UDC 911:004 (075.8)+316.334 **Sergiy Kostrikov**

SCALE APPROACH TO URBAN STUDIES WITH GIS-TOOLS

This paper represents the well-known scale approach in urban studies upon a new perspective. This perspective to involve through GIS-tools in relevant research not only traditional integer-valued scale measurements and modelling, but also fractal ones reveals the unique level of details in urban system analysis. The paper explains while the scale approach became drastically crucial for contemporary human geographers – because of newly technological advances. Few key basics of urban studies with the scale approach through GIS-tools have been introduced. The survey detailed enough due to applying fractal dimensions in the urban spatial structure analysis with the original GIS software has been provided. Some case studies and examples of the software GUI with the scale approach implemented have been introduced.

***Key words**: scale approach, GIS, urban studies, fractal dimensions, urban spatial structure, urban system analysis, original software*

***Сергій Костріков. МЕТОДОЛОГІЯ МАСШТАБУВАННЯ ЧЕРЕЗ ГІС-ЗАСОБИ В УРБАНІСТИЧНИХ ДОСЛІДЖЕННЯХ.** Стаття представляє відому методологію масштабування в урбаністичних дослідженнях, доповнену оригінальним дослідницьким підходом, який дозволяє подати цю методологію в удосконаленому вигляді. Йдеться про застосування не тільки і не стільки традиційного моделювання через цілочислові масштабування та виміри, але і про застосування фрактального підходу при аналізі урбогеосистем. В статті також пояснюється, чому саме впровадження із урахуванням останніх технологічних досягнень оригінальних доробок методології масштабування грає надважливу роль для сучасної соціальної географії. Стаття також подає декілька ключових принципів впровадження методології масштабування в урбаністичні дослідження через засоби ГІС. Доводиться, чому оптимальний рівень деталізації дослідження урбаністичної системи може бути досягнутий лише на підставі фрактальних вимірів. Характеризуються ключові риси авторського програмного забезпечення, наводяться приклади відповідного графічного інтерфейсу користувача. Також подаються приклади застосувань розробленого ПЗ на окремих міських територіях (Близький Схід, ОАЕ).*

***Ключові слова:** методологія масштабування, ГІС, урбаністичні дослідження, фрактальні виміри, просторова структура міста, аналіз урбогеосистем, авторське програмне забезпечення*

***Сергей Костриков. МЕТОДОЛОГИЯ МАСШТАБИРОВАНИЯ НА ОСНОВЕ СРЕДСТВ ГИС В УРБАНИСТИЧЕСКИХ ИССЛЕДОВАНИЯХ.** В статье обсуждается известная методология масштабирования в урбанистических исследованиях, дополненная оригинальным исследовательским подходом, который позволяет представить эту методологию в усовершенствованном виде. Речь идет о применении не только и не столько традиционного моделирования на основе целочисленных масштабирования и измерений, но и об использовании фрактального подхода при анализе урбогеосистем. В статье также объясняется, почему применение с учетом последних технологических достижений оригинальных усовершенствований методологии масштабирования играет чрезвычайно важную роль для современной социальной географии. Статья представляет несколько ключевых принципов внедрения методологии масштабирования в урбанистические исследования через средства ГИС. Объясняется, почему оптимальный уровень детализации исследования урбогеосистемы может быть достигнут лишь на основании фрактальных измерений. Описываются ключевые характеристики авторского программного обеспечения, приводятся примеры соответствующего графического интерфейса пользователя. Также представлены примеры применений разработанного ПО на отдельных городских территориях (Ближний Восток, ОАЭ).*

***Ключевые слова**: методология масштабирования, ГИС, урбанистические исследования, фрактальные измерения, пространственная структура города, анализ урбогеосистем, авторское программное обеспечение*

Introduction to the research problem. Examining, describing and formalizing the descriptions for both the natural environment and their settlements have been the ultimate human purposes and skills since the ancient hunters and gatherers began to obtain information about their achievements and errors and share this information with other members of the communities afterwards. The travel papers of almost all prominent navigators in the Great Geographic Discoveries epoch contained the detailed data on natural and human resources discovered in the most distant lands and seas. After decades and centuries had passed, the cartographers developed and created very accurate and informative *paper maps* just because they managed to choose an appropriate *detail level* for putting information on the map, what in its turn has been done due to the *scale approach* elaborated effectively.

For us, contemporary geographers, the scale approach issue that provides a proper detail level for geographical information has become even much more actual, because of the recent centuries technological advances. To all intents and purposes, for the time being space satellites gather information about Earth natural and human landscapes in huge amounts and great details. This information is transmitted into computer networks and the World Wide Web, and it may already exceed the information volume previously accumulated by the mankind in all papers and books ever issued, what some scientists did suppose even 20 years ago and then discussed in the recent years [1, 2]. The case is there are up to five hundred millions square kilometers of Earth landscapes. When only each 1 m^2 is described through some GIS-tools with only two symbols to characterize a type of land use existed on it, then we obtain a final information volume of about one petabyte. The latter is approximately the same data set size, which was equal the total amount of information what could be got from the Internet only few years ago.

Upon this data press the detail level of geographical research, which is determined by so called “scale approach in Geography” can hardly be overvalued. It overlaps both physical and human geography research, and in both subject areas mentioned this paper author has already represented the results relevant to the scale approach, in general, and to its fractal methodology, in particular [3-6].

A large number of books and papers were already published on this subject, but since a literature review is not an ultimate purpose of our this research, we only point out to that fact, according to which from our opinion the study of the scale approach underwent a dramatic change at the beginning of the two-thousandth with publication of a book that introduced various scale models in different research domains [7]. It proved that *the Scale* for a long time was a fundamental concept in both Physical and Human Geography, and its importance has raised exponentially with GIS appearance, where the computational domain requirements strongly depend on the rigorous definition and handling of scale.

Following from the basic theoretical frameworks of many previous scale researchers, we take into account that the GIS have had a historically close relation with regional studies and human geography, because both mentioned areas were mainly developed as quantitative trends in the general geographical science.

The scale approach with GIS substantially expedites the matter of decision-making in several most important fields of Human Geography applications, for example, in the urban system analysis, what was already reported by the author in our of our recent papers [6]. While one of the most pressing problem in the current areal management is the constantly increasing demand for new urban areas and the analytical city changes determining with the relevant data base support in the real time, ***the main research purpose*** of this paper is to represent on the base of the scale approach a possibility to identify certain spatial samples within urban sociogeosystems and to form new spatial derivative data for reaching advances in urban studies by the original GIS-tools newly elaborated.

Some key basics of urban studies with the scale approach. The author has outlined the innovative subject field – Environmental Geography – recently [5]. It was emphasized then that one of the key peculiarities of this field would be awareness about human-natural interactions within an environmental system. The urban system is usually introduced as the set of cities or a set of one city components in a certain territory. Thus it completely meets all demands for being the environmental geography research subject. If the environmental geography has to describe just spatial aspects of interactions between the humans and the natural environment, what directly corresponds to the GIS area, as we referred in the mentioned paper, then the scale approach must be provided in urban studies by default. Moreover, it is widely known that the urban system theory has the number of advantages, but the key one is a linkage of relationships and interactions among the city (one or many) spatial components [8]. The scale approach is sharply significant within a city borders because of the drastic gradient of human impact over several areal units in comparison with other non-urban (e.g., natural and rural) environmental systems. Within an urban system scale regularities provide the key solutions for effective formalizing, since it let us to ignore minor differences over short distances, because they are likely to be non-significant. The scale in urban system studies is one of the most fundamental issues, because how this system will be characterized in the case of scale, will determine future decision making completed on the base of these studies. For example, scale measuring completely nullifies traditional estimation of population density as "a number of people divided by square kilometers". In this case any evaluation depends on the metric scale at which population density is measured.

These scale contradictions can be resolved by introducing the original approach, which links computer modelling of environmental system / human society processes with geoinformation technology, what we already stated in the paper referred above [5]. According to the environmental geography concept there are two basic modelling principles, which can be successfully introduced into the urban studies too. Firstly, it is a representative choice of functional interdependencies and parameters describing interrelations among components of both environmental and urban system. Secondly, it is a thorough choice of a solution procedure for differential equations, because the equations describing environmental / human medium systems (sociogeosystems) are featured by a very high order and strong nonlinearity. We emphasized in the paper, that it would be evident that both of these somewhat unilateral approaches may distort some important characteristics of the environmental geography research area [5].

Contemporary unbelievable even a decade ago computer facilities in environmental geography both prove and sharpen two mentioned principle, since give us an opportunity to vary with a form of the natural-human environment description. The scale approach is a key issue in this extent too, because the particular content of this approach in each unique case of description drastically impacts the results we expect to achieve. Moreover, while we were presenting examples of geographical answers with digital maps, we explained several GIS-solutions through the scale, and these solutions outlined the answers not only *where* and *how far is it*, but also *what was measured* in an example [6].

If we look through urban studies, we will find in this area even fewer scale-independent parameters than in many other fields. Even thorough applications of such un-scale models, which are *fractal models* (we are discussing "a fractal" term in details below in this paper), the scientists actually provide the same scale approach [9] we are considering over here. Thus the following conclusion can be made: the modeling scale procedure in urban studies contains two issues – firstly, to operate directly with scale in modeling an urban system; secondarily, to simulate the effect of scale in this system description. Fist issue means that social and economic status of neighboring parts within a city determines locational regularities of many urban attractions. In order to understand these regularities we must measure this status in a certain scale chosen to be the same for different, but relevant for this task city areas. The second issue implies the necessities of changing scale, when we merely have nothing else to do instead, since primary obtained data is extremely coarse. In such a case we seek for models enable to predict effect of scale on GIS-object attributes without actual obtaining those attributes in a necessary scale. The traditional *integer-valued* measurements may not satisfy to building such model requirements.

The key solution for building these models is the *fractal methodology*, which has already been mentioned in the introductory section of this paper, and is applied by the paper author to geomorphic and hydrological research [10, 11]. Our applications were only a particular minor case studies of a unique research approach once introduced by B. Mandelbrot [12]. This author demonstrated that for most naturally occurring phenomena and processes the quantity of resolvable details is *a function of scale*, and that increasing the map scale starts additional complexity, which would be often unnecessary. The scientist soon developed his idea into *the theory of fractals*, which has been applied in many various research fields.

Fractal dimensions in the urban spatial structure analysis with GIS. In our publications referred above we discussed that *the dimensions* would be very essential for representing geometric GIS-objects. For example, when the area of a circle = $\pi r^2 = \pi r^d$ is counted, the radius is squared because this object is a two-dimensional set of points (i.e. $d = 2$). GIS-objects of points, lines, planes, and solid figures have *topological dimensions* that are integers (i.e. $d=Q$, 1, 2, and **3**), whereas *fractal dimensions* may be non-integers - *fractional*.

In general, as we explained it in our recent book [4, c. 200], the fractal method quantifies scaling relationships of the

$$y = x^{\beta} \quad (1)$$

of a territory (either natural, rural or urban) property y over a range of scales x. Mathematically β is evaluated by the slope of a double logarithmic linear regression of the quantifying dependency

$$\ln(y) = a + \beta \bullet \ln(x), \quad (2)$$

and the fractal coefficient is then found by transforming.

We also checked the assumption of some former referred authors [13], that fractal dimension of linear GIS-objects can be formalized as the connection between an object quantity Q and the related linear scale L over which Q is measured [4, c. 201-202]. What can be written as:

$$Q(L) = L^{D_q} \quad (3)$$

where D_q depicts a fractal dimension for a certain quantity Q.

To illustrate the equation (3) in urban studies perspective, let us imagine some route of public transport facilities (simply – a bus route) between its starting and endpoint. If a bus goes in a very straight line, then the distance covered is equal to the referred distance L between the route beginning and and its end, and $D_q = 1$.

If a bus route is random (what actually is a case, if this bus is not a regular one, for example), then $D_q = 2$. Some authors found that even for certain irregular city cab paths were fairly direct ($D_q = 1.09$), indicating that even cabs, which are without a steady route, and they do not act randomly in their movement [13].

Following visual (Fig. 1), that is from a fundamental GIS-in-ecology book of P. Burrough, demonstrates *linear functions* with fractal dimensions varying from $D= 1.1$ to $D= 1.9$ [14]. All five plots (counting from the upper one top the lowest one) demonstrate the dynamics of different environmental objects with growing chaos of their behavior, which is mirrored by a certain value of D (the greater value, the more chaos). Each unique form plot illustrates a particular kind of objects behavior by aggregating linear string data with respect to a certain position of an object set (see Fig. 1). While the mentioned author applied the fractal dimensions of linear string to GIS-models for the land resource assessment, from our point of view, in general, the fractal dimension field can easily be introduced into urban studies, not only for finding analogies between urban growth forms [9, 15], but also for *the automated building extracting procedures* on the base of remote sensing data and for *the city change management* subject area. Basic frameworks for this is that many city territories share such common characteristics as the presence of building density gradient, alometric growth, fractal growth and a certain range to which city growth fills available rural areas nearby.

Thus, in addition to formalizing the complexity of point, linear and area GIS-features, fractal dimensions in urban studies first of all can be applied to describe the complexity of two-dimensional patch arrays generated from remote sensing data. In Euclidean geometry the area A of any *patch*, which we associate with some set of buildings (or one building) in the area, is related to the diameter L by the relationship

$$A = B \bullet L^2 \quad (4)$$

For those sets of urban forms, which can be associated with *disks*, B is a constant equal to $\pi/4$. The connection is formalized to fractal patches by the relationship between a certain urban area and a modeled patch length:

$$A = \beta \bullet L^{D_a} \quad (5),$$

where the referred length scale (L) is the distance between the two most distant points at this area perimeter, and D_a is the fractal dimension of this urban area. High dimensions ($D_a \sim 2$) show an obtuse shape of the delimited urban area.

With this approach we modeled the spatial structure of an urban system, proceeding from remote LiDAR data for Seattle (USA) (Fig. 2).

This second visual demonstrates the results of fractal dimensions applying in order to measure the degree of irregularity of land uses within an urban spatial structure. This complete structure can be obtained by our (it is an original product of GIS-developing company GeoCloud, www.geocloud.com.ua) unique software *UrbanGeo* by LiDAR data (point clouds) processing. Initial visualization of raw data (the *right window* of *UrbanGeo* Graphic User Interface – GUI).

The prediction of the urban settlement spatial structure (the *left window* of *UrbanGeo* GUI) has been achieved by algorithms based on fractal dimension methods (1)-(5), including regularities of linear functions having fractal dimensions stated by P. Burrough ([14] and Fig. 1). Obtaining the fractal urban structure by specialized software (the *UrbanGeo* example – see Fig. 2), which algorithms use fractal dimensions to characterize the complexity of *2D* (two-dimensional) patches of the urban spatial structure, is to a certain extent similar to testing different shapes of Sierpinski carpets, when it was found that the majority of buildings were located within Sierpinski carpet [15].

All stated above in this paper section is only one more example of an effective applied GIS-implementation of some spatial analysis theory. We imply the fractal dimension methods in urban land use classification (see Fig. 2). By the way, there are quite a few such examples in recent and earlier years. For instance, elaborated in early nineties fundamental basics of an alternative approach of urban growth modeling and urban land use alteration modeling based on the fractal urban structure [16], became the effective GIS-software algorithms in eight years [17].

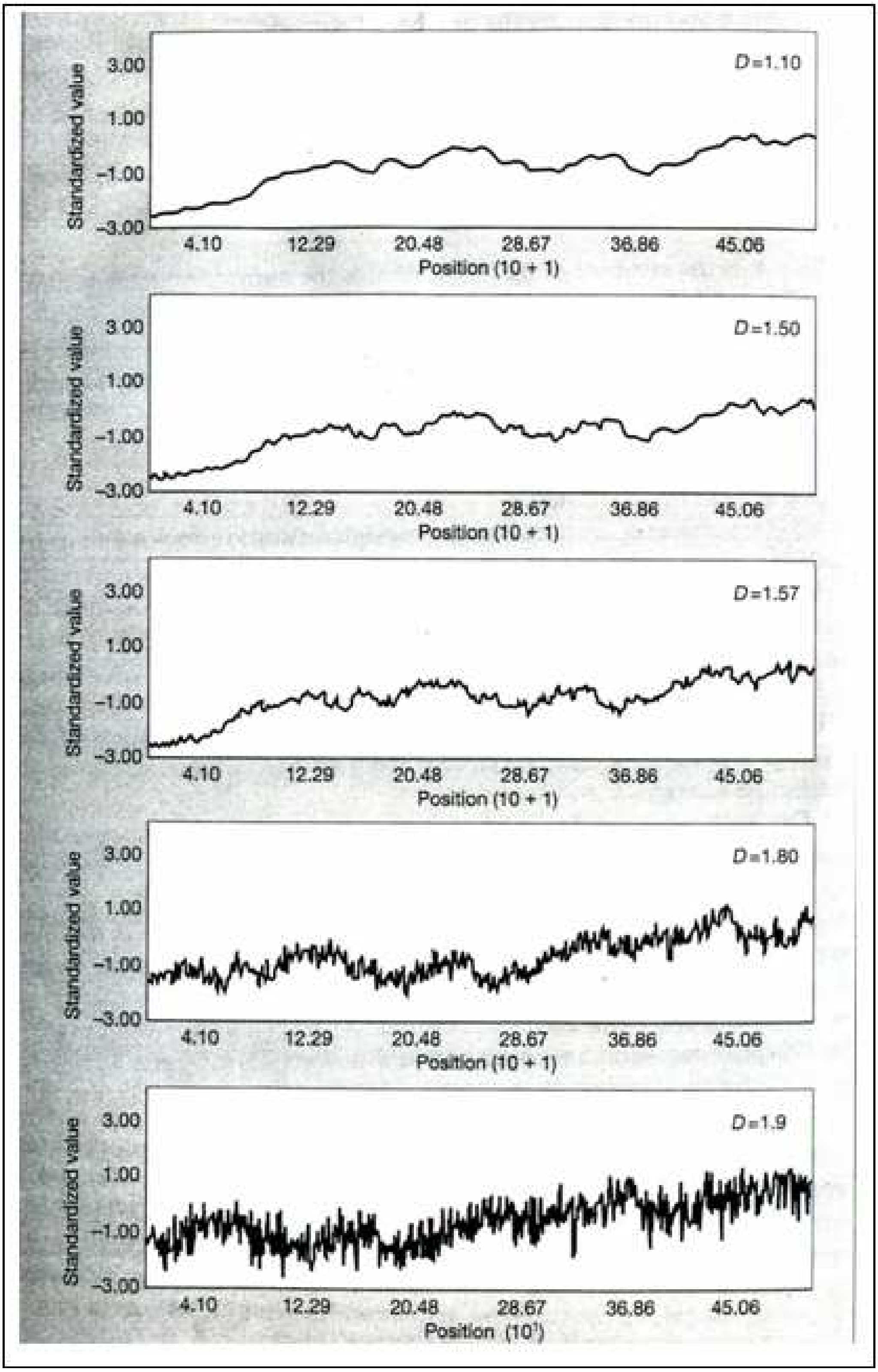

Figure 1. Linear functions of environmental dynamic objects with various D functions (from a book of P. Burrough [14])

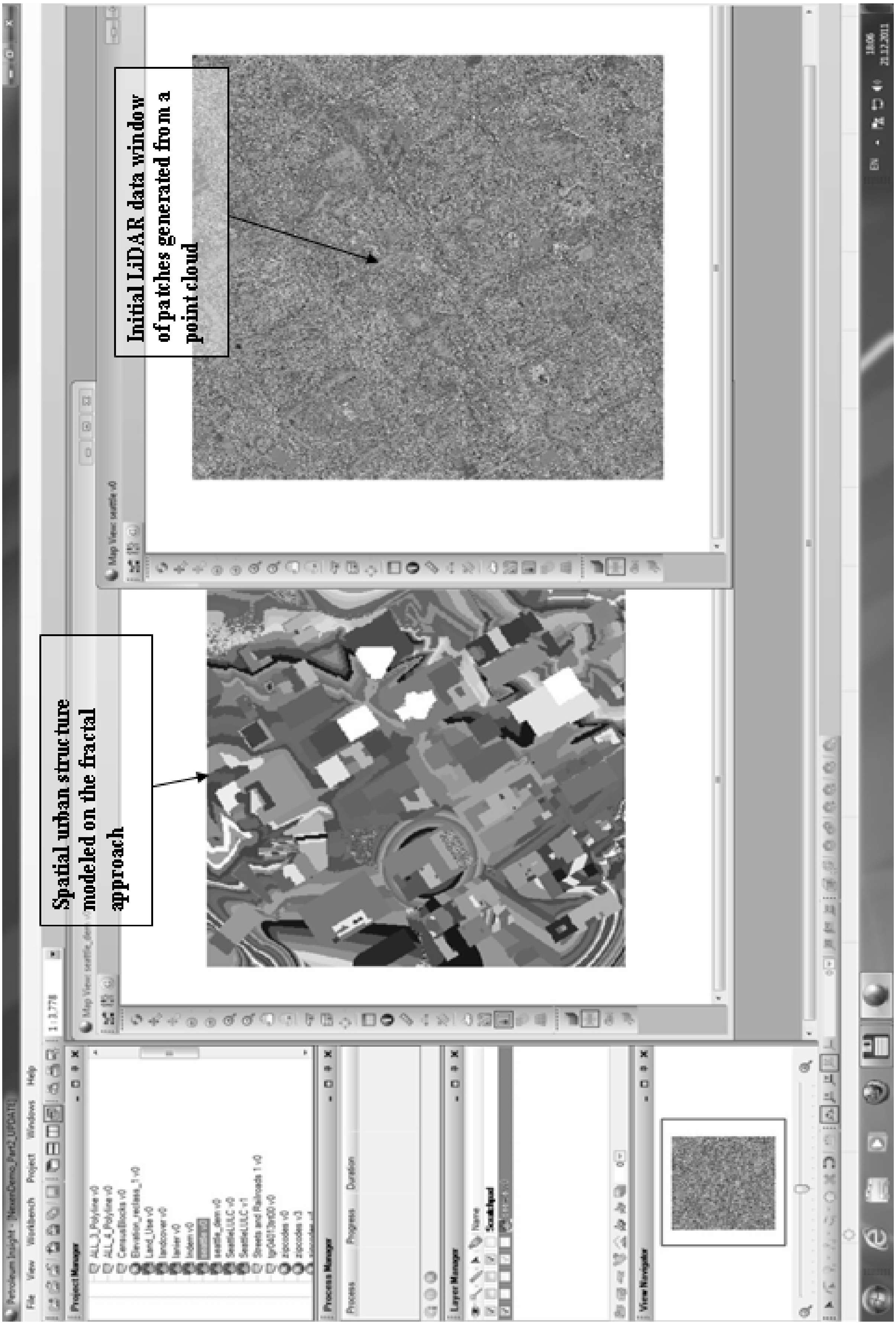

Figure 2. The results of two-dimensional patch arrays (generated from remote LiDAR data, the right window) processing by the original software using fractal dimensions: the complete urban spatial structure for Seattle city, USA (the left window)

Original GIS-software for urban system analysis through the scale approach and case studies. We have already emphasized above that for the time one of the most pressing challenge in urban land use planning is the constantly growing demand for new settlement areas. Since in the functional perspective urban settlements do not possess definitely defined boundaries, applying for urban GIS development the scale approach introduced throughout this paper, can hardly be overvalued.

We have already mentioned in the previous section of this paper our original *UrbanGeo* software intended to reveal be scale approach spatial irregularity and self-similarity of urban area boundaries. Its functional scheme is given below (Fig. 3).

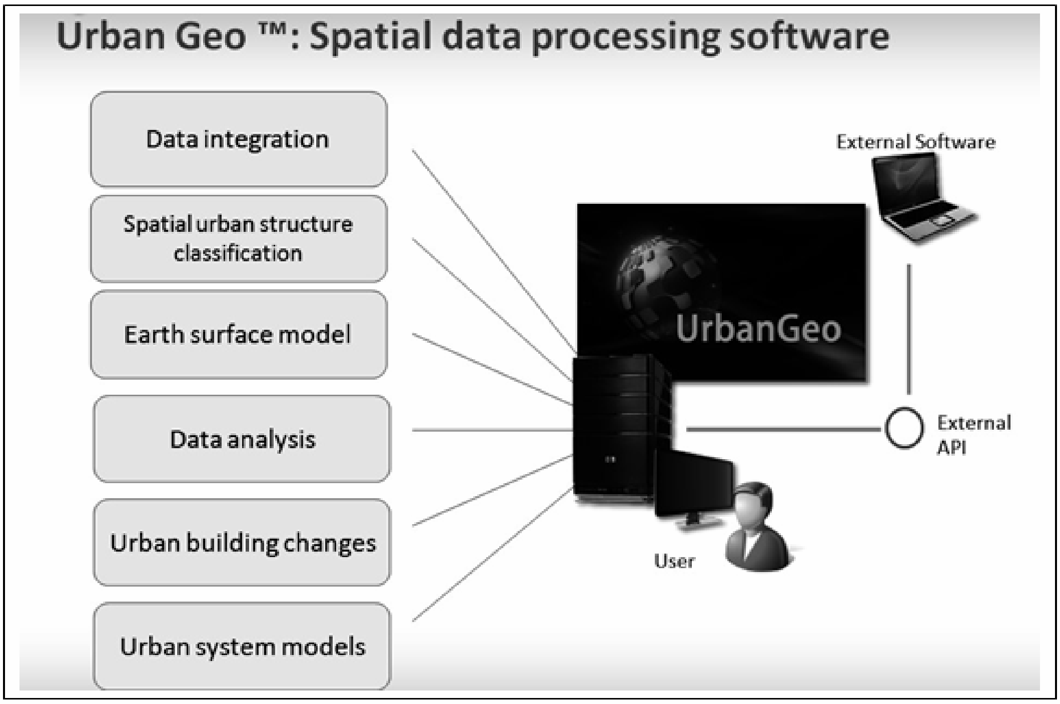

Figure 3. The functional scheme of GIS-software UrbanGeo developed for the purposes of urban studies

We have already discussed recently [6], that actually there are several ways to receive accurate locational and attributive data for 3D urban features, most of which are buildings, bridges, roads, sidewalks, pathways, highways and trees [18]. All of them usually are geocorrected images from either aerial photography, high resolution satellite pictures, airborne LiDAR data, etc. All these data are processed within the following six *UrbanGeo* plug-ins (software modeling components) exposed on the visual above (see Fig. 3):

- *Data integration* - this plug-in combines those different data mentioned above and it begins actually begins a whole procedure of urban system analysis with the data input for all the sample urban areas;
- *Spatial urban structure classification* – a plug-in directly applies the scale approach in general, and fractal dimensions methods in particular; spatial classification of an urban area land-use is completed after dividing the buildings selected for two sets: training set and validation set;
- *Earth surface model* – this module was elaborated following from backgrounds developed by the paper author with respect to the variety of the earth surface topography geoinformation models, while a digital elevation model and flow algorithms represent the preliminary modeling conditions [4];
- *Data analysis* – this software component mainly implies conversion procedures of primary data into derivative ones; just these procedures finally those spatial and temporal data resolutions, which define relationships between a real urban area and its numerous models; for instance, LiDAR data are processed so that to receive from initial "point clouds" "a Visible City model" as an output [6]; point-cloud data volume of laser remote sensing (LiDAR) and its derivative urban digital models proceed from the airborne laser range-finding systems, which permit an airplane to gather quickly a high-resolution height field for some, not very big city; the Automated Feature Extraction technology (AFE) gives a user an opportunity to be able to import, analyze, process and classify LiDAR data and obtain building morphology;
- *Urban building changes* – after the initial classification completed using the fractal algorithms mentioned above, there have been displayed both the urban land-use classes (see Fig. 2, the left GUI window) on a micro-scale level and extracted sets of buildings on the macro-scale; the next visual introduces a case study of *Urban building changes* module application to an urban area of one Middle East cities (UAE); after input of three parameters into the *Find Building Changes* dialog, some aspects of urban system dynamics will be defined (Fig. 4);

Figure 4. The sets of buildings extracted by* Data Analysis *module on the preliminary modeling step before finding building changes in time (relevant modeling dialog is opened)

Urban system model – it is a concluding component of *UrbanGeo* software, which summarizes three classifications organized in hierarchical row: *the first one* – spatial urban structure classification (a relevant module is described above), it approximates the physical layout of land use for each urban area; *the second one* is provided by AFE procedures in *Data Analysis* module, it includes the Automatic bare earth identification (*Ground Maker*) based on Airborne LiDAR point cloud data and the Automatic building extraction (Urban Building Extractor – UBE); this second classification produces ground-based close-up images of buildings, groups of buildings and other urban features as elements of an urban system; thus the purpose of this second classification is to separate "non-residential sets" in a laser data point cloud from "residential" ones; this second classification is supervised by highly accurate DEMs (digital elevation models) and by municipal databases with housing information; *Urban building changes* module is involved for the *third classification*, when the "residential area" and "build area" classes were defined with visualization in *UrbanGeo map-view window* together with "density of household" and "fractal dimension" parameters displayed in *UrbanGeo table-view window*; just in this way the urban system temporal dynamics is demonstrated (Fig. 5).

In our case studies with *UrbanGeo* modeled fractal dimensions for urban areas of several not large settlements in the Middle East (UAE) varied from 1,436 till 1,1511. For each settlement this parameter was counted from *Area* and *Value* columns of the *Urban system model* table report (see Fig.5). The scale of this case study (a size of urban areas, number of households, population density) can be compared with similar research in Foenix (USA) [19]. This can prove *UrbanGeo* software modeling reliability.

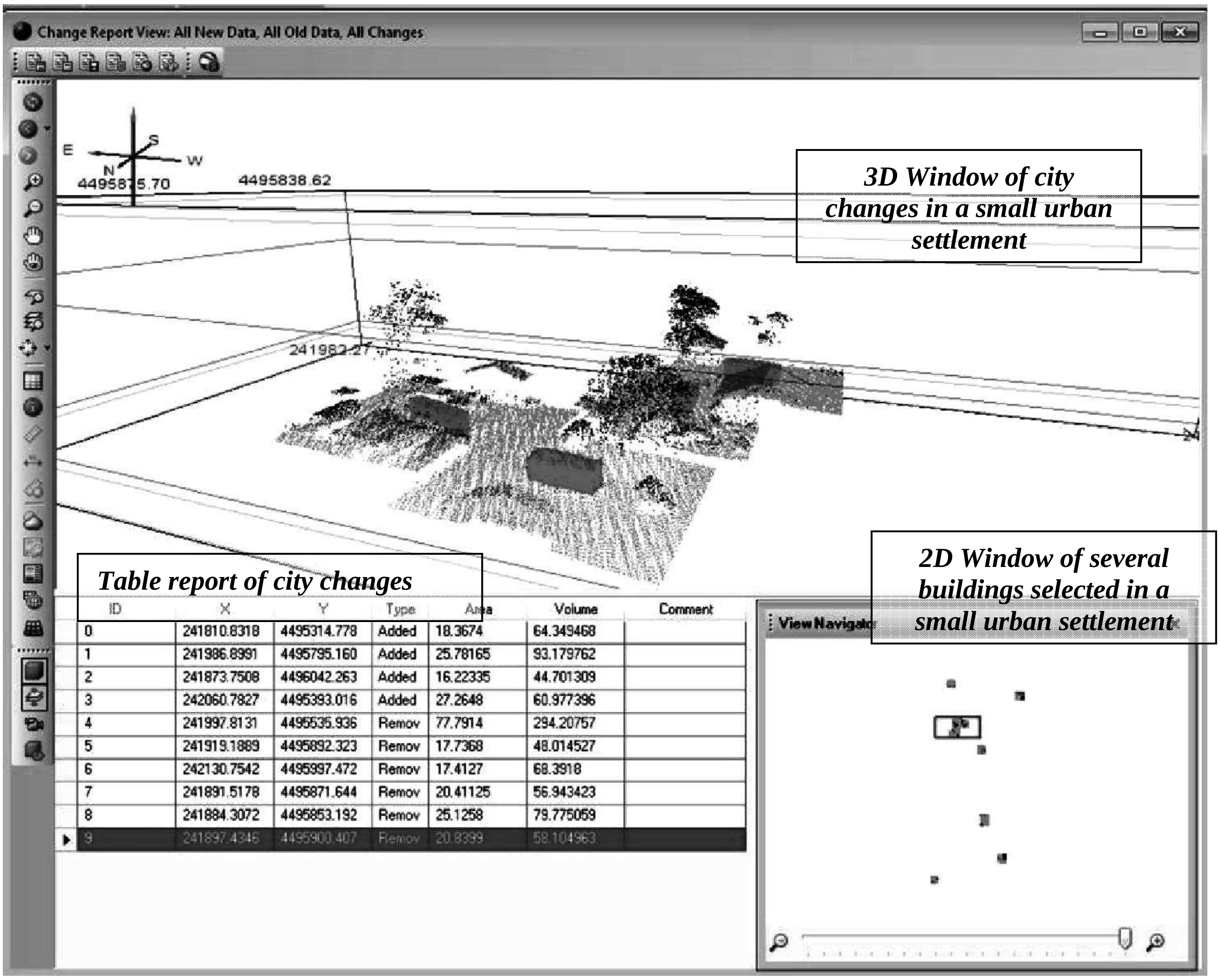

Figure 5. The results of **Urban System Model** *module processing with 2D/3D Map views and Table view*

Conclusions. We have already referred to the concept according to which the urban system analysis has a number of strong constituents, but its main one is that it links together all research results due to all relationship among all city spatial components [6]. Thus there are two ways to identify these GIS-features - points, lines and areas, which correspond to particular urban forms. One way is to input N-Dim data of realistic linkages to indicate the forms of interaction among one city census tracts and among several cities in terms of movements of population, data, goods, money, specific information and so on. Another way is to identify these linkages by gathering the available LiDAR point data for measuring urban characteristics and receiving an answer on a question: what is the nature of urban lands that differs then from rural land or from non-urban land in general?

Our paper has introduced a methodological approach for the generation of characteristics that can be used to describe urban areas. By using *UrbanGeo* software a more objective definition of city changes over an urban settlement can be achieved.

In this paper we have discussed the ways in which scale approach is crucial for the development of new methods in urban structure understanding.

References:

1. *Goodchild M.F., Parks B.O., Steyaert L.T. (editors). Environmental Modeling with GIS / M.F. Goodchild, B.O.Parks, L.T. Steyaert – New York: Oxford University Press, 1993. – 488 p.*
2. *Goodchild M.F. Towards a general theory of geographic representation in GIS / M.F. Goodchild, M. Yuan, T.J. Cova // International Journal of Geographical Information Science. – 2007. – Vol. 21. – N. 3. – P. 239–260.*
3. *Kostrikov S.V. Modelyuvannya eroziynykh merezh na pidstavi metodologiyi fraktalnykh doslidzhen / S.V. Kostrikov, N.V. Dobrovolska // Lyudyna i dovkillya. Osnovy neoekologiyi. – 2010. – № 1 (14). – S. 7-20. [Костріков С.В. Моделювання ерозійних мереж на підставі методології фрактальних досліджень / С.В. Костріков, Н.В. Добровольська // Людина і довкілля. Основи неоекології. – 2010. – № 1 (14). – С. 7-20].*
4. *Kostrikov S.V. Geoinformatsiyne modelyuvannya pryrodno-antropogennoho dovkillya. Naukova monografiya. – Kharkiv: Vyd-vo KhNU im. V.N. Karazina, 2014. – 484 s. [Костріков С.В. Геоінформаційне моделювання при-*

родно-антропогенного довкілля. Наукова монографія. – Харків: Вид-во ХНУ ім.. В.Н. Каразіна, 2014. – 484 с].

5. *Kostrikov S., Segida K. Towards the environmental geography concept / С. Костріков, К. Сегіда // Часопис соціально-економічної географії. – Вип. 14 (1). – Харків: Видавництво ХНУ, 2013. – С. 5-11.*
6. *Kostrikov S., Segida K. Human geography with geographical information systems/ С. Костріков, К. Сегіда // Часопис соціально-економічної географії. – Вип. 15 (2). – Харків: Видавництво ХНУ, 2013. – С. 39-47.*
7. *Tate N.J., Atkinson P.M. (editors). Modelling Scale in Geographical Information Science / N. Tate, P. Atkinson. – Chichester – New York: Wiley and Sons, 2001. – 292 p.*
8. *Bourne L.S. (editor) Internal Structure of the City: Readings on Urban Form, Growth and Policy / L.S. Bourne . – NY-London: Oxford University Press, 1982. – 640 p.*
9. *Batty M. Fractal geometry and urban morphology / M. Batty, Fotheringham A.S., P. Longley // Fractals in Geography. – Caldwell: Blackburn Press, 2002. – C. 211-227.*
10. *Kostrikov S.V. Flyuvialni geomorfosystemy: doslidzhennya y rozrobky Kharkivskoyi geomorfolohichnoyi shkoly / I.H. Chervanyov, S.V. Kostrikov, B.N. Vorobyov // pid red. I.H. Chervanyova. – Kharkiv: Vyd-vo KhNU, 2006. – 322 s. [Костріков С. В. Флювіальні геоморфосистеми: дослідження й розробки Харківської геоморфологічної школи / І.Г. Черваньов, С.В. Костріков, Б.Н. Воробйов // під ред. І.Г. Черваньова. – Харків : Вид-во ХНУ, 2006. – 322 с.].*
11. *Kostrikov S.V. Doslidzhennya samoorganizatsiyi flyuvialnoho relyefu: na zasadakh synergetychnoyi paradyhmy suchasnoho pryrodoznavstva: naukova monohrafiya / S.V. Kostrikov, I.H. Chervanyov. – Kharkiv: Vyd-vo KhNU imeni V.N. Karazina, 2010. – 143 s. [Костріков С.В. Дослідження самоорганізації флювіального рельєфу: на засадах синергетичної парадигми сучасного природознавства : наукова монографія / С.В. Костріков, І.Г. Черваньов. – Харків : Вид-во ХНУ імені В.Н. Каразіна, 2010. – 143 с.].*
12. *Mandelbrot B. Fractal Geometry of Nature / B. Mandelbrot .- NY: Henry Holt and Company, 1983. – 468 p.*
13. *Coucleis H. Cellular worlds: A framework for modeling micro-macro dynamics / H. Coucleis // Environment and Planning. – 1985. – Vol. 17. – P. 585-596.*
14. *Burrough P.A. Principles of Geographical Information Systems for Land Resource Assessment / P.A. Burrough. – Monographs on Soil and Resource Survey No. 12. – Oxford: Oxford University Press, 1986. -220 p.*
15. *Triantakonstantis D. Urban growth prediction modelling using fractals and theory of chaos / D. Triantakonstantis // Open Journal of Civil Engineering. – 2012. – Vol. 2. – P. 81-86.*
16. *White R, Engelen G. Urban Systems Dynamics and Cellular Automata: 1 rectal Structures between Order and Chaos / R. White, G. Engelen // Chaos, Solitons and Fractals. – 1994. – Vol. 4. – P. 563-583.*
17. *Shen G. Fractal dimension and fractal growth of urbanized areas / G. Shen // International Journal of Geographical Information Science. – 2002. – Vol. 16. – No. 5. – P. 519-437.*
18. *Brunn A., Weidner U. Extracting Buildings from Digital Surface Models / A. Brunn, U. Weidner // IAPRS. – 1997. – Vol. 32 (3-4W2). – P. 27-34.*
19. *Berling-Wolff S., Wu J. Modeling urban landscape dynamics: a case study in Phoenix, USA / S. Berling-Wolff, J. Wu // Urban Eco-systems. – 2004. – Vol. 7. – No. 3. – 2004. – P. 215-240.*

Summary

Sergiy Kostrikov. SCALE APPROACH TO URBAN STUDIES WITH GIS-TOOLS.

This paper represents the well-known scale approach in urban studies upon a new perspective. This research approach has actually proceeded from that fact, according to which examining, describing and formalizing the descriptions for both the natural environment and human settlements always was the ultimate human purposes and skills. The perspective to involve through GIS-tools in relevant research not only traditional integer-valued scale measurements and modelling, but also fractal ones reveals the unique level of details in urban system analysis. The paper explains while the scale approach became drastically crucial for contemporary human geographers – because of newly technological advances.

Few key basics of urban studies with the scale approach through GIS-tools have been introduced. The papers explains, why the scale in urban system studies is one of the most fundamental issues, because how this system will be characterized in the case of scale, will determine future decision making completed on the base of these studies.

The survey detailed enough according to applying fractal dimensions in the urban spatial structure analysis with the original GIS software has been provided. In particular, fractal dimensions were applied in order to measure the degree of irregularity of land uses within an urban area.

Some case studies and examples of the software GUI with the scale approach implemented have been introduced for several minor urban settlements in the Middle East (UAE).

Key words: scale approach, GIS, urban studies, fractal dimensions, urban spatial structure, urban system analysis, original software.