Measuring urban concentration: a spatial cluster typology based on public and private sector service patterns

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Abstract: The main objective of this paper is the definition of a methodological framework for the determination, analysis and cross-evaluation of urban clusters which are formulated within wider study areas, such as administrative regions. To this end, different methods and techniques are utilised, that stem from the fields of statistics and quantitative spatial analysis. The geographical delineation of urban clusters is mainly based on different types of variables, such as the demographic characteristics of the cities, the number of public and private sector services located in them, as well as the total length of the road network in the study area. Furthermore, a comparative urban concentration indicator (UCI) is devised, which reflects the role and the relative weight of every urban area in the study region as well as its spatial influence. Both the proposed methodological framework and the UCI are applied to the region of Thessaly, Greece.

Keywords: public services; private services; quantitative spatial analysis; urban concentration; Thessaly; urban clusters; urban growth; sustainable development.


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### 1 Introduction

The rapidly increasing levels of urban growth and concentration recorded in most countries over the last two centuries constitute an unprecedented spatial phenomenon. As a result more than half of the world’s population currently lives in major towns and cities. In the most industrialised areas, where the spatial clustering and social diffusion processes of urbanisation seem to have come to an end, the question of future evolution is still under debate (Antrop, 2004). In this respect, the correct interpretation of actual trends in urban growth is a key issue for predicting further tendencies.

Initially, it was Plato’s ideas (4th century BC) concerning the role of urban centres, which stated that the ideal size of cities could be calculated with mathematic models (Pangle, 1979). Subsequent approaches focused on economic and social criteria; in the mid-1960s, Doxiadis (1964), defined “cities – states” according to the distances travelled on foot from the centre to the borders between sunshine and sundown. Christaller (1966) formulated his central place theory, which was based on the supply and demand of goods and services. In a more recent work, Portnov and Erell (2001) used a location-clustering indicator as a measure of relations between cities and with respect to applied regional policies.

However, during recent years, the role of urban centres in their regions varies, depending mainly on their location and the relations with surrounding cities and settlements. The reason for this is that through their service levels they affect the dependence of settlements at a specific distance from them and thus their further development and the region’s sustainability. Such varying levels of influence and service have led, to the appearance of regional inequalities and many researchers have tried to interpret them through different scientific approaches. In most cases, they focused on the application of methods and techniques as well as the formulation of models, while seeking a theoretical framework.

The aim of this paper is the definition of a methodological framework for the study of spatial connections that are established between settlements, their degree of influence and interdependence, and through these the definition and evaluation of urban clusters. The emphasis is on the analysis of public (education, culture, sports and administrative services) and private (industry, commercial and private services) sector concentration patterns. Additionally, since the proposed framework is mainly based on methods and techniques of spatial analysis applied in a GIS environment it can constitute an important decision support tool for the interpretation of urban system formation and settlements spatial organisation.
2 Urban growth theory and methods

The analysis of urban evolution constitutes a well-established area of research for a plethora of scientific fields aimed at the interpretation of operations and plans that permeate cities. Facilities and activities that are located either in the core or at the outer edges of cities and settlements play an important role in the formation of the urban environment. They offer substantial potential to strengthen each city’s growth while influencing the interaction among people and space.

Sustainable urban growth, defined as “the potential of urban areas to attract new residents while maintaining their existing” (Lehmann, 2010), undoubtedly constitutes a complex phenomenon. However, the above definition is further enhanced by a set of analytical indicators and criteria, which formulate the basis for the interpretation of the relation between the sustainable demographic growth of cities and the attributes of their locality (Portnov and Erell, 2001). According to Wong (1995) indices that can determine growth in an urban and regional planning context must follow three rules:

- quantification of needs and opportunities that each geographic region or locality offers, for the distribution of resources
- placement of the terms with which improvement of an area through public political intervention may exist
- recognition of the most important opportunities and problems for each area as a basis for the determination of political objectives.

Therefore, there are three basic categories of criteria that affect the sustainable growth of urban areas; these are the environment, the population and the economy, which at the same time constitute the basis for sustainability control. Sustainability over the last few years is often related to the term ‘cluster’ which is used in many academic disciplines, such as astronomy, sociology, economy, statistics, geography and regional planning. However, the interpretations of a cluster’s operative causes and future trends in these sectors differ significantly, when we refer to:

- clusters of galaxies (Newton, 1692)
- clusters of data (Grekousis et al., 2012)
- clusters in social groups (Moreno, 1953, 1978)
- clusters of opportunities (Fotheringham, 1991)
- clusters of industries (Weber, 1909, 1929).

In all of the above cases, the term ‘cluster’ mainly describes the same phenomenon: “a set of neighboring objects or entities which are associated through some functional or geographical linkage” (Portnov and Erell, 2001). In the fields of geography and regional planning and when objects refer to cities, such neighbourhoods represent urban clusters. The attempt to interpret the above phenomenon began in the 4th century BC, when Plato made an effort to determine the ideal city-state, considering that this should be constituted from 5,040 landowners and be controlled by 37 law ephods and a 360 member council (Pangle, 1979).
Extending further the above definition, Doxiadis (1964) concluded that the size of cities should be relevant to the total number of trips recorded between sunshine and sundown in their greater area. Thus, for a median city the average distance to the borders should not exceed that of a four-hour walk; one-hour for a small city and seven hours for major cities. Later, three additional definitions of the ideal size of cities were presented by Richardson (1977) and Clark (1982), Howard (1985) and Haughton and Hunter (1994). However, while Clark and Richardson related the ideal size with minimal cost Howard argued that the ideal city size should be 32,000 residents in an area of 3,000 m². Respectively, Haughton and Hunter, defined the ideal size of a city between 100,000–250,000 residents, which in turn, signified potential for economic growth (see Table 1).

Table 1  Empirical Approaches to the definition of ideal city size

<table>
<thead>
<tr>
<th>Writer</th>
<th>Year</th>
<th>Characteristics of ideal city</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platon</td>
<td>4th century BC</td>
<td>5,040 landowners and a council of 360</td>
</tr>
<tr>
<td>Doxiadis</td>
<td>1964</td>
<td>Three kinds of cities—states, depending on the distance that can be covered between sunshine and sundown</td>
</tr>
<tr>
<td>Richardson, Clark</td>
<td>1977, 1982</td>
<td>The size depends on minimal cost</td>
</tr>
<tr>
<td>Howard</td>
<td>1985</td>
<td>Ideal size of 32,000 residents and 3,000 m²</td>
</tr>
<tr>
<td>Haughton – Hunter</td>
<td>1994</td>
<td>Ideal size of 100,000-250,000 residents</td>
</tr>
</tbody>
</table>

2.1 Urban clusters and concentrations

Urban clusters are spatial concentrations of urban places, which have ‘variable’ boundaries and in most cases, include major cities. Inside these boundaries each urban settlement asserts ‘its’ own commuting range and belongs to a cluster of populated places. Initially, the only criteria for the determination and categorisation of urban clusters were population, area and distance travelled within their limits; however, later on, economic, social, historical, political even psychological characteristics were also considered. The first set of the above parameters coincided with the introduction of central place theory by Christaller (McCann, 2002). According to it, cities attract a set of facilities whose functions and activities belong to and are differentiated into three categories:

- **general**: undertaken by the city, in order to serve the neighbouring countryside
- **transport**: usually related to transportation and transport networks
- **special**: carried out in smaller or larger parts of the area (e.g., mining and industrial activities).

Although these categories may be regarded as important factors of urbanisation, there is no doubt that the main role of a city is to act as a regional centre and serve its hinterland. Consequently, two additional criteria for the definition of a central city emerge: critical size, which means the minimum population that is required in order to support and establish an urban service, and geographical extent, which reflects the furthest distance to which goods or services are offered. (Argyris, 1997)
Golany (1982) stated that the role of urban clusters is evaluated through its contribution to the reduction of the spatial isolation of disadvantaged regions. This means that, clusters of cities scattered in disadvantaged areas may have economic profits by decreasing total infrastructure and transport costs. In a similar framework, Krakover (1987) analysed the advantages and disadvantages of urban clusters in Northern Carolina and Piedmont utilising statistical data. He managed in this manner to define two distinct stages of growth for cities which form urban clusters:

- In the first stage, cities are relatively small and existing economic, technological and spatial conditions coincide with accumulated economies.
- In the second stage, after cities surpass a certain population limit, a number of services and authorities relocate to the suburbs. Such an economic diffusion is considered less likely to evolve in a cluster of smaller cities.

Another basic issue for the establishment of urban clusters and the definition of urban systems is the hierarchy of settlements and towns. Many efforts have been made during recent years for the adoption of a particular mode of hierarchy. In certain cases most of them were applicable, depending on the urban system of each country (Haggett, 1966). In order to explain the urban systems and assessed of their hierarchical structure, the microeconomic theories reached the conclusion that this is influenced by increasing the size of the urban centre. For example, Fujita and others (1994) make the assumption that the system optimises the operation of establishing a balance between supply and demand for services in the medium term of the city, while people optimise their position by maximising their usefulness. Rozenblat and Pumain (1992) indicate that the greater economic integration gets within the European Economic Community and the more links between all European countries proliferate; the more urban systems will be changing their structure.

Finally, an important contribution to the definition of urban clusters in the interior of regions came from Portnov and Erell (2001). They focused their analysis on the formulation of an indicator, which reflects whether clusters exist in a greater region and how these can be described based on their distance from the central city [equation (1)]:

\[
IC = \frac{IS}{IR}
\]

(1)

where

- \(IC\) the index of clustering
- \(IR\) the index of remoteness (aerial distance from a settlement to the closest major urban centre, in kilometres)
- \(IS\) index of spatial isolation (number of towns located within a practical range for daily commuting)

Their approach aroused the concept of cities and urban systems in a quantitative way since a system or district of cities is considered as the entire urban territory. Consequently, Pumain (2004), in a concentrations assessment concept argued that the number of cities in a given territory would always be in an inverse geometric progression of their sizes.
3 Methodological framework

Since urban concentrations assessment is critical for the interpretation of phenomena in an urban or rural context, methods and techniques from the quantitative spatial analysis toolbox are needed. According to the proposed approach, a thorough study and evaluation of the spatial relationships between settlements and central cities can be achieved with the adaptation of the following methodological framework (Figure 1).

**Figure 1** Proposed methodological framework

In the first step of the process is data collection and organisation, which eventually lead to the spatial database creation and management; both are essential for the definition of urban clusters, so they must be thoroughly examined and updated in order to ensure the validity of the final results. The next step is the categorisation of settlements, aiming to define discrete groups in the study area. A typical way to deal with this issue is based on the population that each settlement has and the degree to which it corresponds to the term ‘urban’. Accordingly, the critical problem parameters are defined. These refer to the strength and potential of the area’s urban centres at the demand, supply, and service level. Furthermore, they contain data concerning the number of public facilities and private sector enterprises, along with measures that reflect the overall accessibility of surrounding areas. Such measures are based on attribute data of the area’s road and railway network as well as the public transport system. Specialised methods and techniques of spatial data analysis (Photis, 2002) are adopted in a geographic information systems (GIS) environment, in order to support and accelerate a combined exploitation of multivariate information.

The service area calculation performed at the second stage is based on each settlement’s accessibility cost (network time or distance) defined either by allocating each settlement to the nearest urban centre or through the formulation a locational indicator (Koutelekos et al., 2008). In a GIS environment and with respect to road
network arcs, attribute data must include the category they belong to by means of max
travel speed allowed. Following the delineation of service areas, existing urban patterns
and formations are defined. To this end, settlements and services concentrations are
assessed and thus, urban clusters are roughly evaluated.

Finally, a numerical indicator is defined which derives its value from the strength of
clustering around each urban centre in the study area. The attribute variables utilised refer
to critical infrastructural and developmental characteristics of each settlement-centre.
These also reflect its importance in the study area. The performance and effectiveness of
the proposed methodological framework are evaluated through its application for the
definition of urban clusters in the region of Thessaly, Greece. The specific area, due to its
demographic characteristics, geomorphology, inadequate and obsolete road network as
well as its, sometimes extreme, climatic and weather conditions is considered as an ideal
case study.

Each settlement, depending on its population size, holds operations and services,
which attract smaller populations from neighbouring places. In this respect and in a GIS
environment, around each large or smaller (based on population) urban centre, its service
areas can be realised as a specific network radius.

In multivariate analysis, cluster analysis refers to methods used to divide up objects
(cases or lines) into similar groups, or, more precisely, groups whose members are all
close to one another on various dimensions (characteristics or columns) being measured.
There are two main methods of cluster analysis: hierarchical, which starts with equal in
size groups and progressively merges similar groups until a dendrogram which contains
the total number of cases is formulated, and bisectional, which starts with a set that
contains the total number of cases and progressively removes cases based on
dissimilarity, creating new groups and redistributing cases, until a predefined number of
groups is optimally formulated (Maloutas, 1994).

4 Spatial concentration patterns in Thessaly

According to the proposed methodological framework, the settlements of Thessaly were
categorised into the following groups, which in large part coincide with the groups that
the National Statistical Service of Greece (2001) has adopted:

- settlements with a population of less than 2,000 residents (922 occurrences)
- secondary settlements with a population of more than 2,000 and less than 10,000
  residents (28 occurrences)
- primary settlements with a population of more than 10,000 residents (4 occurrences).

In this paper and with respect to urban clustering strength and level of analysis set, only
settlements with 2,000 to 10,000 residents and settlements with more than 10,000
residents were examined. For the definition of service areas in the GIS environment, two
digital geographic datasets were used: a point coverage, with additional information
about each settlement’s population and altitude (2001 census data) and a line coverage of
the road network, with length and maximum speed data. The three types of roads that
were considered are based on their international categorisation (Gutierrez and Urbano,
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- 1st category, with an average speed of 120 Km/h, in which the E-75 highway belongs
- 2nd category, with an average speed of 100 Km/h, in which the E-90 motorway belongs
- 3rd category, with an average speed of 70 Km/h, in which the rest of the national road network belongs.

4.1 Service area definition

Based on the each settlement’s (node) accessibility to the nearest city (centre), the service areas of cities with population larger than 10,000 residents and population 2,000–10,000 residents were defined. In this respect, each node \( i \) is assigned to the centre \( j \) for which the indicator of interaction \( L_i \) takes the minimum value \( L_{ij} \) according of the following equation (2):

\[
L_i = \min L_{ij} = \frac{W_j}{d_{ij}}
\]

where

\( i = 1, \ldots, n \)
\( j = 1, \ldots, k \)

\( L_{ij} \) is the intensity of node’s \( i \) interaction with centre \( j \)

\( W_j \) is the weight (population or number of public or private sector services) in each centre \( j \)

\( d_{ij} \) is the distance between node \( i \) and centre \( j \).

The above indicator shares common ideas with that of Portnov and Erell (2001) described in section two. The main difference is in the way attractiveness or interaction is calculated. Portnov and Erell group towns located within a practical range for daily commuting (in kilometres) according to their aerial distance from the closest major urban centre. Our indicator not only utilises network distances but also contains the notion of relative interaction since it considers all \( k \) centres that can serve a town \( i \). Furthermore, interaction is calculated based on three different realisations of weight (population, number of public sector services, number of private sector services).

Maps 1, 2 and 3 display the defined service areas and settlements of each centre with population, more than 10,000 (primary) in the four Prefectures of the Region of Thessaly. The indicator’s \( L_{ij} \) weight is formulated either according to population \( P_j \), the number of public facilities \( F_j \) or the number of private enterprises \( E_j \) of each centre \( j \). Colours are assign to each point depending on the centre which serves it according to \( L_i \). Since administrative borders are also displayed some initial conclusions can be asserted.

Respectively, Maps 4, 5 and 6 exhibit the resulting spatial assignments in the form of adjacent polygons for the urban centres with population sizes between 2,000–10,000 residents (secondary).
Measuring urban concentration

Map 1  
Population weighted service areas of settlements with population more than 10,000 residents (see online version for colours)

Map 2  
Public sector weighted service areas of settlements with population more than 10,000 residents (see online version for colours)
Map 3  Private sector weighted service areas of settlements with population more than 10,000 residents (see online version for colours)

Map 4  Population weighted service areas of settlements with population between 2,000–10,000 residents
Measuring urban concentration

Map 5  Public sector weighted service areas of settlements with population between 2,000–10,000 residents

Map 6  Private sector weighted service areas of settlements with population between 2,000–10,000 residents

Following the determination of service areas for each settlement–centre additional data were created and added to the database regarding the number of settlements covered, the total population served, the percentages of road network per category and their sizes. It should be stressed that while in the prefectures of Trikala and Larisa for settlements with populations of more than 10,000 residents the served settlements are more than 200, in the prefectures of Karditsa and Magnisia they never exceed 100. With respect to centres with population 2,000–10,000 residents in Map 6 a slightly changed pattern is shown.
Higher concentrations, exceeding 30 served settlements on average, were noticed in the western parts of the Karditsa and Trikala prefectures, as well as in the southern part of Larissa prefecture, while in the prefecture of Magnesia the higher concentration was observed in its centre. On the other hand, lower concentrations, with less than 20 served settlements, are observed in the northern part of the prefecture of Larissa.

4.2 Analysis of settlements concentrations

Our approach focused on urban centres of 2,000–10,000 residents, since (in most instances) these coincide with concentrations of settlements inside the study region’s boundaries. According to the proposed methodological framework, and in order to assign settlements to this category of centres, K-means analysis was adopted. Settlements were grouped into three categories with respect to a set of variables. More specifically, for the public sector we utilised settlement population and number of facilities in sports (athletics fields – track, basketball, football etc.), education (school in all levels), culture (theatres, cinemas, museums etc.), and the emergency sectors (police stations, fire stations and health services). For the private sector we utilised population and number of businesses in industry, commerce and service sectors. Tables 2 and 3, show the groups which were formulated when the variables referring to the number of public services were considered. Respectively, Tables 4 and 5, show the groups according to the number of private enterprises were considered.

A first conclusion is that values of groups 1 and 3 are better than Group 2 in all categories. More specifically, service centres that belong to group 3 perform well in all categories but sports (education, culture and emergency), where Group 1 has the higher values. This fact redefines settlements of Group 1 and 3 as major service centres (MSC) of Thessaly. On the contrary, Group 2 exhibits different, and in most cases lower, service levels. Thus, the resulting settlement-centre hierarchy is Group 3 – Group 1 – Group 2.

Table 2  K-means public sector clusters of settlements with 2,000–10,000 residents

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampelonas</td>
<td>Agia</td>
<td>Karditsomagoula</td>
</tr>
<tr>
<td>Elssona</td>
<td>Agria</td>
<td>Kranea Elassonas</td>
</tr>
<tr>
<td>Palamas</td>
<td>Velestino</td>
<td>Livadi</td>
</tr>
<tr>
<td>Giannouli</td>
<td>Megala Kalyvia</td>
<td>Tsaritsani</td>
</tr>
<tr>
<td>Goni</td>
<td>Mouzaki</td>
<td>Falani</td>
</tr>
<tr>
<td>Dimini</td>
<td>Nea Aghialos</td>
<td>Farkadona</td>
</tr>
<tr>
<td>Zagara</td>
<td></td>
<td>Nikaia</td>
</tr>
</tbody>
</table>

Table 3  Public sector cluster characteristics for settlements with 2,000–10,000 residents

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of population</td>
<td>0.079900</td>
<td>0.038400</td>
<td>0.106000</td>
</tr>
<tr>
<td>% of education</td>
<td>0.049155</td>
<td>0.024424</td>
<td>0.072811</td>
</tr>
<tr>
<td>% of emergency</td>
<td>0.037736</td>
<td>0.033019</td>
<td>0.045283</td>
</tr>
<tr>
<td>% of culture</td>
<td>0.043860</td>
<td>0.032237</td>
<td>0.044737</td>
</tr>
<tr>
<td>% of sports</td>
<td>0.090909</td>
<td>0.026515</td>
<td>0.039394</td>
</tr>
</tbody>
</table>
In the same manner, the examination of the following two tables (see Tables 4 and 5) indicates that Groups 1 and 3 also contain settlements representing MSC’s of Thessaly. Respectively, they share common characteristics, while Group 2 exhibits different and in most cases lower service levels; the resulting settlement-centre hierarchy in this case is Group 1 – Group 3 – Group 2. A first conclusion that derived from the application of K-means analysis is that the resulting groups successfully reflect the notion of urban clusters, in terms of their centre’s degree of diachronic development.

Table 4  
**K-means private sector clusters of settlements with 2,000–10,000 residents**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalampaka</td>
<td>Agia</td>
<td>Karditsomagoula</td>
</tr>
<tr>
<td>Agria</td>
<td>Kranea Elassonas</td>
<td>Ohalia</td>
</tr>
<tr>
<td>Ampelonas</td>
<td>Farkadona</td>
<td>Sourpi</td>
</tr>
<tr>
<td>Sofades</td>
<td>Livadi</td>
<td>Sykouri</td>
</tr>
<tr>
<td>Gonoi</td>
<td>Megala Kalyvia</td>
<td>Tsaritsani</td>
</tr>
<tr>
<td>Dimini</td>
<td>Mouzaki</td>
<td>Falani</td>
</tr>
<tr>
<td>Zagora</td>
<td>Nea Aghialos</td>
<td>Palamas</td>
</tr>
</tbody>
</table>

Table 5  
**Private sector cluster characteristics for settlements with 2,000–10,000 residents**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of population</td>
<td>0.0935</td>
<td>0.0417</td>
</tr>
<tr>
<td>% of industry businesses</td>
<td>0.1984</td>
<td>0.0299</td>
</tr>
<tr>
<td>% of commercial businesses</td>
<td>0.1684</td>
<td>0.0356</td>
</tr>
<tr>
<td>% of private services businesses</td>
<td>0.4043</td>
<td>0.0324</td>
</tr>
</tbody>
</table>

4.3 Urban concentration indicator (UCI)

The applied methodological approach can form the basis for the creation of an indicator which may compare settlements in terms of clustering status and potential, taking into consideration their critical service characteristics and determining at the same time their dominance and importance in the region. The mathematical formulation of the UCI is [equation (3)]:

$$D_j = \left\{ \frac{\sum_{i=1}^{N} a_{ji} + 1}{N + 1} \right\} \left\{ \frac{P_j + \sum_{i=1}^{N} P a_{ji}}{P_j + \sum_{i=1}^{N} P_i} \right\} \left\{ \frac{S_j}{\sum_{j=1}^{M} (S_j)} \right\} \ast 1,000$$

(3)
where
\[ a_{ij} = \begin{cases} 
1 & \text{if } d_{ij} < m_j \\
0 & \text{if } d_{ij} > m_j
\end{cases} \]

\[ m_j = \text{average distance travelled} \quad m_j = \frac{\sum d_{ij}}{N} \]

\( d_{ij} \), the distance between \( i \) and \( j \)

\( m' \) is the medium distance of settlements with \( d_{ij} > m \)

\( P \) = population of each settlement or centre of service

\( S \) = number of services

\( j = 1, \ldots, M \) service centres

\( i = 1, \ldots, N \) settlements served (inside region)

The aim of the above indicator is to analyse and evaluate the infrastructural capacity and potential of settlements-centres and the urban concentrations around them, based on two main parameters; the clusters of serviced settlements and the settlement-centre. Consequently, its deducted form can be expressed as [equation (4)]:

\[ D = \text{CLUSTER} \ast \text{SERVICE CENTRE} \ast 1,000 \]  

(4)

The first term of the equation examines the serviced settlements cluster based on the number of settlements, the population served and their average distance, and reflects its clustering status and perspective.

### Table 6  Public sector urban concentration indicator for settlements with population of 2,000–10,000 residents

<table>
<thead>
<tr>
<th>Rank</th>
<th>Settlement – service centre</th>
<th>UCI</th>
<th>Rank</th>
<th>Settlement – service centre</th>
<th>UCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tyrnavos</td>
<td>369.7837</td>
<td>14</td>
<td>Agria</td>
<td>159.1259</td>
</tr>
<tr>
<td>2</td>
<td>Farsala</td>
<td>366.2827</td>
<td>15</td>
<td>Agia</td>
<td>156.2878</td>
</tr>
<tr>
<td>3</td>
<td>Almyros</td>
<td>311.0211</td>
<td>16</td>
<td>Moyzaki</td>
<td>153.4448</td>
</tr>
<tr>
<td>4</td>
<td>Nea Aghialos</td>
<td>301.2717</td>
<td>17</td>
<td>Farkadona</td>
<td>141.2366</td>
</tr>
<tr>
<td>5</td>
<td>Elassona</td>
<td>295.2091</td>
<td>18</td>
<td>Sykourio</td>
<td>132.565</td>
</tr>
<tr>
<td>6</td>
<td>Kalampaka</td>
<td>253.3141</td>
<td>19</td>
<td>Nikaia</td>
<td>128.6869</td>
</tr>
<tr>
<td>7</td>
<td>Palamas</td>
<td>251.3871</td>
<td>20</td>
<td>Oihalia</td>
<td>128.3622</td>
</tr>
<tr>
<td>8</td>
<td>Sofades</td>
<td>226.9316</td>
<td>21</td>
<td>Sourpi</td>
<td>114.9073</td>
</tr>
<tr>
<td>9</td>
<td>Giannouli</td>
<td>184.1596</td>
<td>22</td>
<td>Livadi</td>
<td>110.3783</td>
</tr>
<tr>
<td>10</td>
<td>Ampelonas</td>
<td>168.7334</td>
<td>23</td>
<td>Megala Kalyvia</td>
<td>97.91365</td>
</tr>
<tr>
<td>11</td>
<td>Kranea Elassonas</td>
<td>164.1392</td>
<td>24</td>
<td>Karditsomagoula</td>
<td>96.80786</td>
</tr>
<tr>
<td>12</td>
<td>Zagora</td>
<td>163.0302</td>
<td>25</td>
<td>Goniol</td>
<td>92.21739</td>
</tr>
<tr>
<td>13</td>
<td>Velestino</td>
<td>159.1302</td>
<td>26</td>
<td>Dimini</td>
<td>88.56842</td>
</tr>
</tbody>
</table>
Measuring urban concentration

Table 7  Private sector urban concentration indicator for settlements with population of 2,000–10,000 residents

<table>
<thead>
<tr>
<th>Settlement – centre of service</th>
<th>UCI</th>
<th>Settlement – centre of service</th>
<th>UCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Farsala</td>
<td>512.3282</td>
<td>14 Megala Kalyvia</td>
<td>96.10815</td>
</tr>
<tr>
<td>2 Kalampaka</td>
<td>508.5882</td>
<td>15 Ampelonas</td>
<td>95.55118</td>
</tr>
<tr>
<td>3 Tyrnavos</td>
<td>479.1138</td>
<td>16 Farkadona</td>
<td>95.30963</td>
</tr>
<tr>
<td>4 Elassona</td>
<td>458.7954</td>
<td>17 Mozyaki</td>
<td>94.13456</td>
</tr>
<tr>
<td>5 Almyros</td>
<td>447.0259</td>
<td>18 Agria</td>
<td>92.04151</td>
</tr>
<tr>
<td>6 Velestino</td>
<td>419.7764</td>
<td>19 Sykourio</td>
<td>88.71854</td>
</tr>
<tr>
<td>7 Giannouli</td>
<td>338.9321</td>
<td>20 Nikaia</td>
<td>59.20964</td>
</tr>
<tr>
<td>8 Nea Aghialos</td>
<td>221.7873</td>
<td>21 Oihalia</td>
<td>47.24823</td>
</tr>
<tr>
<td>9 Agia</td>
<td>201.3452</td>
<td>22 Sourpi</td>
<td>42.29568</td>
</tr>
<tr>
<td>10 Karditsomagoula</td>
<td>166.2898</td>
<td>23 Gonoi</td>
<td>33.94385</td>
</tr>
<tr>
<td>11 Sofades</td>
<td>158.2677</td>
<td>24 Zagora</td>
<td>32.73217</td>
</tr>
<tr>
<td>12 Dimini</td>
<td>130.4029</td>
<td>25 Kranea Elassonas</td>
<td>24.16688</td>
</tr>
<tr>
<td>13 Palamas</td>
<td>115.6648</td>
<td>26 Livadi</td>
<td>18.05716</td>
</tr>
</tbody>
</table>

The second term examines the capacity of the settlement-centre in association with the number of public services, as cultural, educational and emergency, or the private businesses services as industry, commercial and private services, that it offers. Based on the UCI, the settlements with populations of 2,000–10,000 residents were ranked and the results appear in Tables 6 and 7.

Table 8  Hierarchy Placement Comparison

<table>
<thead>
<tr>
<th>Settlement – centre of service</th>
<th>Difference in hierarchy public vs. private</th>
<th>Settlement – centre of service</th>
<th>Difference in hierarchy public vs. private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kranea Elassonas</td>
<td>−14</td>
<td>Oihalia</td>
<td>−1</td>
</tr>
<tr>
<td>Zagora</td>
<td>−12</td>
<td>Sourpi</td>
<td>−1</td>
</tr>
<tr>
<td>Palamas</td>
<td>−6</td>
<td>Farsala</td>
<td>1</td>
</tr>
<tr>
<td>Ampelonas</td>
<td>−5</td>
<td>Elassona</td>
<td>1</td>
</tr>
<tr>
<td>Nea Aghialos</td>
<td>−4</td>
<td>Farkadona</td>
<td>1</td>
</tr>
<tr>
<td>Agria</td>
<td>−4</td>
<td>Giannouli</td>
<td>2</td>
</tr>
<tr>
<td>Livadi</td>
<td>−4</td>
<td>Gonoi</td>
<td>2</td>
</tr>
<tr>
<td>Sofades</td>
<td>−3</td>
<td>Kalampaka</td>
<td>4</td>
</tr>
<tr>
<td>Tyrnavos</td>
<td>−2</td>
<td>Agia</td>
<td>6</td>
</tr>
<tr>
<td>Almyros</td>
<td>−2</td>
<td>Velestino</td>
<td>7</td>
</tr>
<tr>
<td>Mozyaki</td>
<td>−1</td>
<td>Megala Kalyvia</td>
<td>9</td>
</tr>
<tr>
<td>Sykourio</td>
<td>−1</td>
<td>Karditsomagoula</td>
<td>14</td>
</tr>
<tr>
<td>Nikaia</td>
<td>−1</td>
<td>Dimini</td>
<td>14</td>
</tr>
</tbody>
</table>

In order to compare the resulting ranking for both the public and private sector indicators, Table 8 was formulated; it presents the fluctuation of each settlement – centre of service
positioning, for the value of public and private sector indicators respectively. According to this, the first seven cities (green cells) are centres that achieved higher values for the private than the public sector indicator, while the reverse holds for the last six cities (yellow cells), which obtained higher values for the public sector indicator. The other settlements constitute the group with similar levels of development for both indicators.

Comparing the results of these two approaches, and with regard to settlements ranking and grouping, a more detailed conclusion is that Almyros, Kalampaka, Tyrnavos and Farsala constitute the four MSC of the area, whereas Velestino, Sofades and Elassona steadily define the second-best group.

A closer look at the same table showed that public sector agencies have a greater impact on the main centres while the reverse is true for the centers of Dimini of Karditsomagoula and Meglala Kalivia. Finally, there are centres where public and private sector participate equally, such as Tyrnavos, Almiros, Farsala and Elassona.

5 Conclusions

The role of urban centres is crucial for the configuration of any urban system, such as in the case of the Greek one. This comes as a result of relationships created among centres, cities and the neighbouring settlements that they serve, formulating urban clusters that strengthen the overall developmental process. In order to better define and manage urban concentrations, new methods, techniques, models and indicators of spatial analysis are needed in a robust decision to support a methodological framework, which could be applied to different scales of urban and regional planning. Furthermore, there is no doubt that the geographical location of urban centres and their relations with neighbouring settlements constitute two of the most important parameters influencing their longitudinal development. Such direct or indirect relations acquire greater importance with respect to the size of both the urban centre and the neighbouring settlements that they serve. In this paper, a methodological framework for the analysis and comparative evaluation of service areas of urban centres was determined, mainly based on their topological and institutional characteristics and applied to the region of Thessaly, Greece. Moreover, the proposed methodological approach was strengthened with the formation of a comparative UCI, which, while assisting the analysis of urban clusters, constitutes an alternative estimator of their role.

The overall effectiveness of the approach is dependent on the type and the volume of initial information and the quality of the variables taken into consideration. Furthermore, by examining the phenomenon of urban clusters, it can be stated that their diachronic development and degree of growth are influenced, and in most cases are determined, by the number of facilities and services located in any settlement. In this manner, a major city with significant population size, number of services and an efficient road network attracts settlements within a critical distance, while in the opposite case isolation may be observed. The resolution of such problems although not in the objectives of this study, can stem from the reformation of performed regional policies and the redefinition of various political and developmental objectives from the corresponding agencies and institutions.
References


Maloutas, C. (1994) Quantitative Methods of Geographic Analysis: Notes, Department Urban Planning and Regional Development, University of Thessaly, Volos, [in Greek].


Notes

1 According to Oikonomou (1999), a settlement is an aggregation of buildings in a small scale and in relatively high density, which meets and host human needs and activities.