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VALUATION AND VALORISATION OF URBAN LANDSCAPE IN OLSZTYN

Abstract: The valuation and valorisation of the landscape in urbanised areas are vital elements of spatial economy. Landscape economy, *i.e.* the proper management of the landscape potential, is very often a factor of a city development. The author presents the examples of the valuation and valorisation of the landscape in Olsztyn as an essential source of information in the context of the broad understanding of the city development and the proposition of using the theory of the scale-free networks by Barabási in the process of landscape management in urbanised areas.
Key words: Valuation and valorisation of landscape, the model of aesthetic value of landscape, scale-free networks, land development.

Introduction

There is a correlation between a structure of a city and its functions, which is determined by spatial components (natural environment and anthropogenic elements). Various functions may develop inside one structure of a city, just as the same functions may develop in different urban structures [Domański 2006]. The element that appears invariably is landscape, regardless of its function or spatial structure. It is common knowledge that the aesthetical value of landscape undergoes a natural process of observation, and – whether we want it or not – has an influence on numerous aspects of life and decisions one makes, from planning a holiday to planning a large-scale investment and functions in the area. Land development – strictly a proper management of the landscape potential is the determinant of a city economic development. Olsztyn is a unique city because of its exceptional landscape potential, which is important for spatial policy. In the city limits of Olsztyn there are 11 lakes and over 1850 hectares of forests (the forestation of the city exceeds 21%) All forms of green areas take 50% of the city area. The city is crossed by the river Łyna valley. Olsztyn is an urbanised area with a rather unique physiographic conditioning, which plays the role of industrial, educational cultural, as well as equally important recreational and touristic centre of Warmia and Mazury. The potential of the city is its land-

scape, which simply urges to take steps to develop the last two functions mentioned above. Effective policy of spatial development clearly depends on current and reliable data, and constant creating, updating and improving the data bases play a vital role. Moreover, a proper methodology of data analysis and an optimal use of gathered information are important. Therefore, one ought to search for new instruments that will allow to take concrete actions in the range of the management of landscape potential.

A data base of landscapes of Olsztyn has been created. It consists of iconographic materials, assessment cards of the city landscape and cartographic materials. The geo-data of landscape aesthetic qualities has been collected, systematised and analysed as the measure of organisation of recreation and touristic space of Olsztyn. The paper presents a proposition of using the theory of the scale-free networks by Barabási in the process of optimising the use of landscape potential and presents the examples of cartographic study of landscape data.

Generally, landscape is defined as all spatial phenomena created on terrestrial surface, both by nature and by human cultural activity. These phenomena are the expressions of a particular place and moment that we all perceive and assess [Łuczyńska-Bruzda 1978; Skalski 2007]. Analysing urbanised areas, one can diagrammatically describe the role of landscape as a determinant of economic development (Figure 1).

Landscape makes a specific resource of nature and has features that are economically and socially useful. It has became an economic good (an economic service) that to a large extent differs from the conventional economic goods and services, because its usage is not usually connected with market transactions. Landscape as such is not a subject of a turnover, as it has no measured worth defined by the market and translated into prices. On the other hand, one can say that an attractive landscape is an economic good, because people are prone to pay for it. The payment for the good of landscape can be "hidden", *e.g.* included in the price for a real estate or it can be

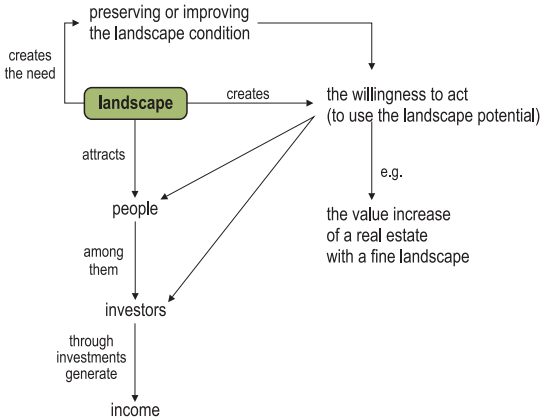


Figure 1. The role of landscape as a determinant of economic development

Source: Own analysis.

direct, *e.g.* as a fee for entering places of considerable landscape value. Landscape, like most resources of nature has the features of public goods. It means that no one possesses a private title deed for landscape, excluding the others from using it. Public goods are characterised by an easy, common and often uncontrolled access, which may lead to their excessive exploitation and consequently to their destruction. Currently, more and more effort is being put to protect the environment and to support the processes of its reconstruction in an anthropogenic way. This is the source of the view that all natural resources have their value [Bajerowski *et al.* 2007].

The valuation and valorisation of landscape as a one part of nature can be approached in two ways:

- due to the influence of landscape on the value of the prices of real estates,
- due to the value of landscape itself.

In the following study, the author focuses on the value of landscape itself as a measure of the spatial economy.

1. Valuation and valorisation of landscape

In the space of years, numerous methods of valuation and valorisation of landscape have emerged. After the analysis of various approaches towards the subject and different methods of landscape assessment, Cymerman, Falkowski and Hopper [Cymerman *et al.* 1992] distinguish three groups of landscape valuation methods:

I – Methods based on the valuation of natural value of particular elements of landscape.
II – Methods based on the valuation of the aesthetic/scenic values of landscape.
III – Methods meant to determine the purpose of a given landscape.

The methods in the first group assume that the value of landscape depends on the natural value of its elements, their significance for the environment and the degree to which their qualities and features remain intact. The methods in the second group use the urban-architectural approach towards landscape. The features of aesthetics and harmony of a given landscape elements have the predominant role. The third group includes the methods that determine the purpose of a given landscape, *e.g.* recreation or environmental protection.

Bajerowski [Bajerowski *et al.* 2007] suggests a rather different division of landscape valuation methods:

I – Depending on the way of obtaining information – one can distinguish the field methods, the indoor methods and the mixed methods.
II – Depending on the way (the range) of using the information resources – the fragmentary methods and the comprehensive methods.
III – Depending on the aim of the valuation – methods elaborated for specific enterprises and universal methods.

IV – Depending on the way of creating value – subjective methods (surveys) and objective (scientific) methods.

V – depending on the accepted, primary interpretation of value – aesthetical methods and "economic" methods.

Assigning the methods to groups I, II and III is clear. Group IV includes survey methods that ought to be understood as creating the standard of landscape value on the basis of the answers to the question that appears during conducting the survey, namely: "What landscapes, landscape features and landscape elements should be considered as valuable or positive, and which should not?". This criterion of the values is subjective regardless of qualifications or education of the questioned people.

Objective methods are often based on classification constructions referring to pure sciences. The fundament of group V is distinguishing what is primary in a given method: the landscape-ecological value or the economic value. The methods of landscape valorisation are shown in Figure 2.

There are numerous systems of valorisation of land, and Hopfer (Hopfer *et al.* 1982) names several of them:

- The general valorisation of the natural environment. It is performed on the basis of numerous features. When considering the valuation of physiographic conditions for the need of organising a settling net, Różycka [Hopfer *et al.* 1982] focuses on the lie of the land, geological conditions, climatic conditions, water supplies and building mineral resources.
- The valorisation of landscape. The valorisation has numerous features similar to the physical-geographical valorisation. Szczęsny [1982] assesses the following elements of landscape: the lie of the land, soil, water, climate, plant cover and animal kingdom. The Fines system created in Britain [Hopfer *et al.* 1982] assumes that human appreciates mountain landscape and forest landscape more than flat terrains and urbanised landscape. Accordingly, the system categorises the landscape from its lowest to highest

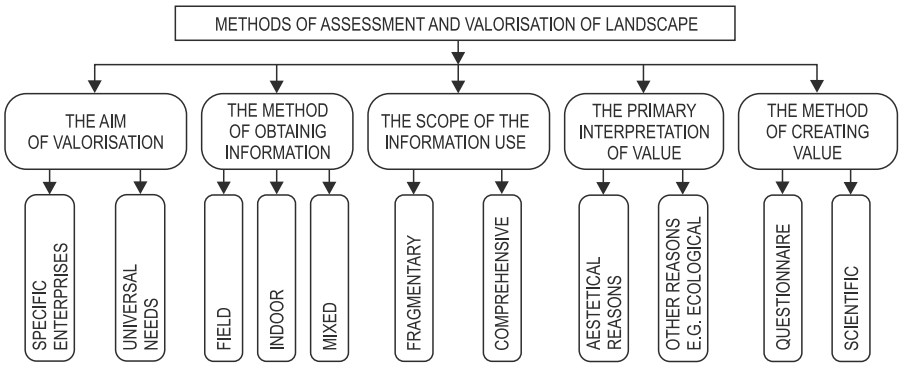


Figure 2. The classification of valuation methods and landscape valorisation, and the way of selecting (choosing) a method depending on an aim

Source: [Bajerowski *et al.* 2007].

value: 1 – hilly terrain, 2 – forests, groups of trees, 3 – flat terrain or slightly corrugated terrain with traces of human activity, housing and industrial development, 4 – terrain destroyed by the excessive human activity, housing and industrial development.

- The recreational-touristic valorisation. It is the effect of the endeavour to regulate a sudden coming of a society to places with recreational and touristic potential, and to protect the terrains from other forms of land exploitation. According to Kostrowicki [1970], the measure of the terrain utility for recreation and tourism is: settlement flexibility (a possibility of modification), the critical load of undergrowth (the one that does not degrade the plant cover), the degree of the antrophogenisation of the plant cover (*i.e.* the degree and the direction of flora modification as a result of human activity), bioclimatic attributes of the plant cover). The attractiveness of a field is expressed through the points given to particular fragments of an area for specific factors.
- the valorisation of the agricultural use of land. It aims at indicating areas of diverse agricultural usefulness, and therefore presenting productive usefulness of a given area. One of the methods aiming at determining the agricultural use of land is the classification of soils, *i.e.* a valorisation of land based on series of features of soil. Another widely known method is a division of agricultural production space into sets of the agricultural usefulness of soil, [Hopfer *et al.* 1982].

2. Valuation and valorisation of landscapes in Olsztyn

2.1. A method selected to evaluate a landscape

As a result of the analysis of literature concerning methods of valuation and valorisation of landscape, it has been decided that the perception curve method will be used to evaluate the urban landscape. The method is modified by Bajerowski with the use of the "Selektor" program and the urban landscape assessment card. The listed methods have been characterised beneath. The issue of the basic fields of assessment used in the research have been outlined as well.

The method of the impressions curve by Wejchert

The method has been worked out by Wejchert to assess the scenic attractiveness of downtown space-time routes. Cymerman, Hopfer, Korelski and Magiera-Braś [Cymerman, Hopfer 1988] used this method to evaluate the open landscape of rural areas in Polish conditions.

This method of landscape valuation is rather accessible in the technical respect, however, it requires a decent knowledge of the theory of aesthetic as well as well-developed perception of the assessing person. In the perceptual cognitive process, our mind creates a critical image of what we sense mentally and what we perceive through senses. The creation of this image allows a given person to assess various

qualities of landscape, which appear as a result of merging the subjective feelings the person has with the objective knowledge [Skalski 2007]. The method of impressions curve consists in a graphic representation of the tension of impressions and emotional experiences which stir the observer while they move through the space-time routes. The technique of valuation consists in describing the intensity of impressions on a properly selected scale, in precise time intervals, in specific distance, on the route.

The impressions and experiences should be identified in the form of a graph, where the horizontal axis is a time and linear scale, on which the subsequent viewpoints assessed by the observer are marked on the route [Senetra, Cieślak 2004]. On the vertical axis, the observer marks the intensity of impressions made under the influence of the valuation of landscapes which have different values.

The impressions curve ought to be interpreted as an illustration of average impressions, to which one cannot decide on one measurement. It is only a means which is used for comparing given fragments of landscape.

There is a number of basic parameters that must be considered while valuating landscape from given viewpoints:

- the degree of the landscape variety,
- the degree of devastation,
- the saturation of infrastructure,
- the harmony of all elements.

The procedure of landscape valuation through a chosen method of the impressions curve is as follows [Cymerman *et al.* 1992]:

1) The division of the area into naturally bordered zones (*e.g.* a road) or zones that take shapes of squares which side measures about 500 meters.
2) Moving on routes that are outlined by the borders of zones (*e.g.* a road or sides of a square)
3) Stopping at regular intervals (every 3-5 minutes) or after covering a specified distance (100-200 meters) to evaluate the impression from both sides of the route from a given point. The scale of points can vary: 0-5, 0-10, 0-100. The 0-10 scale is used the most often. Larger scales (*e.g.* 0-100) requires big experience of the evaluator and a detailed assessment, however smaller scales may cause blurring of the differences between given landscapes and consequently generalising their value.
4) Making of the impressions curves for particular routes
5) Marking the places on the charts that require more appreciation of an aesthetic kind. The need of appreciation is defined in a range of degrees (points from 0 to 10):
   - large degree – areas that get less than 4 points,
   - middle degree – areas that get from 4 to 7 points,
   - zero degree – places that get more than 7 points.
6) Transferring data from the impressions curve to the map of the valued area and mapping areas of various demand for aesthetic appreciation. A given landscape is valuated according to one's personal impressions and experiences.

Lynch's researches [Lynch *et al.* 1964] have contributed to the urban space valuation and structuralisation. He introduced the term of cognitive mapping as a method. The method of cognitive mapping is mainly based on the perception of places in the aspect of the environmental psychology and is criticised mainly for the difficulties in mapping the evaluated space. Unlike Lynch, Wejchert describes a sum of some elements that can be found in a given area. They organise the space and their relations undergo valuation [Wejchert 1974]. Similarly, Böhm presents the possibilities of using the analysis of urban interiors to evaluate urban environment [Böhm, Patoczka 1988].

The above mentioned method of the impressions curve is a simple and clear. As it has already been mentioned, complications can be caused by a non-specified route of the itinerary. Additionally, a large number of view points causes the basic criteria of the valuation and the experiences gained through subsequent sights to blur. As one of few, this method is dedicated to valuation of urban landscape. In this method, landscape is evaluated from an aesthetic angle. The method can be used for the need of building a net of view points through the processes of shaping landscape by removing and/or adding new elements. It seems to be proper especially in cities that have predispositions and natural conditionings for the development of touristic and recreational functions. Beautiful landscapes are rare goods, which causes the necessity of supporting the processes that shape and protect the landscape.

The method of Bajerowski – the method of direct comparisons

The proposition of modifying the impressions curve method is described by [Bajerowski 2000; Bajerowski *et al.* 2007]. It consists in:

- Choosing the route going along the borders of landscapes that are determined according to the rules described in the methods proposed by Wejchert.
- A technical facility, when the evaluator marks the comparison of his aesthetic impressions while standing in a given viewpoint with the impressions he had in other viewpoints. The evaluator marks arrows on a specially prepared matrix diagram (Figure 3). Such attitude eliminates difficulties in specifying the value of landscape in an arbitrarily chosen scale, and with mathematically prepared results of the observations, it enables the valuation to be made.

We add points (as the example shows in the lines) and we get data necessary to draw the impressions curve.

Numbers in the first column and the first line indicate the distance from the beginning point of the route. Such a diagram ought to be prepared for each space-time routes. The valuation should be done from the left to the right side of the route. The matrix is symmetrical, allowing to a convenient implementation of data, and the data under the diagonal can be implemented in indoor conditions. A simple notation of symbols (↑, =, ←) is convenient, minimalising the possibility of making a mistake.

Some inconveniences concerning the use of the modification described above may appear, as a result of:

Table 1

The example of notations and the scale of value of landscape in a comparison matrix

Notations	Number of points	Description of the value
←	2	Landscape more valuable than... (*e.g.* in point 100 more valuable than in point 0)
=	1	Landscape as valuable as... (*e.g.* in point 400 as valuable as in points 0, 100, 200)
↑	0	Landscape less valuable than... (*e.g.* in point 500 less valuable than in points 100 and 400).

Source: [Bajerowski *et al.* 2007].

	0	100	200	300	400	500	∑
0		←	←	←	=	↑	7
100	↑		↑	↑	=	←	3
200	↑	←		←	=	↑	5
300	↑	←	↑		←	=	3
400	=	=	=	↑		←	5
500	←	↑	←	=	↑		5

Figure 3. The example of valuation landscape diagram
Source: [Bajerowski *et al.* 2007].

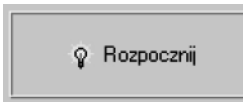
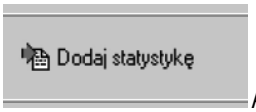
- A large number of viewpoints; in such case the evaluator may forget his previous impressions.
- The length of the route, which determines the total number of points; this problem can be overcome with a mathematic analysis of the observations result. An invariable number of viewpoints cannot be implemented as it excludes the repetitiveness of the valuation conditions.

In case of a large number of data in the direct comparison method, the computer program "Sector ver. 1.01" by Sieheń and Wojeński can be used. In the program, any pictures can be compared with one another. As a result, the Excel format spreadsheet (*.xls) is received, and it can undergo further statistic analysis. The pictures that will be compared should be in JPEG (*.jpg) format. Table 2 illustrates working in the program.

Undoubtedly, the drawback of the program is the lack of possibility to save the already made appraisals during working with it. It is possible only when all pictures from a catalogue have been compared and the statistics have been added. Conse-

Table 2

The procedure of using the "Sektor" program equal

Actions	Button or view
– start the program	 Start
– select the catalogue that contains only the pictures that are chosen and meant to be analysed in the JPEG format	
– select a more attractive area or regard it as equal to every presented pair (during evaluation process, the Excel spreadsheet is created in the bottom of the window, including the user's assessments, where the arrows signify the more attractive areas, whereas '0' signify the equal ones)	
– while finishing the valuation, statistics can be added to the spreadsheet that is being created. (it contains the end result of the proceeded valuation and the score of the photos for each pair: 2 points – choosing, 1 point – regarding the area as equal, 0 point – choosing a different area)	 Add statistics
– save the Excel (*.xls) format on the hard disk	 Save

Source: Own study on the basis of "Sector" program.

quently, the work may be lost due to a power failure or a computer failure. Moreover, the experience of working with this program shows that it is able to create the statistics only up to 100 pictures being evaluated.

The valuation card of urban landscape

Urban landscape valuation requires a detailed appraisal of: communication routes (*e.g.* functionality of pedestrians crossings, pavements, free space accessibility, security), smell (*e.g.* unpleasant/pleasant smell), architecture, land development, noise, litter pollution, *etc.* On account of that, during the valuation process, the urban landscape valuation card has been additionally used in the study. The card has been proposed by Czachorowski for the need of didactics [http://www.uwm.edu.pl/czachor/dyda/krajob.pdf], and modified by the author. In the aspect of environmental psychology, this method appraises aesthetic values as well as functionality. The valuation has been made on the basis of categories and rules included in Table 3.

Table 3

Criteria of urban landscape valuation proposed by Czachorowski, modified by the author

No.	Elements of scoring	Rules of valuation and assigning points	Number of points and the valuation scale
1	Aesthetics	The elements introduced by human are properly integrated into natural environment The style of anthropological elements is not totally adapted to the surrounding There is a distinct lack of harmony between the natural environment and artificial elements (of anthropological origin)	5 3 0
2	Land development	Functional and rational Some noticeable flaws Entirely impractical and irrational	5 3 0
3	Communication routes	The valuation of functionality of pedestrian crossings, the facilities for cyclists (as well as skaters and roller bladders) and the disabled. Is there a clear conflict between road traffic and pedestrians?	0-5
4	Smell	Clean fresh air Not intensive unpleasant smell Constant intensive smell or high pollen count	5 3 0
5	Noise	None or a very low level low level Constant high level	5 3 0
6	Litter	None Little amount A lot	5 3 0
7	Flora	Sufficient amount Partial supplement required None	5 3 0
8	Signs of vandalism	None Few A lot	5 3 0

Source: Own study (Tables 3-5).

The valuation card contains a table worked in the Excel program; in an analogue form, in which all the blanks are to be filled in respectively (on photographic locations). Table 4 serves an example of a filled evaluation card.

Table 4

A filled valuation card of urban landscape proposed by Czachorowski, modified by the author

General localisation of the field and additional information	Elements of scoring	Score (from 0 to 5 points)
Field No. 90 is located in the south-west edge of Olsztyn city.	Aesthetics	3
	Land development	3
	Communication routes	0
	Smell	3
	Noise	3
	Litter	3
	Flora	3
	Signs of vandalism	3
	Σ	21

Basic unit of valuation

The choice of a proper basic unit of valuation is an essential element in the process of valorisation. According to the definition [Hopfer *et al.* 1982], it is a unit of surface to which one can ascribe a given value taken from the appraisal of the geographical environment, and which characterises the whole surface.

In case of the landscape aesthetic valuation, a regular grid seems to be the most proper. It eliminates the problem connected with interpolation. The vagueness of borderlines of the separated landscape zones makes it pointless to mark them precisely on the map; therefore, it eliminates the necessity of marking the grid for the second time. For the need of this study, a regular grid (bricks with 250 meters sides) has been used, which gives a basic valuation unit of 62,500 m^2 (625 a = 6.25 ha) (Figure 4 on coloured insert, p. 2).

2.2. The example of valuation and valorisation of urban landscape in Olsztyn

The landscape quality analysis of Olsztyn city has been made by using the impressions curve method modified by Bajerowski, with the use of photographs.

Landscape, which makes the aesthetic representation of the natural environment condition, is a basic criterion for the valuation made by a tourist (a person visiting, as well as inhabitants of a given area). The valuation has an influence on the aesthetic value ascribed to a place, and consequently, it determines whether it is eagerly visited or not, and whether it measures up to one's aesthetic expectations or evokes disappointment.

Photographs were used because they could be taken immediately (also because they could be immediately examined from a technical aspect, and retaken if necessary)

and be used for a reliable (objective) picture (landscape) valuation. If stretched in time, a valuation of a very large number of compared objects would be less objective. For the need of the landscape valuation of Olsztyn city, 1,336 photos have been taken. Figure 5 on coloured insert, p. 3 presents a cartographic analysis of the materials collected for the research together with the recording places of particular landscapes (the red spots on the map).

The process of taking pictures have been proceeded in a way that allowed their objective analysis afterwards. The photographer tried to capture the whole area of a specific basic unit to make the photo represent the area as accurately as possible. All pictures have been taken in the same season, with similar weather conditions. After choosing a specific place, of a given valuation field, the photo of the landscape has been taken with a digital camera and the valuation unit has been marked on the analogue map (in accordance with the number of the photo on the memory card), and the landscape valuation card (described in chapter 3.1) has been filled in. At first, the photo has been appraised from the technical perspective. The next step was to segregate of the photos due to the numbering of the basic units (*e.g.* 1, 2, …, 1235 …). Finally, 1,336 photos have been appraised.

The basic criteria for valuation of landscape are:

- aesthetics of the surrounding landscape (the harmony of composition),
- land development,
- communication routes quality,
- greenery places saturation, their condition and diversity,
- signs of devastation.

As a result of those actions, the aesthetic values of the analysed landscapes have been received in various stations of valuation.

3. The study of the collected data – the study of the data concerning the landscape aesthetic value of Olsztyn in the "Surfer 8" program – the cartographic and 3D models

3.1. A map of actual isarithms of the aesthetic landscape value of Olsztyn

The decision where to place points of references has been made while taking photographs of landscape in the researched area. The selection of interpolar axis and the making of interpolation (*i.e.* indicating the location of an indirect value among two values of the reference points) have been made in the "Surfer 8" program. The inverse-square weighting method has been used for the study of a numerical model of landscape

aesthetics of Olsztyn city. In the data obtained with this method, the mean mistake of interpolation was the smallest (minimum 30,30, maximum 75,60). A mean mistake of a similar size appeared in the close vicinity method as well. While analysing the created model and the networks, it was stated that the hubs and nodes were localised similarly.

The created map of the actual isarithms, in the study also called the ViewLines, is shown in Figure 6 on coloured insert, p. 3.

According to the map presented above, the highest aesthetic values of landscapes cumulate in the north-west and west area of the city. The data may be presented in various ways. Figure 7 and Figure 8 on coloured insert, p. 4, present 3-D models made with various methods of interpolation.

As it can be noticed, various methods of data presentation give a possibility to look at the issue from a hyperspectral perspective. The models presented above provide us a clear illustration of how the aesthetic values of landscape in Olsztyn are developed.

3.2. A tourist information signature map of Olsztyn

The signature map was studied on the basis of an ortophotomap taken from the IKONOS satellite (Figure 9 on coloured insert, p. 5). The map of Olsztyn city presents basic information about tourist, communications and spiritual services that can be useful to both tourists and inhabitants of the city. Additionally, the network of the landscape aesthetic value growth was marked on the map according to the rule of minimum value growth. The map indicates how one should move from one point to another so that the landscape aesthetic value would grow. In order to do so, arrows of value growth were used and quantity signs were designed (Table 5).

Table 5

The arrow of value growth and quantity signs used in the creation of the map

No.	Sign	The sign meaning
1		The arrow of landscape aesthetic value growth
2		Point of I order (a starting and connecting view point)
3		Point of II order (a connecting view point)
4		Point of III order (a connecting view point)
5		Point of IV order (a destination view point)

4. The theory of scale-free networks in the process of landscape potential management in urbanized areas

A problem of landscape development – *e.g.* for tourism – is constantly a current issue in Olsztyn. In order to create proper conditions for improving the landscape development planning effectiveness, *e.g.* for tourism or recreation, proper tools need to be found. The answer to it is to use the concept of the scale-free networks by Barabási.

There is a wide range of specialist literature on the scale-free networks, and the roots of Barabási's theory lie in science [Barabási, Bonabeau 2003]. The scale-free networks can be briefly characterised by:

- the occurrence of hubs – the majority of nodes have few connections with others, whereas some nodes have a great number of connections. These nodes, called hubs, can have hundreds, thousands, or even million connections. In such a case, the networks distinguish themselves as scale-free.
- a great sensitivity to intentional "attacks" on hubs – scale-free networks are very sensitive to attacks organized intentionally on a given point – a network hub. An intentional attack on several hubs may lead to a total destruction of the network (Figure 10 on coloured insert, p. 6).
- resistance to random "attacks" – an accidental attack on a node does not have such a detrimental effect as it has on random networks. Owing to the composite structure, there are always some connections left that keep the whole network active (Figure 10).
- The scale-free networks are characterised by the phenomenon of the preferential choice of connections (in the growth of the real networks, the more developed nodes have more possibilities to establish connections. When a new node appears, it has a tendency to connect with nodes that have a large number of connections, and this favourable feature makes the nodes have more and more connections in contrast to the adjacent nodes that have fewer connections).
- the versatility of use – considering those features, the knowledge about the scale-free networks could be used in new fields of science.

Determining whether a network is scale-free is vital in understanding the behavior of the system. For the need of this study, the characteristics of the scale-free networks that apply to their extension and the sensibility of the hubs have been analysed. An attempt to prove the usefulness of the scale-free networks theory in the process of land potential management has been made.

The construction of the spatial connections network model of landscape aesthetics has been started from the analysis of data in the Gravity program. Sieheń and Wojeński are the authors of this program. It has been constructed for didactic purposes. The authors aimed at creating a simple algorithm of emerging spatially diverse regions that connect into networks according to six basic rules:

Fot. 1. A photograph taken on viewpoint no 297, in which one of the two positive centres has been created on the way of maximum growth of value

Fot. 2. A photograph taken on viewpoint no 862, in which one of the two positive centres has been created on the way of maximum growth of value

Source: [A. Kowalczyk, 2008].

- on the way of the largest growth of value;
- on the way of the least growth of value;
- on the way of the largest fall of value;
- on the way of the least fall of value;
- on the way of the biggest differences in value;
- on the way of the smallest differences in value.

It has been assumed that the space of Olsztyn is represented by the basic units. Their centres have been given the values that they received in the landscape quality valuation (Chapter 3). Furthermore, the basic units diversify the geographical space in the aspect of the landscape value.

As a consequence, some network models that show the spatial diversity of Olsztyn landscape aesthetics have been build according to the six proposed ways. Below is a network model example of landscape aesthetic value according to the way of the minimal growth of value (Figure 11 on coloured insert, p. 7).

In the networks organized in this way, the number of connections of every node on each level of aggregation has been counted, and the "nature" of these connections has been described (Figure 12 on coloured insert, p. 6).

In the researched area, according to the presented decision-making rule (of minimal rise of value) two central nodes have been created (Fot. 1 and Fot. 2), and in this sense, the network manifests its scale-free aspect. On account of such nature of the analysed network, its characteristics can be used to identify landscapes that ought to be retained and supported in a special way, as well as those that need to be transformed.

Conclusions

Olsztyn city has assets including: the location of numerous lakes, large surface of forest and greenery in the city area, picturesque valley of Łyna river and the Old Town, that favour the development of tourist and recreational functions. The strengths of the city (*The Strategy for Socio-economic Development of Olsztyn 2006-2020*, Analytical Technique 'Strengths, Weaknesses, Opportunities, Threats", 2005) are: attractive eco-physiographic conditioning, a university centre, localisation of the economic area in Olsztyn. It needs to be emphasised that regardless of high unemployment rate and inefficient communication system, Olsztyn is an attractive city which plays an essential role for the region. A growing number of inhabitants causes the negligence in land management. The weaknesses of Olsztyn (*The Strategy of Socio-economic development of Olsztyn 2006-2020,* Analytical Technique 'Strengths, Weaknesses, Opportunities, Threats", 2005) include: the negligence in greenery management, low aesthetics and technical condition of public use facilities, deficiency and inadequate location of recreational facilities, negligence in recreation management of river Łyna banks and lakes, lack of plans of land development and lack of concepts and programs for activation of a tourist movement.

On the model of the network of landscape aesthetic connections presented above, one can identify places that have strong influence on the development of tourist and recreational functions. The "positive" hubs and nodes that require preservation and support to the landscape and the base of tourist services modelling have been marked. The "negative" hubs and nodes that require changes have been marked as well.

Through the simulation of attacks on given hubs or nodes, one can predict the damages, the same time one can see what area of influence has been subjected to given hubs or nodes, indicating their significance in the network structure.

In the model of landscape aesthetic values created on the way of minimal growth of value, two hubs have been singled out. A hub is a specific point on the land surface, it should be subjected to particular protection, however, landscape seen from the hub ought to be protected even more. In this, the open-space landscapes are the most attractive. The devastation of such landscape happens through implementing close elements that are partially or totally blocking the view of the landscape or implementing the disfiguring elements "far". The devastation of a hub can be done through for example the devastation of a viewpoint (bomb explosion, privatisation, fencing the area, a building that hinders looking at the area, *etc.*), the devastation of the atmosphere (constant giving off unpleasant smell that makes positive feelings and concentration impossible, litter, *etc.*). By modelling the aesthetic values in a scale-free network, one can simulate the separation of given nodes and hubs from the network structure, as well as create new hubs of the network.

The development of a network, in the sense of not being "a scale", allows to conclude that this process leads to consolidation, stabilisation and possibilities of bet-

ter monitoring of landscape changes. If a scale has more scale-free hubs, a collapse of a system, in case of any failure or elimination of one of the hubs, is less. The area is more divided – a scale has more complex structure, and the damage of a hub influences the disintegration of the scale to a less extent. The role of the damaged hubs can be taken by the remaining hubs (to a limited extent).

The process of valorisation and valuation of the area of Olsztyn and the creation of a model, especially the network model of landscape aesthetics, lies a solid base for the elaboration of tourist routes or didactic paths, etc, and they assure the use of the city landscape values. Designing the routes that lead through viewpoints from which a beautiful view spreads, seems to be logical. Routes can be designed in a form of an incomplete loop so that the route back does not coincide with the beginning of the route. Aesthetic impressions will be felt gradually, with the tendency to grow. It is possible to model the routes in a micro scale (districts) and a macro scale (area of Olsztyn city).

On the basis of the conducted researches, it should be stated that the process of valuation and valorisation of landscape is an essential tool in the process of land development. The data that has emerged as a result of the aesthetic valuation is an irreplaceable source of information and ought to play an important role in deciding on land development of urbanised areas.

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