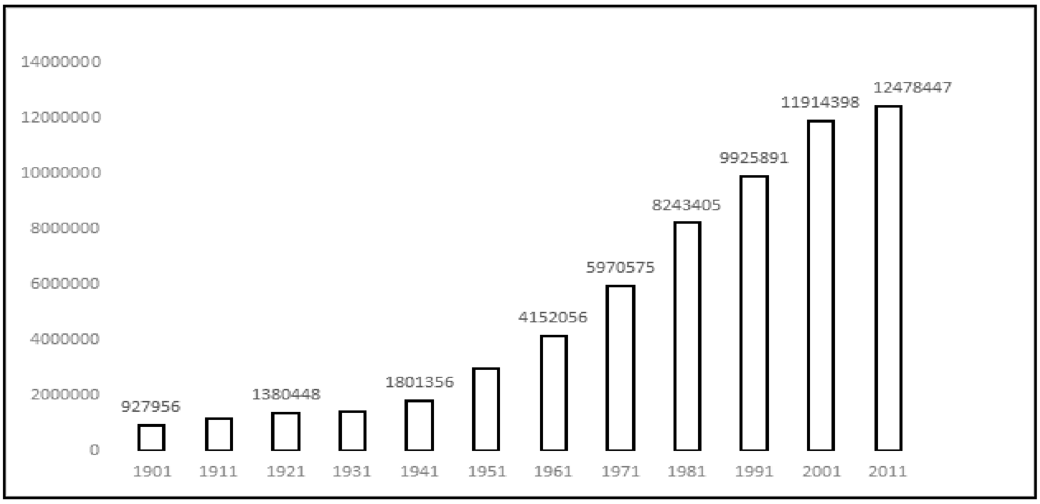


*Fig. 2* **– Temporal population since 1901**
Source: Census of India (2001)

media, communication and information technologies, and real estate and property development sectors (Pacione 2006). The GDP per capita is 43, which is higher than for other cities.

*Table 1*

**Area, Population and Population density of Mumbai**

| **City** | **Area (sq. km.)** | **Year** | **Population (lakhs)** | **Population Density (Persons per sq. km.)** |
|---|---|---|---|---|
| Mumbai | 3571.05 | 1971 | 5970575 | 1671 |
| | | 1981 | 8243405 | 2308 |
| | | 1991 | 9925891 | 2780 |
| | | 2001 | 11914398 | 3336 |
| | | 2011 | 12478447 | 3494 |

Source: Census India (1971-2011)

*Urban Development Planning and Infrastructure*

The urbanisation process in Mumbai has led to the expansion of the city and provision of many industries resulted in a large scale migration (Prasad et al. 2009). The city planning development process is controlled by the town planning departments and the Urban Development Authority. The Greater Mumbai Municipal Corporation also known as Brihat Mumbai Municipal Corporation (BMMC) is one of the most affluent civic bodies in the country and it covers an area of 4,355 km$^2$ (Neelima 2003). Mumbai Metropolitan Region Development Authority (MMRDA) was setup in 1975 under the Mumbai Metropolitan Region Development Authority Act, which is responsible for the planning and development activities in the Mumbai region (Neelima 2003).

**Data**

Data used for assessing the urban dynamics included multispectral data of Landsat series and collateral data (such as the Survey of India topographic sheets), which are listed in Table 2.

*Table 2*

**Data used for assessing urban dynamics**

| Data | Year | Purpose |
|---|---|---|
| Landsat Series Multispectral sensor (57.5m) | 1973 | Land cover and Land use analysis |
| Landsat Series Thematic mapper (28.5m) and Enhanced Thematic Mapper sensors | 1992, 1998, 2009 | Land cover and Land use analysis |
| Survey of India (SOI) topo sheets of 1:50000 and 1:250000 scales | - | To Generate boundary and Base layer maps |
| Field visit data – captured using GPS | - | For geo-correcting and generating validation dataset |

**Method**

Urban dynamics was assessed using temporal remote sensing data of the period 1973 to 2010. The time series spatial data acquired from Landsat Series Multispectral sensor (57.5 m) and thematic mapper (28.5 m) sensors for the period 1973 to 2010 were downloaded from a public domain (http://glcf.umiacs.umd.edu/data). The Survey of India (SOI) topographic sheets of 1:50000 and 1:250000 scales were used to generate base layers of city boundary, etc. The process of the analysis is threefold as described in Figure 3, which includes pre-processing, analysis of land cover and land use, and finally, the gradient wise zonal analysis of Mumbai.

1. *Pre-processing:* Remote sensing data (Landsat series) for Mumbai, aquired for different time periods, were downloaded from Global Land Cover Facility (http://www.glcf.umd.edu/index.shtml and http://www.landcover.org/), United States Geological Survey (USGS) Earth Explorer (http: // edcsns 17. cr. usgs. gov/ NewEarthExplorer /) and Glovis (http://www.glovis.usgs.gov). The remote sensing data obtained were geo-referenced, geo-corrected, rectified and cropped pertaining to the study area. Geo-registration of remote sensing data (Landsat data) has been done using ground control points collected from the field using pre calibrated GPS (Global Positioning System) and also known points (such as road intersections, etc.) collected from geo-referenced topographic maps published by the Survey of India. The Landsat satellite data of 1973 (with spatial resolution of 57.5 m x 57.5 m, nominal resolution) and of 1992 - 2009 (28.5 m x 28.5 m, nominal resolution) were resampled to 30 m in order to maintain uniformity in spatial resolution across different time periods. The study has been carried out for the Mumbai administrative area with 10 km buffer, which helps in accounting the region experiencing sprawl.

2. *Land Cover analysis:* Land Cover analysis was performed to understand the changes in the vegetation cover. Normalised Difference Vegetation Index (NDVI) was found suitable and it was used for measuring vegetation cover. NDVI values range from -1 to +1. Very low values of NDVI (-0.1 and below) correspond to soil or barren areas of rock, sand, or urban built up. Zero

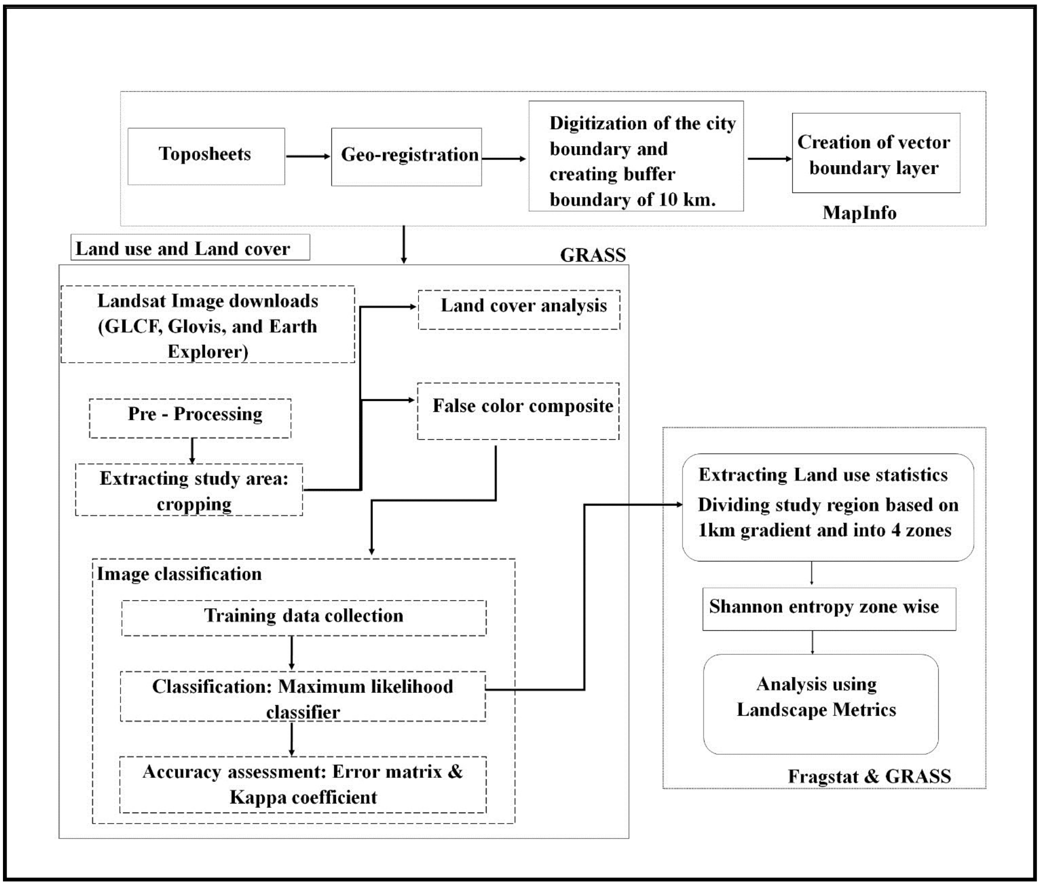


*Fig. 3* **– Procedure adopted for classifying the remote sensing data and the computation of metrics**

indicates water cover. Moderate values represent low density vegetation (0.1 to 0.3), while high values indicate thick canopied vegetation (0.6 to 0.8).

3. *Land use analysis*: The method involves a) generation of False Colour Composite (FCC) of remote sensing data (bands – green, red and NIR). This helped in locating heterogeneous patches in the landscape, b) selection of training polygons (these correspond to heterogeneous patches in FCC) covering 15% of the study area and uniformly distributed over the entire study area, c) loading these training polygons co-ordinates into pre-calibrated GPS, d) collection of the corresponding attribute data (land use types) for these polygons from the field. GPS helped in locating respective training polygons in the field, e) supplementing this information with Google Earth, f) 60% of the training data has been used for classification, while the balance is used for validation or accuracy assessment.

Land use analysis was carried out using supervised pattern classifier - Gaussian Maximum Likelihood Classifier (GMLC) algorithm. Remote sensing data was classified using signatures from training sites that include all the land use types detailed in Table 3. Mean and covariance matrix are computed using the estimate of maximum likelihood estimator. This technique has proved to be a superior classifier as it uses various classification decisions using probability and cost functions (Duda et al. 2000, Ramachandra et al. 2012).

Maximum likelihood classifier is then used to classify the data using these generated signatures. This method is considered as one of the superior methods as it uses various classification decisions using probability and cost functions (Duda et al. 2000). Mean and covariance matrix were computed using the estimate of maximum likelihood estimator. Land use was computed using the temporal data through the open source program GRASS - Geographic Resource Analysis Support System (http://ces.iisc.ernet.in/foss). Signatures were collected from field visits and with the help of Google Earth. 60% of the total generated signatures were used in classification and 40% of the signatures were used in the validation and accuracy assessment. Classes of the resulting image were re-classed and recoded to form four land-use classes

Accuracy assessment methods evaluate the performance of classifiers (Mitrakis et al. 2008). This is done either through comparison of Kappa coefficients (Congalton et al. 1983). For the purpose of accuracy assessment, a confusion matrix was calculated. Accuracy assessment and Kappa coefficient are common measurements used in various publications to demonstrate the effectiveness of the classifications (Congalton 1991, Lillesand and Kiefer 2005). Recent remote sensing data (2010) was classified using the collected training samples. Statistical assessment of classifier performance is done based on the performance of spectral classification considering reference pixels which include computation of kappa ($\kappa$) statistics and overall (producer's and user's) accuracies. For earlier time data, training polygon along with attribute details were compiled from the previously published topographic maps, vegetation maps, revenue maps, etc.

*Table 3*

**Land use classification categories adopted**

| Land use Class | Land uses included in the class |
|---|---|
| Urban | Residential area, industrial area, and all paved surfaces and mixed pixels having built up area |
| Water bodies | Tanks, Lakes, Reservoirs |
| Vegetation | Forest, Cropland, Nurseries |
| Others | Rocks, Quarry Pits, Open Ground at Building Sites, Kaccha Roads |

4. *Zonal Analysis:* City boundary along with the buffer region was divided into 4 zones: North-east (NE), Southwest (SW), Northwest (NW), Southeast (SE) for further analysis as the urbanization is not uniform in all directions. As most of the definitions of a city or its growth are defined in terms of directions, it was considered more appropriate to divide the region in four zones based on direction. Zones were further divided into concentric circles of 1 km incremental radius from the central pixel (Central Business district). The growth of the urban

areas along with the agents of change is understood in each zone separately through the computation of urban density for different periods.

5. *Division of these zones to concentric circles (Gradient Analysis):* All of the zones were divided into concentric circles with a consecutive incrementing radius of 1 km from the center of the city. This analysis helped in visualising the process of change at a local level and to understand the agents responsible for the changes. This helps in identifying the causal factors and locations experiencing various levels (sprawl, compact growth, etc.) of urbanization in response to the economic, social and political forces. This approach (zones, concentric circles) also helps in visualizing the forms of urban sprawl (low density, ribbon, leaf-frog development). The built up density in each circle is monitored overtime using time series analysis. This helps the city administration in understanding the urbanization dynamics to provide appropriate infrastructure and basic amenities.

6. *Shannon's Entropy:* Further to understand the growth of the urban area in a specific zone and to understand if the urban area is compact or divergent, the Shannon's entropy (Sudhira et al. 2004, Ramachandra et al. 2012) was computed for each zone. Shannon's entropy (Hn), given in equation 1, explains clearly the development process and its characteristics.

$$\mathrm{Hn} = -\sum_{i=1}^{n} \mathrm{Pi}\log \qquad (1)$$

Where Pi is the proportion of the built-up in the $i^{th}$ concentric circle. As per Shannon's Entropy, if the distribution is maximally concentrated in one circle, the lowest value – zero – will be obtained. If the distribution is even among the concentric circles, Hn will have maximum of log n.

7. *Computation of spatial metrics:* Spatial metrics are helpful to quantify spatial characteristics of the landscape. Selected spatial metrics were used to analyse and understand the urban dynamics, while FRAGSTATS (McGarigal and Marks 1995) was used to compute metrics at three levels: patch level, class level and landscape level. Table 4 below gives the list of the metrics along with their description considered for the study.

*Table 5*

**NDVI output generated results gives idea about vegetation versus non vegetation**

| Year | Vegetation (%) | Non- vegetation (%) |
|---|---|---|
| 1973 | 53.63 | 46.38 |
| 1992 | 39.77 | 60.23 |
| 1998 | 37.43 | 62.55 |
| 2009 | 33.76 | 66.23 |

**Results**

1. *Land Cover Analysis*: Land cover analysis was performed using NDVI and results are provided in Figure 4. NDVI ranges from -1 to 1. The negative value indicates the presence of non-vegetation such as built-up, water, sand etc. The positive values indicate the presence of vegetation. Table 5 tabulates the results of NDVI analysis. NDVI generated indicates that there has been a loss of green cover in the study region. Vegetation declined from 53.63 (1973) to 33.76 % (2009). There has been a loss in vegetation up to 62.79% during the past four

*Table 4*

**Spatial metrics chosen for the urban pattern analysis**

| Indicator | Formula | Description |
|---|---|---|
| **Number of patches (Built-up)** (NP) | $N = n_i$<br>Range: NP= 1 | NP equals the number of patches of the corresponding patch type. $n_i$ is the number of patches of a particular type. |
| **Percentage of landscape (Built-up)** (PLAND) | $PLAND = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A} (100)$<br>Range: 0<Land= 100 | PLAND equals the percentage the landscape comprised of the corresponding patch type.$a_{ij}$ = area ($m^2$) of patch ij. A = total landscape area ($m^2$). |
| **Patch Density** (PD) | $PD = \frac{n_i}{A} (10{,}000)(100)$<br>Range: PD> 0 | PD is the number of patch of urban patch divided by total landscape area. |
| **Largest patch Index (Built-up)** (LPI) | $LPI = \frac{\max_{j=1}^{n} (a_{ij})}{A} (100)$<br>Range: 0< LPI= 100 | LPI approaches 0 when the largest patch of the built-up patch becomes increasingly small and LPI = 1 when the entire landscape of the patch type of the built-up class. |
| **Largest Shape Index** (LSI) | $LSI = \frac{e_i}{mne_i}$<br>Range: LSI=1, without limit | LSI equals the total length of edge (or perimeter) involving the corresponding class, given in number of cell surfaces, divided by the minimum length of class edge (or perimeter) possible for a maximally aggregated class. |
| **Mean Patch Size (Class/Landscape)** (MPS) | $MPS = \frac{A}{N_{patch}} (10000$<br>Range: MPS > 0, without limit | MPS equals the sum of the areas ($m^2$) of all patches of the corresponding patch type, divided by the number of patches of the same type, divided by 10000 (to convert to hectares). |
| **Normalised landscape shape Index (NLSI)** | $NLSI = \frac{e_i - \min e_i}{\max e_i - \min e_i}$<br>Range: 0 to 1 | Normalized Landscape shape index is the normalized version of the landscape shape index (LSI) and, as such, provides a simple measure of class aggregation or clumpedness. It measures the perimeter-to-area ratio for the landscape as a whole. |
| **Edge Density** | $ED = \frac{E}{A} (10{,}000)$<br>Range: ED $\geq$ 0 when there is no edge in the landscape; that is when entire landscape and landscape border if present consist of single patch | ED standardizes edge to a per unit area basis that facilitate comparison between landscapes of different sizes. |
| **Clumpiness Index** (Clumpy) | $G_i = \left[\frac{g_{ii}}{\left(\sum_{k=1}^{m} g_{ik}\right) - \min e_i}\right]$<br>$CLUMPY = \left( \begin{array}{c} \left[\frac{G_i - P_i}{P_i}\right] \text{ for } G_i < P_i P_i < 5; else \\ \frac{G_i - P_i}{1 - P_i} \end{array} \right)$<br>Range: Clumpiness ranges from -1 to 1 | Clumpy = -1 when the focal patch type is maximally disaggregated, Clumpy = 0 when the focal patch is distributed randomly and approaches 1, when patch type is maximally aggregated. |
| **Aggregation Index** (AI) | $AI = \left[\frac{g_{ii}}{\max g_{ii}}\right] (100)$ | $g_{ii}$ = number of like adjacencies (joins) between pixels of patch type (class) i based on the single-count method. max $-g_{ii}$ = maximum number of like adjacencies (joins) between pixels of patch type (class) i (see below) based on the single-count method. |
| **Interspersion and Juxtaposition Index (Landscape level)** (IJI) | $IJI = \frac{-\sum_{K=1}^{m}\left(\left[\frac{e_{ik}}{\sum_{k=1}^{m} e_{ik}}\right] \ln \left[\frac{e_{ik}}{\sum_{k=1}^{m} e_{ik}}\right]\right)}{\ln (m-1)} (100)$<br>Range: 0 < IJI = 100 | eik = total length (m) of edge in landscape between patch types I and k. m= number of patch type present in landscape. |

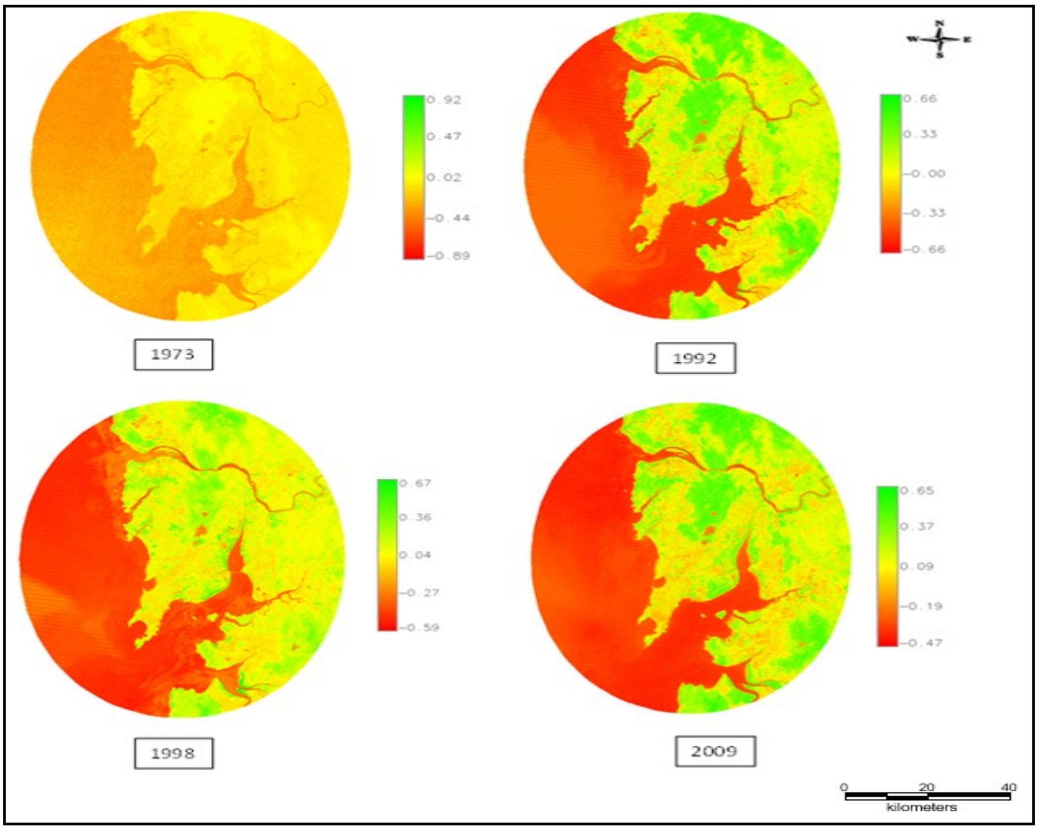


*Fig. 4* **– NDVI from Landsat 1973, 1992, 1998 and 2009 for Mumbai region**

decades. Vegetation class includes forests, agriculture, plantation, etc. Land use analysis would help in getting details under each land use category.

2. *Land use analysis*: Temporal remote sensing data of the study area were classified using GMLC with training data. Data that was kept for validation were used to generate another set of classified images. Accuracy assessment of both the sets of classified images was done using error matrix, overall accuracy and Kappa statistics. Figure 5 shows the classified images of the study region. Table 6 lists details of land use categories and Table 7 provides the overall accuracy and Kappa statistics of the classified data.
Land use statistics, as tabulated in table 6, indicates that there has been a phenomenal growth of urban area of 155% during the past four decades. Figure 6 depicts the process and diffusion of urban pockets in the study region during the past four decades. Further, the study area was divided into 4 zones and into concentric circles of 1km radius from the city centre. Figure 7 depicts the circle-wise land use statistics.

3. *Shannon's entropy (Hn)*: Table 8 lists the Shannon's entropy calculated for the data of 1973 to 2009. Figure 8 indicates the direction-wise Shannon's entropy. This shows an increasing trend for NE and SW directions which indicates that urban patches are getting fragmented in time. In NW direction, Shannon's entropy values show an increasing trend till 1998 that slightly

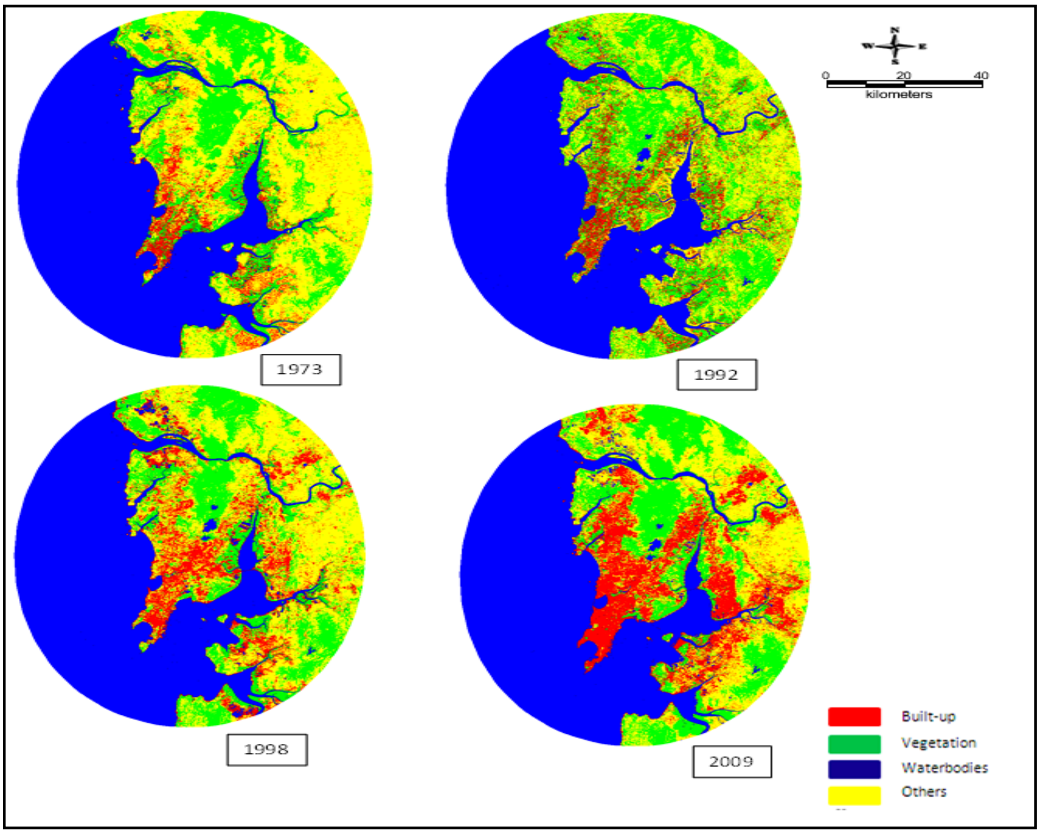


*Fig. 5* **– Spatial extent of land use categories in Mumbai**

*Table 6*

**Land Use statistics of the classified images**

| **Land Use category** | **Built-up** (%) | **Vegetation** (%) | **Water body** (%) | **Others** (%) |
|---|---|---|---|---|
| 1973 | 3.32 | 35.04 | 43.22 | 18.42 |
| 1992 | 7.37 | 21.92 | 45.82 | 24.89 |
| 1998 | 9.28 | 20.26 | 45.71 | 24.75 |
| 2009 | 14.26 | 16.19 | 44.74 | 24.80 |

*Table 7*

**Overall Accuracy and kappa statistics of classified images**

| **City** | **1970s** | | **1980s** | | **1990s** | | **2000s** | |
|---|---|---|---|---|---|---|---|---|
| | **OA** | $\hat{k}$ | **OA** | $\hat{k}$ | **OA** | $\hat{k}$ | **OA** | $\hat{k}$ |
| MUMBAI | 73 | 0.9471 | 98 | 0.8115 | 99 | 0.8225 | 99 | 0.8193 |

*Table 8*

**Shannon's entropy for Mumbai region**

| | NE | NW | SE | SW | Reference value |
|---|---|---|---|---|---|
| 1973 | 0.02 | 0.11 | 0.21 | 0.14 | 1.59 |
| 1992 | 0.20 | 0.16 | 0.26 | 0.13 | |
| 1998 | 0.31 | 0.22 | 0.27 | 0.14 | |
| 2009 | 0.32 | 0.30 | 0.43 | 0.22 | |

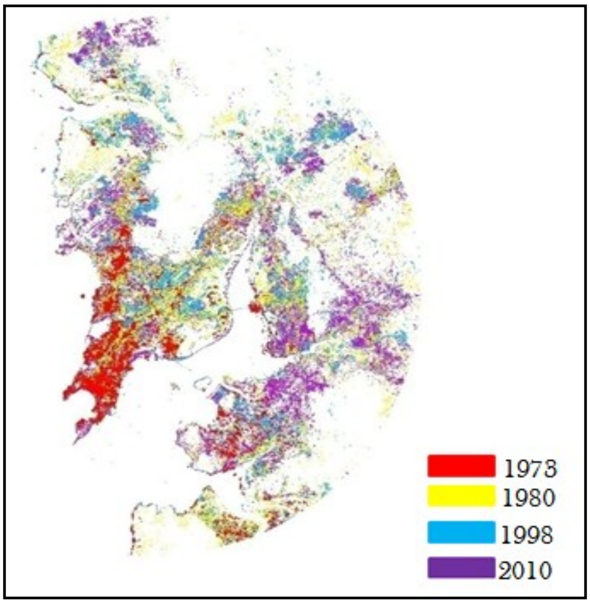


*Fig. 6* – **Urbanisation pattern of Mumbai in past 4 decades**

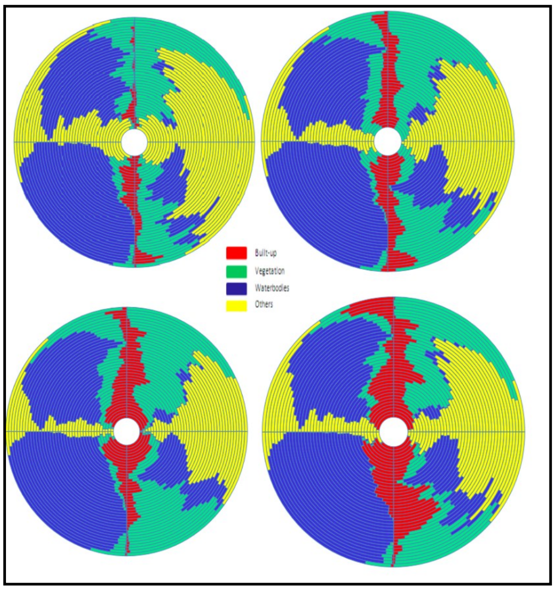


*Fig. 7* – **Circle-wise land use statistics for Mumbai**

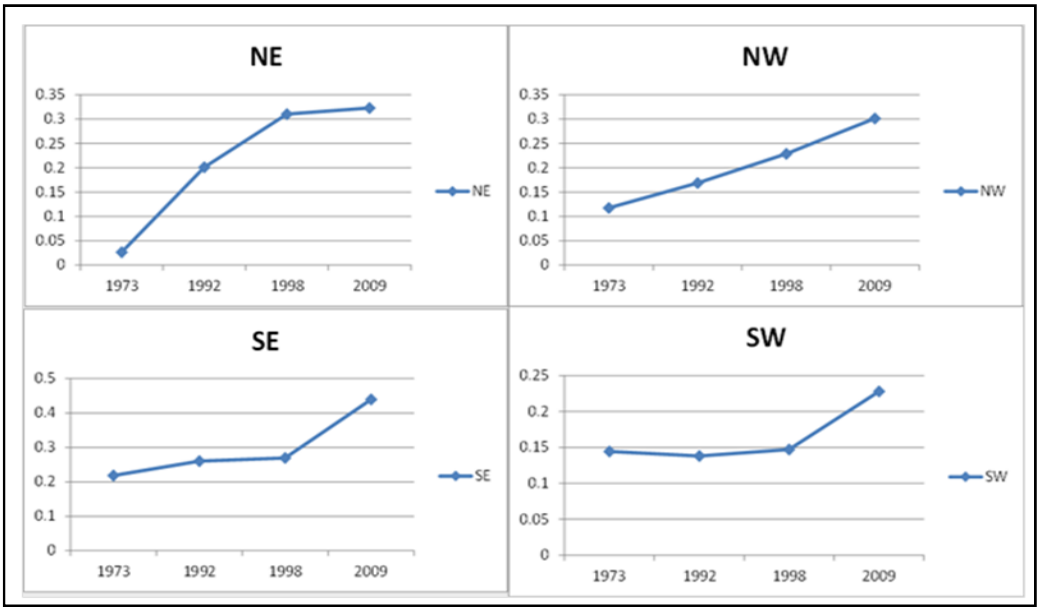


*Fig. 8* – **Shannon's entropy for the year 1973 to 2009**

decreases in 2009 indicating compactness. In SE direction, there has been an increasing trend from 1973 to 1992 with a sudden decline in 1998 (which shows compactness) and a slight increase in 2009 with increasing fragmentation.

4. *Spatial metrics analysis*

4.1. Percentage of landscape (PLAND): PLAND (Fig. 9a) equals the percentage of landscape comprised of the corresponding class patches. Built up percentage was computed to understand the ratio of built up and its increase in the landscape. Percentage of landscape gives a similar trend as the class area. In northeast direction, maximum PLAND is depicted in C13, C17, C25 and C27 in 2009. In northwest direction, the maximum value was found in C11, C12, C13, C14 and C15. Similarly, in SE (C13 to C27) and in SW (C5 to C21), the landscape comprised of a high rate of the urban patches as depicted in the graph below.

4.2. Number of patches (NP): Number of patches (NP) equals the number of built up patches in hectares in a landscape. It indicates the level of fragmentation in built up landscape (Fig. 9b). In NE direction, C19 and C27 show a greater number of urban patches which imply that the patches are getting fragmented (more values found in 1992 and 1998 compared to 2009, whereas 1973 has a very low value which indicates the compact features of urban patches). In NW direction, the number of patches is varying for all circles (more variation is found in 1992 and 1998 compared to 2009, whereas, 1973 has a very low value which indicates the compact features of urban patches). In SE and SW directions, the number of patches is low, which indicates the compactness of patches except for circles (C21 to C29) in southeast direction (i.e., maximum values found for the year 2009 indicates fragmentation).

4.3. Patch Density (PD): Patch density (Fig. 9c) is an indicator of urban fragmentation and as the number of patches increases, patch density increases, which connotes to higher

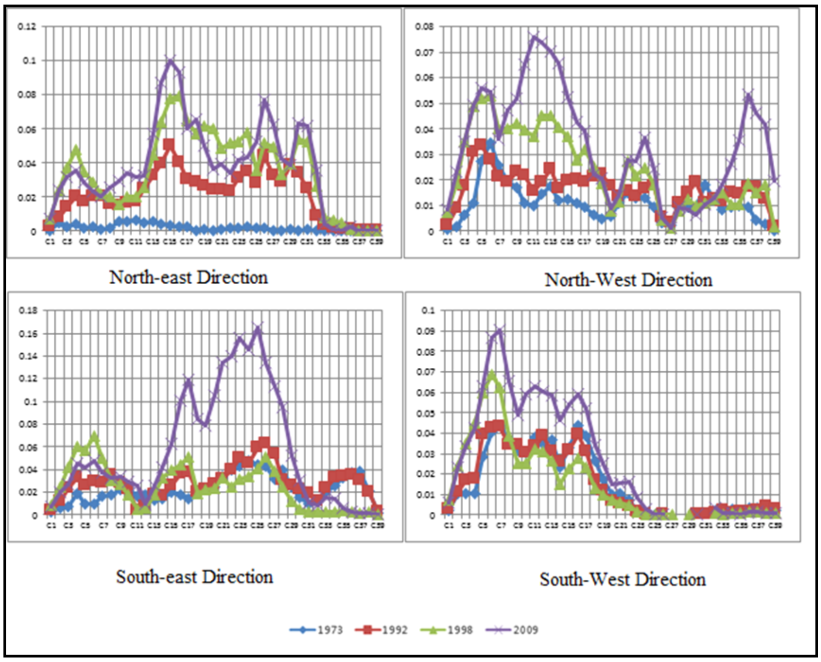


*Fig. 9a* **– PLAND direction and Circle wise**
(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

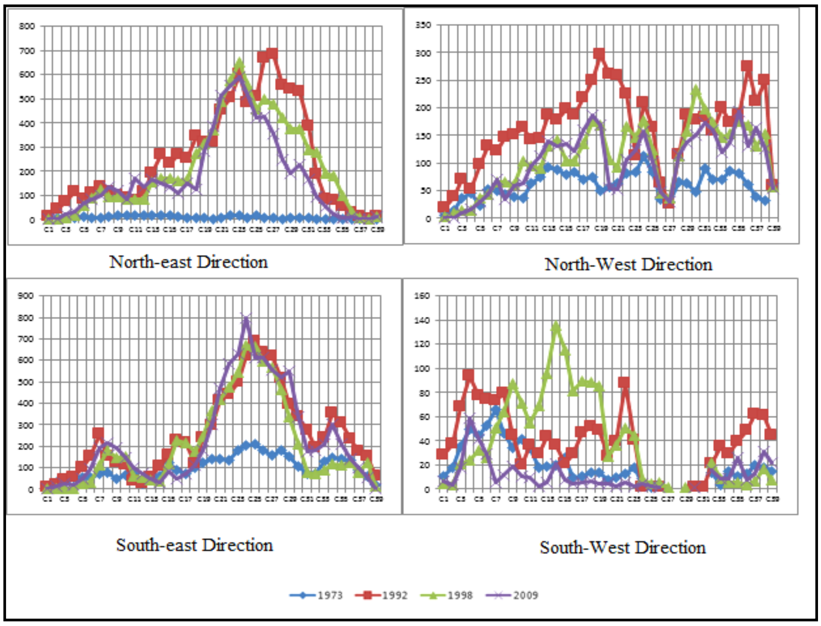


*Fig. 9b* **– Metric NP direction and Circle wise**
(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

fragmentation. The metric shows results similar to the number of patches. In NE direction, C19 and C27 show more number of urban patches, which connotes that patches are getting fragmented in time and hence higher values for the patch density were noticed in 1992 and 1998 (compared to 2009, whereas 1973 has a very low value which indicates the compact

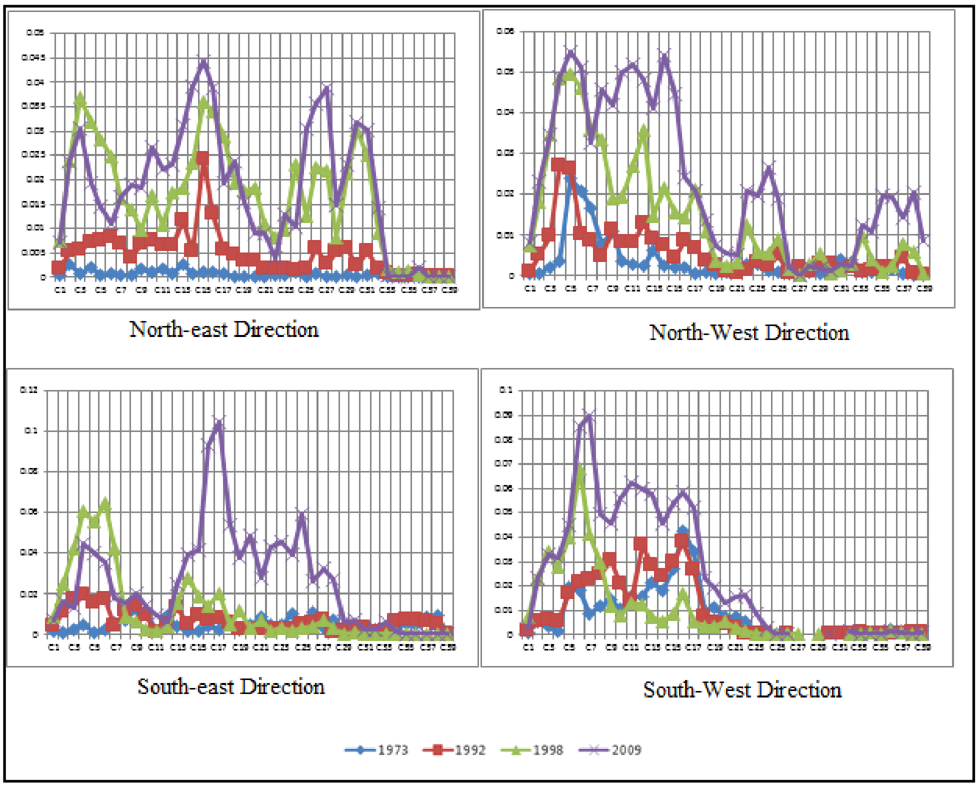


*Fig. 9c* **– PD direction and Circle wise**

(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

features of urban patches). In NW direction, patch density is varying for all circles (more variation of values were found in 1992 and 1998 compared to 2009, whereas 1973 has a very low value which indicates the compact features of urban patches). In SE and SW directions the patch density is low, which connotes to the compactness of patches except for circles (C21 to C29) in SW direction.

4.4. Largest patch index (LPI): Largest Patch Index (LPI) was computed to represent the percentage of landscape that contains the largest patch (Fig. 9d). The NE and SW directions show that the largest urban patches for the circles C13 to C20 indicate a less number of urban patches connoting to compactness of urban features (i.e., mostly in 2009). In NW and SW directions, the bigger urban patches are largely present towards the city center, connoting to more compact urban patches (i.e., circles from C1 to C17 showing maximum values for all years).

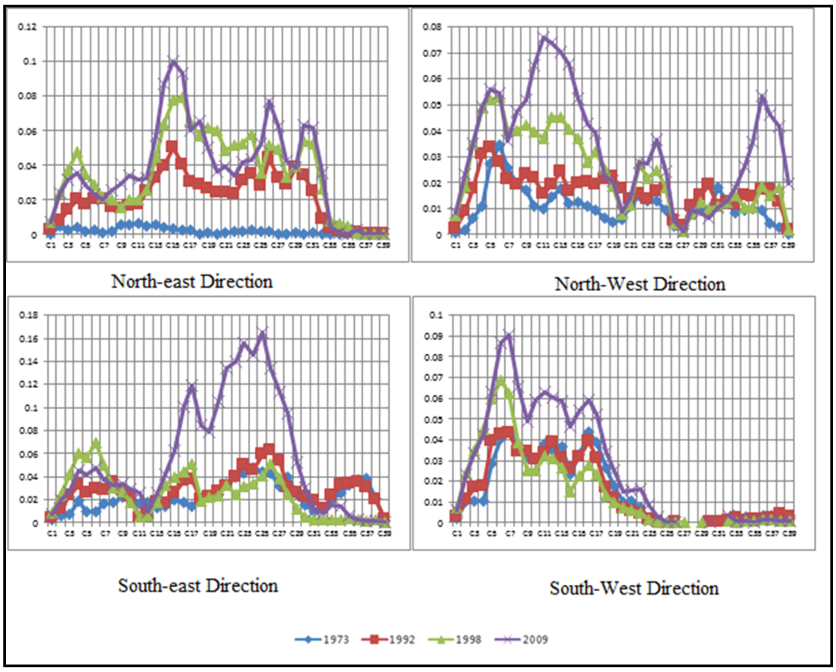


*Fig. 9d* **– LPI direction and Circle wise**
(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

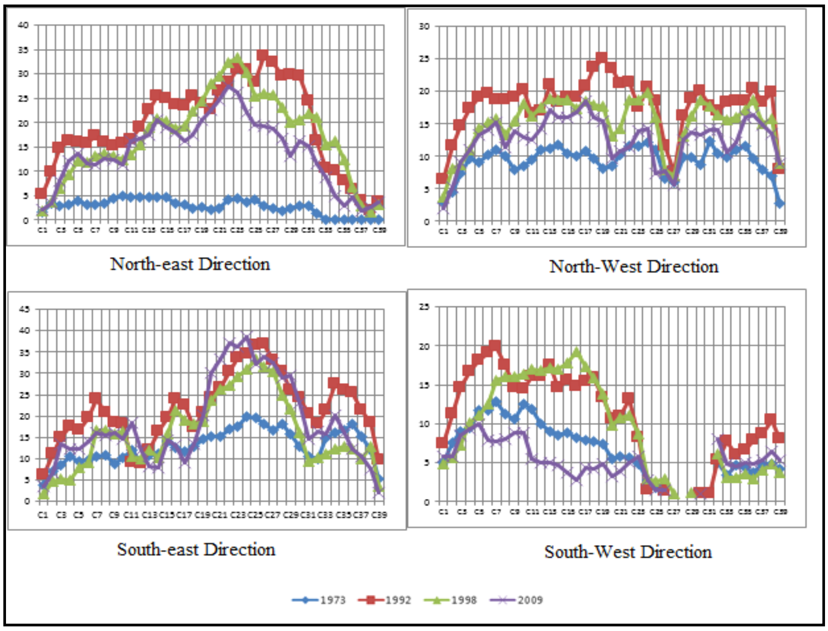


*Fig. 9e* **– PD direction and Circle wise**
(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

4.5. Landscape shape index (LSI): Landscape shape index (Fig. 9e) provides a simple measure of class aggregation or clumpiness and it is measured via class edge surfaces. Fig 9e depicts the complex structure of urban patches that are found in mid circles (circles 10 to 19) compared to the circles present in the urban center and fringes. In the NE direction, the metric value is less for the year 1973 for all circles indicating a simple structure and compact shapes, whereas the years 1992 and 1998 have maximum values compared to 2009, which implies that 2009 has compact patches compared to 1992 and 1998. Similarly, the NW direction shows a similar trend as the NE direction, i.e., 1973 shows compact features while 1992 and 1998 have maximum values compared to 2009, indicating more fragmentation in the years 1992 and 1998 for all circles. The SE direction shows a similar trend as the NE and NW direction. In SW direction, the urban patches show a simple structure for 2009 compared to 1992 and 1998 in all circles.

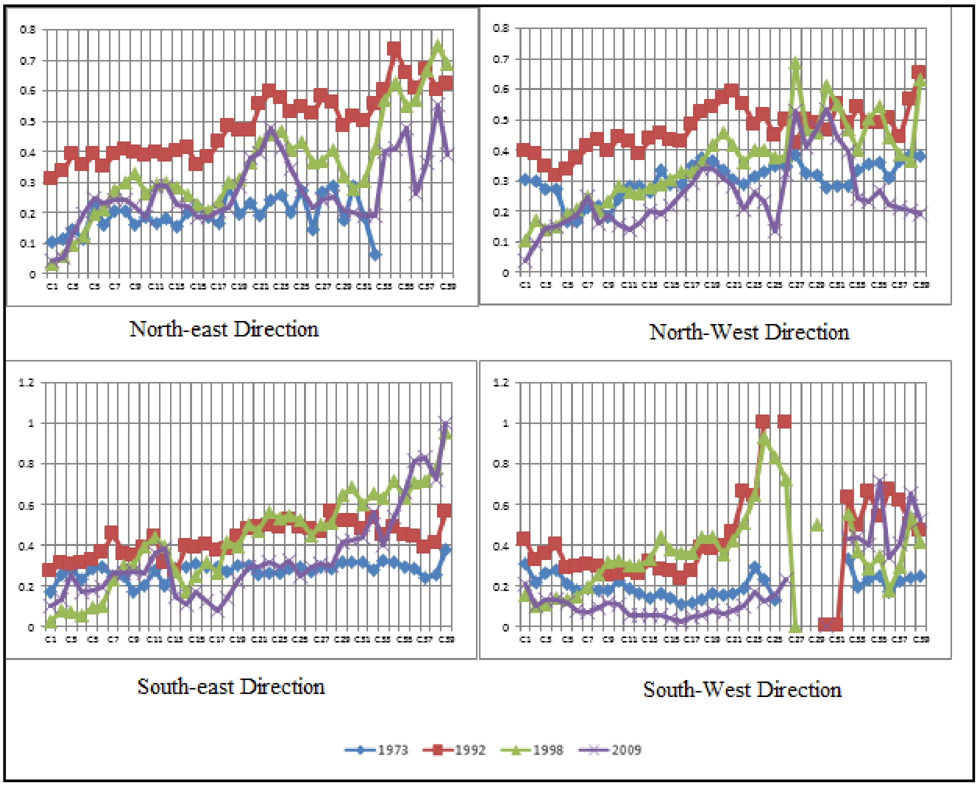


*Fig. 9f* **– NLSI direction and Circle wise**

(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

4.6. Normalized Landscape Shape Index (NLSI): Normalized Landscape Shape Index (Figure 9f) is similar to landscape shape index but this represents the normalized value. This index provides a simple measure of class aggregation or clumpiness. Figure 9f below depicts the variations in the value and indicates that complexity of urban patches increases as it moves away from the core area. The analysis showed that the circles at the centre in 2009 were clumped compared to 1973, whereas circles (circle 28 onwards) show the characteristics of fragmented growth towards 2009.

4.7. Edge Density (ED): Edge Density (Fig. 9g) computes the total amount of edge present in a landscape. Edge Density (ED) represents the ratio of total edges of all the patches to total area. With increase in fragmentation, the number of patches increases and so does the number of edges. Hence edge density is the measure of fragmentation of the landscape. Figure 9g

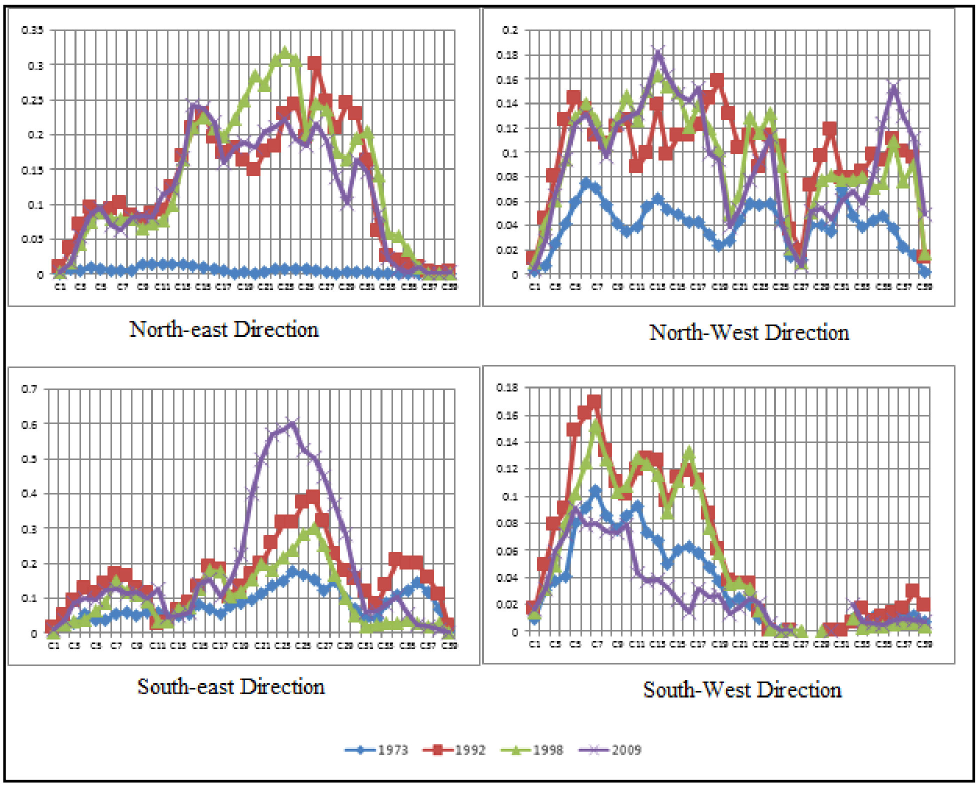


*Fig. 9g* **– ED direction and Circle wise**
(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

indicates that the edge density has maximum value for the circles C11 to C29 indicating greater fragmentation (i.e., greater values found in 1992 and 1998 compared to 2009, whereas, 1973 has a very low value which indicates the compact features of urban patches). In NW direction, maximum values for all circles were found in the year 1992 and 1998 compared to 2009, indicating greater fragmentation in 1992 and 1998 compared to 2009. In SE and SW directions, the number of patches is low, which connotes to the compactness of patches, except for circles C21 to C29 in 2009 in SE direction, which indicate fragmentation.

4.8. Clumpiness index (CLUMPY): Clumpiness index (Fig. 9h) is the measure of patch aggregation. It measures the clumpiness of the overall urban patches. Clumpiness ranges from -1 to 1, where clumpiness is equal to -1 when the urban patch type is maximally disaggregated.

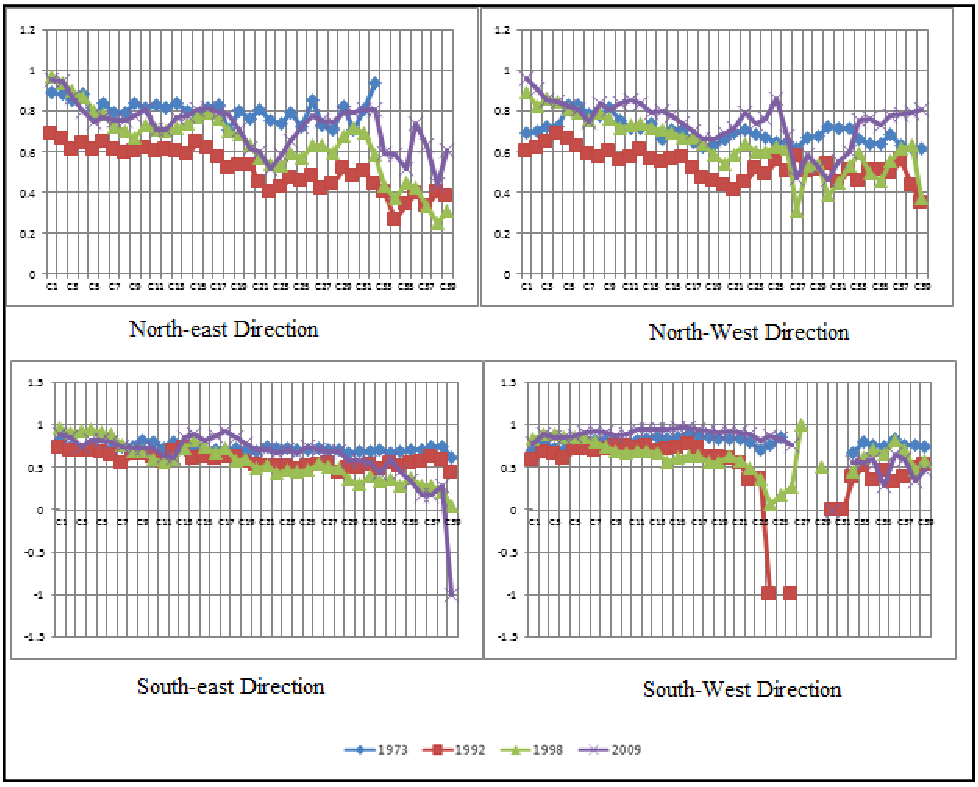


*Fig. 9h* **– ED direction and Circle wise**

(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

Clumpiness is equal to 0 when the patch is distributed randomly and clumpiness approaches 1 when urban patch type is maximally aggregated. The graph shows that the value ranges from 0 to 1, which implies that the patches are getting aggregated in time for northeast and northwest directions. SE and SW directions also show a similar trend, but C39 (SE) and C23, C25 (SW) show values of -1 indicating maximum disaggregation of urban patches.

4.9. Interspersion and Juxtaposition Index (IJI): The Interspersion and Juxtaposition Index (IJI) (Fig. 9i) measures the extent to which patch types are interspersed (not necessarily dispersed). Higher values result when the urban patch types are well interspersed (i.e., equally adjacent to each other), whereas lower values characterize landscapes in which the patch types are poorly interspersed (i.e., disproportionate distribution of patch type adjacencies) (McGarigal and Marks 1995). These metrics' analysis showed same results as that of the clumpiness index, stating that the lower values are found in the inner circles in 2009 and the higher values were near the boundary (circles 7 to 27).

4.10. Aggregation Index (AI): Aggregation Index (Fig. 9j) gives the similar indication as clumpiness i.e., it measures the aggregation of the urban patches. The aggregation index showed the similar trend as the clumpiness index. The aggregation index has maximum value at the city center and urban patches get disaggregated for the circles away from the city center as depicted in figure 9j.

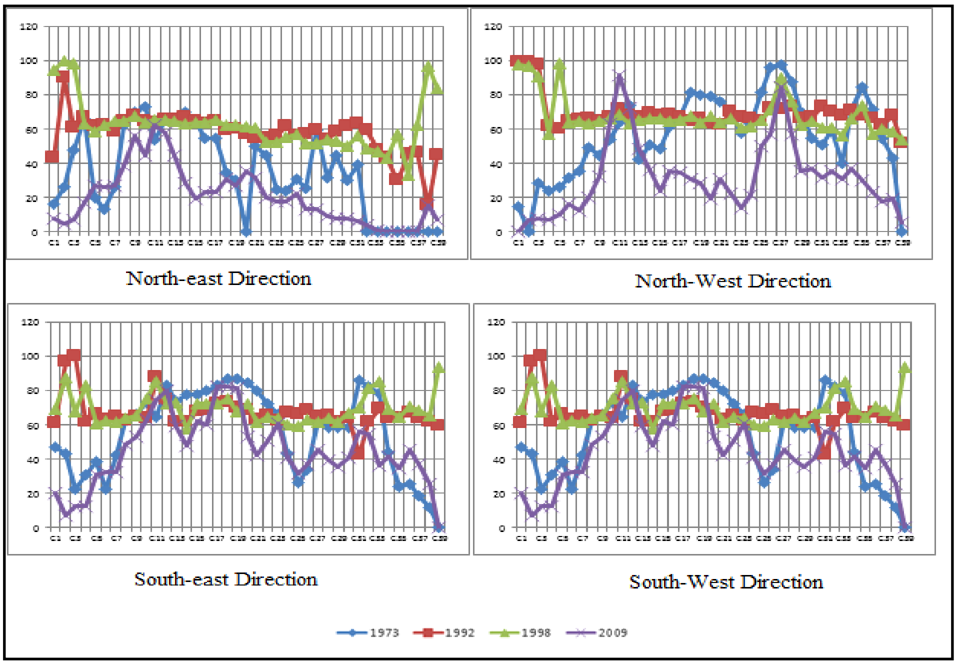


*Fig. 9i* **– IJI direction and Circle wise**
(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

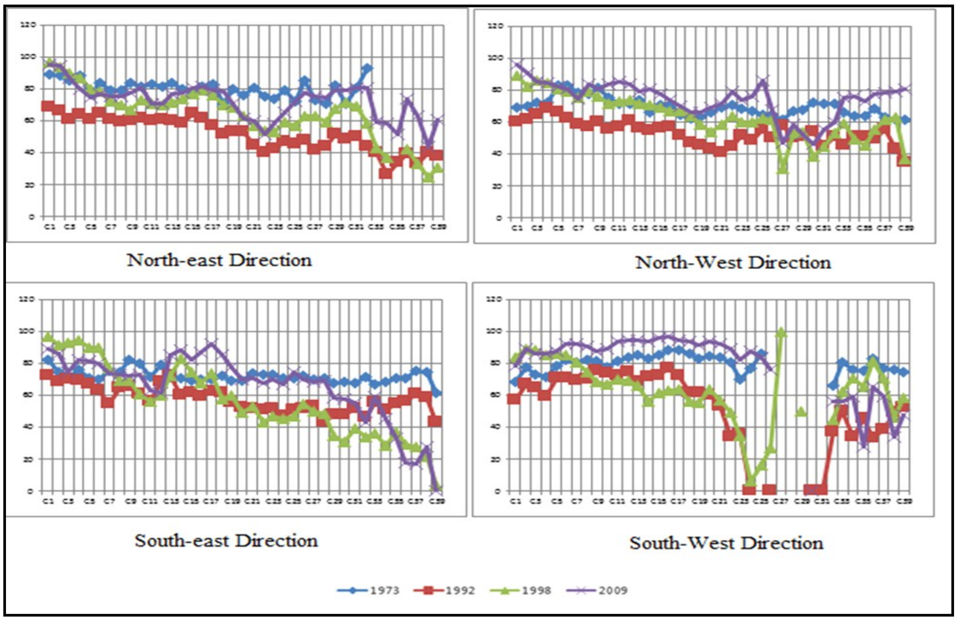


*Fig. 9j* **– AI direction and circle wise**
(Note: X axis indicates circles considered, Y axis indicates the value of the metrics)

## Conclusion

The urban footprint has been quantified considering the proportion of paved surface (built up, roads, etc.) with the reduction of other land uses. This communication discusses the urban footprint dynamics of Mumbai using multi-temporal remote sensing data with spatial metrics. Mumbai has a population density of 4583 persons per square kilometre (Census of India 2001). Mumbai urban agglomeration is ranked third after Tokyo and Mexico City. Urban dynamics was assessed using temporal remote sensing data of the period during 1973 to 2010. Vegetation declined from 53.63 % (1973) to 33.76 % (2009). There has been a net loss in vegetation up to 62.79% in the past four decades.

Over the past four decades, urbanization has significantly modified the land use of Mumbai city and its outskirts. The built-up area has significantly increased by 155%, at the expense of non-forest land in the study region, which includes Mumbai metropolitan area with 10 km buffer. Urban sprawl is seen toward the southwest and northeast sectors of the metropolitan area.

The landscape metrics clearly brought out the facts of the process of urbanisation and the urban sprawl in the study region. Comparative analysis of change in built-up patch density in relation to the spread pattern indicates that all zones have relatively contributed to the development of urban area at different stages of urbanization. This analysis also reveals the infilling effects of urban development as spreading away from the urban core. These indices can provide information on urban land conversion which would help the urban planners and city development authority as a hands-on tool to understand the process and for further developmental planning.

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*Correspondence:* Indian Institute of Science, Bangalore, Karnataka, 560 012, India

E-mail: cestvr@ces.iisc.ernet.in

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# ADDRESSING SERVICE ACCESS BARRIERS FOR HOMELESS YOUTH: A CALL FOR COLLABORATION

*Jeffrey L.* **PERRON**
University of Ottawa, Canada

**Abstract:** Homeless youth are among the most vulnerable individuals in North American society. The day-to-day stressors they face while living on the streets pose a great threat to their mental and physical health. A number of barriers that youth face in accessing care have been identified in the literature. This discussion article highlights work that has been done to apply geographic theory to issues of service access among homeless youth. To date, most such work has been theoretical in nature, with collaborations between geographers and homeless youth researchers to make applied recommendations for the location of services. Urban geographers and homeless youth researchers are implored to collaborate in order to make recommendations that will increase the access to service, particularly for rural homeless youth.

**Key Words:** *homeless, youth, health services, health care.*

## Introduction

Homeless youth are among the most vulnerable individuals in North American society (Kidd 2003). Given their vulnerability, victimization, and generally poor physical and mental health, access to health services is critical to survival on the streets (Kidd 2003). However, homeless youths' ability to access the services they need is limited by a number of factors. Well documented barriers to service access for homeless youth and other homeless populations include issues of mistrust towards professionals and authorities, lack of health insurance, and issues related to gender and ethnicity (Thompson et al. 2006a, Kidd 2003, Aviles and Helfrich 2004, Berdhal et al. 2005). Increasingly, however, barriers that are geographic in nature are receiving research attention. This includes research on the location of services and homeless youths' diminished access to adequate forms of transportation. Researchers studying homeless youth are recognizing the role of urban geographic theory in properly addressing the barriers that homeless youth experience in accessing health services (Baker Collins 2013, Elias 2009, Thompson et al. 2006a). That said, the influence of geographic theory and interventions has been more commonly applied to issues concerning adult homelessness. Few works have been dedicated to the application of geographic theory and interventions to issues unique to youth homelessness.

While many of the "on-the-street" stressors are similar for both urban and rural homeless youth, there are key differences as they relate to access to services. The rate of overall homelessness is approximately 14 homeless individuals for every 10,000 people in rural areas. This is less than half the 29 of 10,000 persons rate found to exist in urban settings. The lower number of homeless individuals in rural settings generally means a much lower concentration of homeless youth in rural areas than in urban areas, as would be expected. Perhaps paradoxically, the lack of a "critical mass" of homeless youth in rural settings means that rural homeless youth assistance services and systems are rare. Where they do exist, they often lack the infrastructure to provide comprehensive care to these youth. In addition to the low concentration of homeless youth in rural settings, the lack of available affordable housing, limited public transportation, and low levels of governmental funding contribute to the maintenance of inadequate care for homeless youth in rural settings (National Alliance to End Homelessness 2010).

Further inter-disciplinary collaboration between geographers and mental health professionals will be critical in harnessing urban geographic theory to alleviate these barriers to access, particularly for rural homeless youth. With that in mind, this paper has three aims: 1) it seeks to orient the reader to the nature of life on the streets for homeless youth in North America (the scope is limited to the United States and Canada); 2) it seeks to provide a brief overview of research related to the influence of geography and location to homeless youths' ability to access services (of note, discussion of works related to the application of geographic theory and interventions to issues of adult homelessness are outside the scope of the paper); and, 3) it seeks to be a call-to-action for both urban geographers and researchers focused on homeless youth, encouraging discussion and collaboration to address service access barriers.

## Materials and Methods

In order to gather sources for this discussion paper, searches were conducted using the PsycInfo database. Keywords such as: 'homeless', 'geography', 'youth', 'urban', 'rural' were used along with the criterion that articles were published between 1960 and 2013. Article abstracts were reviewed for relevance. Articles that did not focus on the location or configuration of homeless youth services were rejected. Based on this review, articles most relevant to the current discussion were selected for further analysis.

## Life on the Streets

An understanding of the nature of life as a homeless youth serves to elucidate the grave need for access to appropriate services. This section outlines research conclusions which have outlined the chief characteristics of day-to-day life on the streets for homeless youth. Of note, the majority of this research comes from samples of urban homeless youth given the paucity of research related to rural homeless youth. While the majority of findings apply to some extent to both rural and urban homeless youth, further research is needed to clarify the extent to which life on the streets for rural homeless youth is different from life on the street for urban homeless youth.

Undoubtedly, life on the streets for both sub-populations is characterized by chronic stressors, the most salient of which may be the need to secure shelter and food (Thompson et al. 2006b). Homeless youth who live with this uncertainty with regard to basic needs, spend much of their emotional energy trying to quell the anxiety and fear that stem from these stressors (Thompson et al. 2006b).

Many of the harsh conditions of life on the street translate into serious physical health maladies (Ensign and Bell 2004). Some of the most prevalent aspects of street life leading to physical illness include malnutrition caused by the lack of food or poor quality food and eating habits (Thompson et al. 2006a) and instable or inadequate housing. Furthermore, homeless youth often engage in behaviours that indirectly or directly cause decreases in overall health, such as substance abuse or deviant and criminal activity (Halcon and Lifson 2004). The high rate at which homeless youth engage in risky sexual behaviour has been well documented by researchers (Halcon and Lifson 2004). The result of high rates of such behaviour is the high rate of sexually transmitted infections found among the homeless youth population (Halcon and Lifson 2004, Thompson et al. 2006a).

Youth are also targeted for victimization in many forms by other adults as well as peers (Whitbeck et al. 2001). This is most common for females and younger youth who may have more difficulty protecting themselves against physical attacks (Paradise and Cauce 2002, Whitbeck et al. 2001). Youth report that those who purport to be friends with another youth sometimes use the other person for sex, shelter, drugs, or money (Chun and Springer 2005).

Once these significant mental and physical health stressors are made clear, so too is the need for appropriate health care and support interventions for homeless youth. It is crucial that these youth have access to mental and physical health care before health issues become chronic and result in long-term quality of life decreases (Aviles and Helfrich 2004). Early intervention is crucial, as the longer a youth remains homeless, the greater the likelihood of him or her developing chronic physical and mental health issues (Brooks et al. 2004, Kidd 2003, Berdahl et al. 2005, Thompson et al. 2006a).

The need for such services is rarely met. Even where support exists, the number of barriers to accessing care means that existing services do not always reach their intended recipients. Access to care is particularly grave for rural homeless youth. It is a common belief that the homeless exist only in urban centres and not suburbia. The implications of this belief are a wide -spread lack of services for homeless individuals living outside of urban centres. Given the lack of resources to secure reliable transportation, rural homeless youth must often leave their current region in order to access services in more urban settings (Baker Collins 2013, Edwards et al. 2009). This can result in an influx of homeless individuals to urban centres that have facilities to aid the homeless.

To put this problem into context it is helpful to consult sources providing information regarding the geographic dispersal of homeless individuals. The American Interagency Council on the Homeless (1999) found, in a survey of 2938 homeless individuals, that 30% of these individuals *did not* live in urban centres (21% in suburban/urban fringe areas and 9% in rural areas). As such, any approach to improving service access for homeless youth should take into account the unique needs of rural homeless youth.

The struggle to provide homeless youth with adequate support to meet their myriad physical and mental health needs clearly has a geographic (or, locational) component. As such, it is critical that in order to be comprehensive, proposed solutions take, at least in part, a geographic perspective.

## An Overview of Geographic Approaches to Improving Homeless Youth Services

A brief history of the relationship between geographic and social service theory serves to set the stage for how geographic theory can be further harnessed, specifically in order to address the needs of homeless youth, particularly those living in rural environs.

In fact, geographic theory has long been applied to social services. Teitz's (1968) 'public facility location' theory acts as a landmark for the beginnings of geography applying itself to human and social concerns. The underlying premise of Teitz's early research was that optimal locations for public facilities differ from the optimal locations for private facilities. Though seemingly obvious at the present time, this theory had major implications, particularly by suggesting that urban geography can and should concern itself with social/political decisions.

Before long, a considerable amount of research in geography that examined efficiency and equity in public service availability and access was published (DeVerteuil 2000).

However, it was not until the 1980s that urban geography was applied to social issues much in the same manner as it is today. The 1980s saw important research which implicated human behaviours in the 'production' of the urban environment. This movement incorporated elements of social psychology in taking into account client needs and behaviours along with the attitudes of communities (DeVerteuil 2000). Part of this movement included research attempting to delineate conditions leading to optimal service access for homeless individuals.

The late 1990s and early 2000s featured a number of influential works in which urban geographic theory was applied to issues of service access for homeless youth (e.g. Paraschiv 2012, Kurtz et al. 2005, Barry et al. 2002, DeVerteuil 2002). A great portion of studies examining service use and access among homeless youth provide both quantitative and qualitative data (a mixed methods approach). Such research provides an understanding of not only structural factors but also the narratives of the individuals who have experienced various barriers to care (Aviles and Helfrich 2004).

Much of this research has concerned itself with whether or not services should be 'clustered', as it is typical of service organization in large North American cities (DeVerteuil 2002). Often, the distance the youth must travel to arrive at a facility that provides a needed health care service precludes access, as the youth will often not have the resources, such as bus tickets, necessary to travel further than walking distance (Barry et al. 2002). Brooks et al. (2004) is an example of research aimed specifically at informing other researchers, policy makers, and youth service operators of the geographic issues affecting youths' ability to access care. Brooks et al. (2004) focus specifically on barriers to care as perceived by the youth themselves. Conducting their work in Los Angeles, California, they maintain that Los Angeles County does not fail to provide facilities offering appropriate health care for homeless youth. However, despite the quality of the region's services, they are under-utilized owing to their concentration in the core downtown area of Hollywood (located within Los Angeles County and characterized by high levels of drug use, drug dealing, and prostitution), limiting access for those living outside the urban core of Los Angeles County, namely rural homeless youth (Brooks et al. 2004).

Similarly, Barry et al. (2002), seemingly in favour of clustering homeless youth services to a degree, give the example of a youth who manages to access health care, but in doing so finds that she or he must access other services to fully meet her or his health care needs. For example, after painstakingly securing transport to an appointment with a physician, a youth may be required to get medication at a pharmacy, which may not be located near the physician's office. Again, this issue is of particular relevance to rural homeless youth. The solution proposed by Barry et al. (2002) is to have a multitude of services located in close proximity or at one site.

Arguing against the clustering of services are often those who suggest that the most effective means of providing health services to homeless youth is through outreach programs. Kurtz et al. (2005) have cited providing care via outreach interventions as a promising method of care delivery as it, in theory, eliminates the need for the client to have transport to the care facility. In the past, outreach efforts have been successful in providing street youth with hepatitis B vaccinations, for example.

Today, geographers have built a considerably large body of research literature on the mobility of homeless individuals. Even these analyses of mobility tend to examine solely mobility across and within urban centres. Specifically, it has been realized that there are significant geographic barriers to the homeless youth's ability to access health care (DeVerteuil 2002). Kidd (2003) points to the increased amount of literature focused on the service needs and barriers faced by homeless youth as a sign that homeless youth researchers are realizing the urgent need to fill gaps in research that informs interventions and barriers to access the services. That said, little research has directly – or in an applied manner – made specific recommendations for the location of services and how optimal location can reduce barriers to access, particularly for rural homeless youth.

## Call to Action

The intersection of urban geography and research concerning homeless youth services has been implicit, rather than explicit. It has been theoretical, rather than applied. Researchers from both camps recognize the relevance of the other to their own field, with researchers specialized in youth homelessness highlighting the relevance of geography and the location of services (e.g. Baker Collins 2013) and geographers acknowledging their ability to comment on issues related to youth homelessness (e.g. Gibson 2011). However, direct partnerships between geographers and researchers specialized in youth homelessness have been rare. Greater partnership between these researchers holds promise for creating cost effective ways of identifying optimizations in service location that will better-serve homeless youth.

Understanding extant research in which access to health services for homeless youth has been viewed from a geographic perspective is helpful in identifying future areas of partnership. Despite some efforts to apply geographic theory to issues pertaining to social services and, more recently, a number of studies that explore geographic theory in relation to homeless youth, there remains little clarity for how best to plan for, and locate services. This lack of clarity is of particular disadvantage to homeless youth living in rural settings.

Ideally, youth homelessness researchers and clinicians will seek consultation from urban geographers in the planning of research and interventions that are influenced by the location of services. Given time and budgetary constraints, particularly in this often-under-funded area of work, researchers have limited opportunities to work together in such a capacity. This is particularly true given that there are few natural intersections such as mutually relevant professional events such as conferences. As such, it is necessary for both urban geography and youth homelessness researchers to proactively initiate collaboration.

In the absence of direct collaboration on research projects and the planning of interventions, the most effective manner of initiating collaboration may be, paradoxically, for urban geographers to independently produce analyses or publications related to issues of youth homelessness. By independently applying their unique skills in such a manner, urban geographers can demonstrate the full scope of their ability to positively influence the condition of homeless youth. These independent works will pave the way for further collaboration between geographers and professionals in fields such as psychology, social work, and nursing.

Of course, professionals from these fields have a responsibility to effectively engage geographers. This is particularly true given the positive influence that urban geography has had on the condition of adult homeless individuals. Leading and innovative professionals from areas outside of geography must recognize the value of a geographic perspective to issues of youth homelessness. As part of increasing awareness and spurning engagement, the author of this paper will seek to have it cross-published in publications related to fields more traditionally connected to homeless youth research and interventions.

This discussion has been meant to alert both homeless youth researchers and urban geographers, particularly in the face of the dire mental and physical health needs of homeless youth. For homeless youth researchers, there must be an awareness of the necessity of collaborating with urban geographers in order to better address the needs of these youth. For urban geographers, there exists an opportunity to extend the reach of their profession by collaborating with homeless youth researchers to make decision about the optimal location of facilities for this disadvantaged population.

Ultimately, research from the field of geography can inform decisions about homeless youth service location, improving the likelihood that members of this young, vulnerable population will receive the mental and physical health care that is critical to their long-term quality of life.

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*Correspondence:* University of Ottawa, Clinical Psychology Program, 136 Jean Jacques Lussier, Vanier Hall, Ottawa, Ontario K1N6N5

E-mail: jperr101@uottawa.ca

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# BOOK REVIEWS

## The City and the Coming Climate: Climate Change in the Places We Live

Brian Stone, Jr., Georgia Institute of Technology, Georgia, USA,
Cambridge University Press, 2012, 187 p.
ISBN: 987-1-107-01671-2

**Reviewed by** ANSAR KHAN[1], SOUMENDU CHATTERJEE[2], DIPAK BISAI[1]
[1]Vidyasagar University, [2]Presidency University, India

The book is a unique and pioneer contribution to the field of urban climatology. It has been intended by the author to describe and illustrate the ways in which cities are altering their own climates and to mull over what actions might put into a slowing of the swift warming by now underway in the urban environments. The requirement for cities to actively manage the growing menace of extreme heat within their jurisdictions has become additionally apparent during the period of the book's writing – an episode in which cities around the world had some of the most extreme climate related events that ever visited the human settlements. Yet, coupled with several urban environmental dilemma of unprecedented intensity in the past few years, it has been an almost complete breakdown for the developed international policy framework to manage the problem of climate change. In the wake of the obvious failure of the Copenhagen Climate Conference to establish a successor agreement to the Kyoto Protocol, a growing list of developed nations have announced their intent to withdraw from the global policy framework altogether by the close of the first commitment period in 2012. These recent events in concert – a growing incidence of extreme weather in the urban environments and a widening climate policy vacuum – require cities to move aggressively to protect their populations from climate-related threats in the present period. In this regard, the author hopes that this book can help to enlighten the development of urban and metropolitan scale strategies to cope with climate change more unswervingly in the places most vulnerable to the effects of extreme heat. To this end, the book has been directed toward a few key purposes.

Out of the manifold climatic and environmental problems which our world is facing today, the increasing heat around the urbanized atmosphere is the most crucial. And the tendency for urbanized areas to amplify heat waves raises a critically important but seldom examined question: To what extent will urbanized areas amplify global warming? Specially, if the IPCC (2007) is projecting a 2 to 12˚F increase in globally averaged temperatures by 2100, should the author expect a comparable increase at the scale of large cities or an even greater rise in temperature? The answer to this question reveals a surprising shortcoming in the global science community's approach to climate research. The main endeavour of this book is to explore the causes that are mostly responsible for the rapid change of climate, particularly in urban areas, and to indicate the possible necessary steps that can be taken to overcome this predicament. Due to the day by day increasing heat, the problems or effects that cities and the whole world are facing has also been indicted. Calamities like urban heat waves, droughts, extinction of some species, excessive flood storms, like tornadoes, are the outcome of such horrible climate change. In such critical situations when urban

environment is about to go to hell, we should take some immediate steps to protect the population from the climate related threats.
This book will help the urban and metropolitan scale strategies to control the rapid climate change which results in extreme heat around the earth atmospheric system. To make this purpose fruit full, the book has been directed towards a few key purposes. The first effort has been to vividly differentiate global from regional scale climate change processes. In the first chapter, the mechanism of the global greenhouse effect has been widely validated and it is generally accepted in the science community with the surety of a physical law.

Again, the world is to face the greenhouse effect that has now broadly come into existence. As a result, the unexpected rise of temperature is in the global surface for which the water level in the ocean is increasing day by day. If it continues like this, our planet will be under water in the future as already predicted by the meteorologist and other earth scientists. So to get rid of it and to save mankind, we have to be conscious of its origin.

In regard to protect our precious mankind and community from the cruel paws of rising temperature, we should not depend only upon the global institutions; we should build up some self-governing institutions, where some environmental approaches can be taken into action for future climate dilemma.

The second objective of this book is to show how land use is playing a great role in the climatic disorder, on the surface energy balance and also on atmospheric carbon, not only in the urban, but also in the rural environment with the arrays that are the direct outcome of it and the physical strategies which are effective in mitigating such problems. Many of the largest urban areas worldwide, including the most populous regions of North America, Europe, and Asia have been found in recent decades to be warming at more than twice the rate of the planet as whole. The clear conclusion to be derived from these studies is that, in the most populous regions of the planet, land use change is often playing a greater role in ongoing warming trends than the emission of greenhouse gases.

The third objective of the book has been to reveal how the global policy framework for climate management has been a hindrance to detect the principal drivers which are taking the cities into the valley of excessive heat; how the recent climate change narrative formed by the framework convention and its associated protocols ignore the land-based causes, which are not less powerful drivers of climate change than the global greenhouse effect; and how instead of scaling back the emission-control efforts in cities, heat management strategies can be reformed more powerfully and robust in order to diminish this problem.

Moreover, this book has been associated with the resilience of cities. If our modern postindustrial city continues to walk on the path that is walking now, the time will come in the future when our forthcoming generation will be devoid from both limitless energy as well as stable and fresh environment; and therefore, it is the time for us to bring the necessary changes to the surface composition and spatial organization of the landscape.

The author has suggested some of the physical changes which are very essential for the urban population and cities to diminish the rapidly rising temperature as far as possible. These changes may be categorized as three general categories of urban climate change management, of which the first gives emphasis on the sun screening strategies such as land-based management: vegetative cover, building envelope, expansion of urban tree canopies, use of reflective materials in building and road resurfaces which are very effective, and immediate to reflect or dissipate heat energy in urban environments; the second stresses upon green belting strategies which can be actualized by restoring the ecological integrity of metropolitan hinterlands, and by protecting and cultivating the moisture efficient species of vegetation in the arid region.

The final category of urban climate management focuses upon the energy conservation and the efforts to minimize the production of waste heat in cities. This can slow the pace warming by limiting the magnitude of fossil fuel combustion for transportation, industry and building climate control. Besides, carbon cooling strategies produce a direct linkage between regional and global scale climate management, by limiting both thermal and green house emission associated with fossil energy.

At the conclusion of the discussion and analysis, the one thing that the author reminds us is that the remedy of this crucial problem is not possible only by institutions, global policy framework or technological capacity but it depends upon the seriousness and recognition on the part of urban governmental sufficiency. Above all, it is the rate at which climate is changing in cities that most clearly illuminates the lessons of the urbanized areas heat wave for urban governments and residents. Where such an event remains a statistical improbability, cities could be forgiven for prioritizing other critical needs above preparations for combating climate change. The author focuses on this question following the heat wave which would show that, in the absence of the influence of human induced warming, an event approaching the intensity and heat wave would indeed remain quite rare, occurring on average once every thousands years. Yet, assuming that global temperatures continue to rise at the rate of recent decades, the frequency of such a heat wave increases substantially – so much so that, by the year 2040, such heat waves may be expected to occur every year. Such a world seems hardly imaginable: temperatures of sufficient intensity and duration to physically warp the steel of railroad tracks and melt the asphalt of streets- every year. To this end, what is most important to provide a bright, fresh and soothing environment and climate to our coming generation, is that we must be more active, sincere and serious of the confronted danger: to what extent will cities desire to cope with their own climate fate or destiny?

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# Atlasul Electoral al României / Atlas Electoral de la Roumanie / Electoral Atlas Of Romania (1990 - 2009)

Corneliu Iaţu (coordinator), Ionel Boamfă, Ciprian Alupului, Sebastian Năstuţă, Silviu Petru Grecu, Romeo Asiminei, Raluca Ioana Horea-Şerban, Voicu Bodocan, Aurelian Giugăl, Cătălin Timofciuc, Trilingual Edition, Editura Universităţii Alexandru Ioan Cuza din Iaşi, 2013, 754 p. ISBN 978-973-703-629-2

**Reviewed by** MIHAI BULAI, University Al. I. Cuza of Iasi, Romania

The book represents an academic premiere both for the multidisciplinary ensemble of the political sciences and for the sphere of human geography, particularly the political one. Through the magnitude of the research and mapping of the post December Romanian electoral phenomenon, the *Electoral Atlas of Romania*, published in three languages, stands as a „Gordian knot" for the revival of the electoral geography, as a border field between political sciences and geographical studies. The research team is an interdisciplinary one, made up of experienced researchers in the field of electoral sociology, studies of electoral behaviour, political sciences and human geography. Therefore, the academic effort of drafting such a „work" is a huge one, both in respect of the analysed historical period and of the structuring of the research by elements related to electoral marketing analysis, political behaviour or vote sociology. All these elements make the *Electoral Atlas of Romania* an unprecedented work within the Romanian academic and political space, and also a valid instrument useful to get a radiography of the local electoral process.

As regards the structure of the paper, we can identify two research plans. The first plan is undoubtedly a pragmatic one, destined to policy makers, collective political actors, specialists in public opinion polls or those within the electoral marketing space. This plan provides the reader a fairly comprehensive image of the evolution of the Romanian post December elections at the level of the main electoral cycles. The amplitude of this work resides in the fact that the authors of the *Atlas* managed to capture the Romanian electoral dynamics for a period of two decades (1990-2009) for all types of elections (local, parliamentary, presidential and Euro parliamentary). The electoral results are presented in an attractive manner, by means of some well-structured cartograms along with a brief statistical analysis based on centrality and variability indicators. The research data are comparatively placed by electoral cycles, so that the reader or specialist outside the electoral geography sphere may grasp the nuances and mutations occurring within the electoral basin from one ballot to another. Both electoral fluctuations and legislative-administrative changes are well captured by the researchers in the field, especially for the first investigated period: 1992-2002. Besides this imagistic dimension, the work manages to depict the internal evolution of the Romanian democracy, from the beginning phase, passing through the stage of building the rule of law, to the phase of political consolidation and integration in a transnational structure. This political evolution occurs synchronously with the evolution of social psychology, with the Romanian electors' mentalities, with their political hopes and disappointments. That is why the work still retains a profound sociological substrate, reiterating the thesis of the two-speed development of the Romanian society.

In this respect, in the preface of the paper, academician Alexandru Ungureanu states the following: "one of the most striking features of the Romanian electoral geography is represented by **the profound regional differentiations** that are typical of present-day Romania, almost to the same degree as in the past. Whoever consults a large part of the atlas maps cannot but be struck by the concreteness with which two contrasting Romanians get shaped – a central-western Romania, mainly Carpathian, with a higher living standard, better marked civilization features, a more compact and better maintained transport network, generally voting in favour of centre parties and a continental Romania, in the east and south, covering hill and plain areas, with deep reminiscences of feudalism and collectivism, marked by a great civilizational backward stage and systematically voting in favour of the left wing" (p. 12).

The image of the two Romanias perfectly overlaps both the classical urban-rural cleavage and the East-West geographical one. This image of the Romanian democracy and society is, probably, the most representative contribution of the authors to the description and explanation of the local collective mental system. From the cartographical point of view, the present electoral maps act as maps of a strongly fractured collective mental system, at the level of which civic activism mixes, in a variable geometry, with the passivity and obedience typical of authoritarian regimes. We consider that this is the absolute advantage of this work: that of nuanced depicting, cartographically and imagistically, the evolution of the Romanian post December society. This evolution may perfectly overlap the pre-war dynamics of Romania, a fact which can be inferred from the historical – electoral analysis at the beginning of the atlas. By means of the interdisciplinary character of the book, the authors certainly managed to overcome the classical grid of drawing up a geographical atlas. This places us in front of a monograph of political sociology, sensitive to all the mutations the fragile Romanian democracy has experienced.

The usefulness of such an approach resides in the comparative working methodology, the whole historical evolution of the Romanian political parties, of the electoral legislation and of the administrative-territorial cuttings having the year 1990 as a reference point. That is why we consider that we can speak of an almost experimental research, at the level of which the image of the Romanian electoral system from 1830 to 1989 can be compared to the cartographical and explanatory approach suggested by the authors for the post December election cycles.

From this point of view, the atlas has a fairly substantial chapter dedicated to the history of the Romanian electoral system, a synopsis of the main electoral events of the $19^{th}$ and $20^{th}$ centuries, as well as a politological analysis of the driving forces that led to the construction of the Romanian modern state. Without such a historical-politological image of the local election mechanisms, the present work would have probably remained only a cartographical reference element for geographers, not being able to express anything of the intellectual consistency of the becoming of a democratic society. That is why the present atlas, drafted in a sociological manner, stands as the first consistent benchmark for the history of the mental collective system and of the electoral attitudes and behaviours.

The second plan of the work, less detectable than the socio-politological one, is the epistemological and methodological plan of the research. In respect of its methodological grid of making a radiography and analysis of the post December electoral dynamics, the atlas stands out through the variety of documentation sources and data processing means. Thus, from the methodological point of view, the authors managed to make a synthesis between the statistical and mathematical processing and analysis of the information and the cartographical plan, specific to geographical studies. Each map in the atlas observes the rules of statistical inference, the authors inserting in the electoral analyses a series of statistical centrality, consistency and validity indicators. In this respect, the atlas represents a rich source of quantitative data and scientific milestones for anyone who is interested in the dynamics of the Romanian elections.

The epistemological dimensions of the atlas derive from the good operationalization of the research concepts, from the attempt at providing a guiding framework for future research of electoral marketing or electoral geography, as well as from the convergence between inferential validity and fidelity of the research instruments. In this respect, the work, a premiere in the Romanian academic space, remains a reference element for the researcher in the field of political science, political sociology, electoral geography or political psychology. The entire intellectual labour of the authors could rather be integrated within an interdisciplinary effort of drawing up a treaty of political sociology, political history or analysis of the psycho-attitudinal features of the Romanian electorate and of a still fragile democratic process.

**Aims and scopes**

Analysis of the urban and regional condition needs to be interdisciplinary. In reality, urban researchers usually tend to belong to a discipline reflecting their training whether as sociologists, geographers, planners or any number of subjects concerned with the study of space and place. Our training very often endorses an appreciation of how other disciplines explore the city. For the journal the acknowledgement of the many disciplines that concerned with understanding cities and regions will be indicated by the different disciplinary back-grounds reflected in the papers published. Articles will be published by geographers, sociologists, planners, economists, political scientists, to mention just few of the disciplines involved in urban and regional study.

The Journal of Urban and Regional Analysis plans to be a key outlet publishing topical articles dealing with cities and regions. In later issues we plan to include sections devoted to notes and comments as well as a policy section outlining and discussing state and non-state initiatives aimed at improving cities and regions, together with the problems confronted by their implementation.

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University of Bucharest - Interdisciplinary Centre for Advanced Research on Territorial Dynamics, 030018, Bucharest, Romania 4-12, Regina Elisabeta Blv.
E-mail: office@cicadit.ro

Ronan PADDISON
University of Glasgow - Department of Geographical and Earth Sciences East Quadragle University Avenue, Glasgow G12 8QQ UK
E-mail: Ronan.Paddison @ges.gla.ac.uk


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