The quality of pedestrian space in the city: a case study of Olsztyn

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Abstract. The system of pedestrian urban space is the primary source of information on the state of the space. Walking around a city, we are perceptually building in our mind its physiognomic silhouette, which becomes the basis for evaluating the attractiveness of a city. Unfortunately, pedestrian traffic is rarely the subject of careful planning and design. Usually it regulates itself or is a side-effect of building an extensive system of road communication. On the other hand, concepts of shaping this system as a primary one appear more and more often, and pedestrian space is seen as high priority public space.

The purpose of the article was to evaluate qualitative evaluation methods determining the current state of pedestrian pathways in the town Giżycko. Valuing quality, as a part of the science called qualimetrics, refers to determining the quality of objects which are the product of human activities, designed to meet the needs of human beings. At the root, it is a science relating to the determination of the quality of market items, supporting the production management process.

As space, particularly urbanized, is created by people to satisfy their needs, it was concluded that quality valuation methods may also be useful to assess the quality of space. The article focuses on the quality of pedestrian routes that are essential to the central part of Giżycko. For these routes, the current state of the features identified as key for their quality was investigated, and quality classes of the routes were determined by analysis.

The procedure can be a tool supporting the planning and implementation of modernization and renovation works for the area of pedestrian communication, and thus the image of the city.

Contents:

1. Introduction

Walking is the main mode of human movement and is necessary for experiencing urban space. While walking, one becomes an observer and judge of the urban landscape. Although pedestrian traffic is the main category in moving around a town, it is frequently regarded as a self-regulating system, created as a "by-product" while developing a vehicle traffic system. The main purpose of the article was to propose an evaluation method for public space intended for pedestrian traffic. This method was proposed by Kolman and was used for determining the quality of usable objects.

Increasing awareness of the significance of public space in towns is accompanied by increasing awareness of systems of pedestrian routes which, together with squares and similar places, have gained considerable importance as public spaces. "Streetscaping" – the intentional professional development of space for pedestrian traffic – is becoming increasingly important (Podolski, 1991; Watson, 2006; Wesołowski, 2008; Cieślak, 2012; Langegger, 2012; Van Damme, 2012).

Detailed guidelines have been developed in recent years, both on the technical requirements applied to creating pedestrian routes and on their aesthetic aspects (Land Transport NZ, 2007; NCHRP, 2008; TeansEko, 2011; The principles of pedestrian ...., 2012). However, such guidelines are required by law only to a limited extent (Rozporządzenie Ministra Transportu..., 1999), and the requirements specified in them are not met by most of the existing pavements. Obviously, optimizing systems of pedestrian traffic is an important aspect of developing a user-friendly urban space. However, the instruments used to evaluate existing systems are still rather modest. The first assessments of the quality of the environment of pedestrian traffic were made by Fruin (1971), whose doctoral thesis contained a description of the levels of service (LOS) for pedestrian traffic. The values of LOS are determined based on a route density index, which is the ratio of the area intended for pedestrian traffic and the number of pedestrians at any particular moment (m^2/person). Fruin identified six levels of service, from A (free flow) to F (crowd). The indexes were modified in the Highway Capacity Manual 2000; they have been referred to as HCM after the publication title (Olszewski, 2007; NCHRP, 2008; Hutabarat, 2009). The modification involved adding a temporal dimension of a walking trip to LOS. The basic value of HCM is modified as needed, depending on the features of the environment under study. Another method, which takes into account the level of safety, has been described by Płoszajski et al. (1991). He identified four levels of pedestrian space quality: very convenient (I), convenient (II) and inconvenient (III) conditions for walking with the last level being "inconvenient and dangerous" (IV). Płoszajski supplemented his assessment with a feature describing differentiation of pedestrian routes in terms of a user's safety. An analysis of the indexes which can be used in a quality assessment of pedestrian routes provides a possibility of their classification. The following analysis is proposed by Olszewski (2007): (a) assessment of pedestrian routes (e.g.: by the method proposed by Fruin (1971); Płoszajski et al. (1991); HCM); (b) assessment of areas intended for pedestrians (e.g.: walkability; walk-through capability of residential quarters; PEF – Pedestrian Environmental Factor); (c) simulation models (analysis of walking streams; mathematical models developed based on methods used for vehicle traffic).

2. Description of the procedure

Every urban space as a product of human work should serve to satisfy human needs. According to current expectations, people create a specific state of space development (Cieślak et al., 2013). It can then be concluded that in developing the surrounding space, people apply the general principles of satisfying needs that are the motivation for the production of all goods and services that create the quality of our life (Cantor et al., 1987). Urban space has its own specificity, which seems to be close to this thesis. For example, our flats, which are subject to similar market principles as other goods and services, could be pointed to as a kind of such space. The quality of residential space that determines the level of prices recorded in the real estate market represents the reflection of the level of satisfaction of human needs in general. Quality, understood as the state described above, is the fundamental notion that became the key component to the present research.

Quality has become the subject of scientific research. It is considered as a fundamental notion and can be described as a representation of the core component in the case of the use and acquisition of goods or services of any type (Kolman, 1971; Borys, 1991; Trullols-Soler, 2006; Nazarov, Krushnyak, 2006). As a result of this thinking, a scientific discipline called qualitology was formed, which is focused on quality and its modelling (Martínez, 2008). According to the considerations of this discipline, quality is defined as a complex characteristic representing a relatively homogeneous set of objects as a multidimensional space of states (Borys, 1991), which means that the space of states is the product of the sets of characteristic values.

Considering the quality of space as an environment of human life, we can say that this attitude is more appropriate. Moreover, the statement that the quality of usable space may be treated as equivalent to the quality of the environment of human life, understood as the set of material objects and influences occurring in that environment, seems a logical assumption.

Focusing research on "measuring quality" in a clearer and more detailed manner is the basic activity of qualimetrics. We can describe it as a valuation of quality, which is nothing more than determining its level (Stadnyk, Motalo, 2013). As is known, quality is not described by any physical dimension. Nevertheless, if specific parameters that are measurable are allocated to it, we can speak of measuring quality.

There is no doubt that there should be consistency between the practical and theoretical basis of quality. This can be accomplished as a result of quantitative determination of the states of quality, i.e. valuation of quality. Valuation is a functional assignment of a specific value to the selected features of an object. Identified values represent the states and quality level of an object. As a result, it offers the possibility of organizing sets of elements in the listed qualitative categories according to value (Kolman, 2009; Wawak, 2011). Valuation of quality may bring significant benefits in different domains of human life, such as real estate management. Correctly applied qualimetrics methods may be a helpful tool in understanding the operation of some market mechanisms and may improve the decision-making process in the area of real estate management.

3. Criteria of quality

Valuation of quality is strongly related to the quality criterion. It is certain that there is no single quality criterion precisely describing the state of quality of the given object of analysis. This is why we should use a set of criteria. Moreover, this results from the fact that one of the important attributes of quality is collectiveness. To create an appropriate set of criteria, we have to remember that the number of the characteristics cannot be excessively large, but also cannot be excessively limited. Defining the set of criteria is very important and is the most demanding task in the case of quality analyses.

In qualimetrics, the weight corresponding to the share of the specific quality criterion in the quality structure of the test subject is called *importance* of this criterion. Importance is an abstract concept, which means the urgency of satisfying the needs or the intensity of the need to satisfy the requirements. It cannot be measured, so it is dependent upon many factors. As an equal importance of all the factors in a set is not possible, diversification

of the importance of these factors is necessary, and it means organization of their arrangement by decreasing or increasing importance.

Grading the importance is done by allocating the importance factor to different states of the characteristics. The importance of individual criteria in the set of the states of quality can be determined in different ways. Determination of the level of correlation between the set criteria and the universal criteria set is one of them (Table 1). This set was established as a group of criteria within which the overall quality of the object of study is built.

Table 1. Set of universal importance criteria

No.	Name	Letter symbol	The criterion carries information
1	Safety	B	on protecting or posing a hazard to health or life
2	Benefit	L	on benefits or outcomes obtained
3	Cost	K	on costs incurred
4	Reliability	N	on reliability, propensity for failure or operational inefficiency
5	Novelty	C	on novelty, modernity, fashion or time factor
6	Efficacy	S	on appropriate performance of the projected tasks
7	Accuracy	T	on the intended use or consistency with the intended use
8	Usability	U	on durability, development or duration of use
9	Defectiveness	W	on defects, failures or that it is well made
10	Looks	P	on the harmony of shape, colours, aesthetic impressions

Source: Kolman, 2009

4. Determination of the state of quality characteristics

The quality of the object is associated with the state in which that object is. To become the subject of analysis, every state of the feature of an object must be precisely defined as a relative value. Only relativized values can be summed and provided as a basis for further research. The absolute states of characteristics result from direct measurement, they have different measures, or they are determined by a descriptive value, and therefore they require transformation. The relative state is the ratio between the reduced absolute value *r*, which is the absolute value decreased by the minimal value of the variability range, to the entire considered range *p* of variability of that value. This is presented by the following formula:

$$s = r/p$$

Based on this, it can be concluded that: $0 \leq s \leq 1$.

This is the significant set of values, based on which not only the relative state of characteristics,

but also the criteria discriminants of those characteristics that reflect the relation of the state of the characteristic to the quality of the object, as well as the quality of the object, are determined. The criterion discriminant of the characteristic, the increase in value of which causes an increase in the value of the object, is equal to its relative state. A quality equal to one is the state of satisfying all the expectations, called complete quality. The process of transition from the absolute state, resulting from the direct observation of the characteristic to the relative state, is called relativization. Taking into account the character of the object of analysis and the type of characteristics describing the quality of that object, we can apply different relativization methods. The set of basic relativization methods includes: (a) metrization; (b) detailed segregation; (c) rough segregation; (d) graded comparison; (e) alternative determination; (f) conditioned evaluation; (g) taxation.

Metrization is the most precise method, but it can be used only for features that have measurable dimensions. This is the most desirable mode in the quality valuation process. The procedure of metrization should be performed in the following stages:

— measurement of the value of the considered dimension showing its absolute state,
— computation of the relative state,
— computation of the criterion discriminant.

The relative state of the criterion is computed according to the formula:

$$s = k_z - k_i / k_a - k_i$$

where:
k_z – measured criterion value determining its current absolute state,
k_i, k_a – the lowest and the highest value the given criterion assumes within the area of its variability.

Detailed segregation is used when the measurable criterion changes within the accepted limits of the admissible range of variability defined as tolerance.

$$T = k_a - k_i$$

where:
T – tolerance,
k_a and k_i are the highest and the lowest permissible value of the criterion.

Detailed segregation is applied when the aim of relativization is to obtain detailed knowledge on the state of the analysed criterion, within the area of its permissible variability, for the purpose of quantitative determination of quality.

Rough segregation is a method which gives an instant set of criteria representative for the ranges of the numeric values changing within the limits of tolerance. In this case, the prepared nomograms are adequate, and there is no need to adapt computation formulas.

Graded comparison is a method where, according to a normalized scale of states specified during preparation of the procedure, the values of the states of the considered criterion are determined. Application of such a scale is used to facilitate decision-making as concerns the value of the relative state of the criterion considered, as well as significant improvement of the accuracy of the evaluation of the state.

Alternative determination is another method. This method designates whether the requirements formulated are satisfied based on the comparison of the present state and the state of the applied standard. An object considered correct can be used as the applied standard.

Conditioned evaluation concerns more complicated issues, where ordinary estimation cannot be used. It refers to more precise relativization of immeasurable criteria. First of all, every imperfection the given object might have must be defined and counted. Based on these figures, the specific criterion discriminant is determined.

Taxation is applied for valuation of immeasurable characteristics that represent quality criteria. Some of the criteria, such as composition of shape and harmony of colours, can be evaluated only by this method. An evaluator based on experience, knowledge, etc. is able to decide whether the state of the criterion is favourable or unfavourable (Kolman, 2009).

In the case of evaluations aimed at determination of the criteria discriminants of the space characteristics, the methods of metrization, segregation, alternative determination and taxation prove to be the most useful (Senetra, Cieślak, 2004). Determination of the criterion discriminant for the criterion of location in the example described below represents an example of applying the rough segregation method.

5. Using a selected example to assess a pedestrian traffic system

The study involved isolating six features of pedestrian routes, which were then analysed in depth. Features were chosen based on the existing assessment methods for public space intended for pedestrians (Ghel, 1987; TransEko, 2011). The features included the following: type of pavement, width, position relative to the road, length, inclination and aesthetic value. In the authors' opinion, length seems to be quite an important feature, because it reinforces the importance of the other characteristics. Each was assigned a specific characteristic, and the values of criteria determinants ranged from 0 to 1. Two methods of relativization were used. One of them was taxation, which used a 3-, 4- and 5-degree scale. A 2-degree scale was used in the alternative method. The determinants assigned to individual states of features are listed in Table 2.

Table 2. Score points depending on the state of the features of some elements of pedestrian routes

No.	Feature of space for pedestrian	Description of the condition	Criteria determinant (q)
1	Pavement C1	Set or pavement slabs	0.9
		Bitumen or concrete of low technical quality	0.7
		Loose pavement, for example: gravel, aggregate	0.3
		Well-trodden native soil	0.1
2	Width C2	2.00 m or more	0.9
		from 1.00 m to 2.00 m	0.5
		less than 1.00 m	0.1
3	Location relative to the road C3	Separate from the road with a vegetation belt	0.9
		Separate from the road with a parking space	0.7
		Immediately next to the road edge	0.3
4	Length **C4**	more than 1000 m	0.9
		from 700 m to 1000 m	0.7
		from 400 m to 700 m	0.5
		from 200 m to 400 m	0.3
		less than 200 m	0.1
5	Aesthetic value C5	Even and undamaged pavement, clean, properly lit, arranged vegetation, street furniture (e.g. benches, litter bins)	0.9
		Even and undamaged surface, clean, minor elements of arranged vegetation and street furniture, proper lighting	0.7
		Surface uneven and damaged in places, a small number of elements of street furniture, no arranged vegetation, poor lighting	0.3
		Uneven and damaged surface, no street furniture, no arranged vegetation, poor or no lighting	0.1
6	Inclination C6	No visible inclination	0.8
		Stairs and ramps	0.0

Source: Own study

In another stage of the study, the relationship was described between the features characterized in Table 1 and the criteria of importance, which comprise ten universal determinants (universal importance criteria, see Table 1). The set of criteria includes the following: safety (B – provides information about threats and protection which one encounters in everyday life), benefit (L – provides information about acquired goods, benefits and effects), cost (K – provides information about the costs incurred), reliability (N – provides information about reliability, solidity or frequency of defects), novelty (C – provides information about modernizations, novelty and temporal factors), effectiveness (S – provides information about effectiveness, efficiency and productivity of tasks), accuracy (T – provides information about the ap-

propriate, right or correct use), usability (U – provides information about usability, durability or the course of use), defectiveness (W – provides information about defects, indicates shortcomings or defects in workmanship) and appearance (P – provides information about appearance, aesthetic value and harmony of the whole). It is a general assumption of the methods based on UIC that full quality (Q = 1) is described evenly by the UIC mentioned above. The procedure of calculation of the significant weight (k) of each feature of the objects under assessment is based on this assumption. The weight depends on the relationship between the feature and universal importance criteria.

In order to increase the reliability of the calculations, the relationship between the features of pedestrian routes and universal importance crite-

ria was determined with the use of a survey. The questionnaire was completed by 50 randomly chosen people. The results of the survey were used to calculate the effect of the six distinguished features of pedestrian routes on the overall quality of such routes (Table 3).

Table 3. Weights of importance criteria

UIC	B	L	K	N	C	S	T	U	W	P
C1	5	0	2	4	5	4	5	4	4	5
C2	4	0	0	1	0	3	1	3	3	3
C3	5	2	3	3	3	1	0	4	4	3
C4	0	0	4	1	2	0	3	0	4	1
C5	1	3	4	0	5	1	4	5	4	5
C6	4	3	3	5	3	0	3	1	1	4
Totality	19	8	16	14	18	9	16	17	20	21
Significant number (Sn)	8	1	5	3	7	2	4	6	9	10

Source: Own study

A summary of the survey provides sufficient data to determine the weight expressed by the significant number (Sn) of each UIC in the overall quality of the objects under assessment. A sum of the products of Sn and the weights of the criteria listed in Table 2, divided by the minimum product, provided the basis for determination of the weight k of the features considered in the study (Table 4).

Table 4. Levels of importance of each feature of space

UIC	P	W	B	C	U	L	T	N	S	K	sums of the products	k_i
(Sn)	10	9	8	7	6	5	4	3	2	1		
C1	50	36	40	35	24	10	20	12	8	0	235	2.47
C2	30	27	32	0	18	0	4	3	6	0	120	1.26
C3	30	36	40	21	24	15	0	9	2	2	179	1.88
C4	10	36	0	14	0	20	12	3	0	0	95	1.00
C5	50	36	8	35	30	20	16	0	2	3	200	2.11
C6	40	9	32	21	6	15	12	15	0	3	153	1.61

Source: Own study

Earlier calculations provided grounds for quantitative determination of the quality of each route. The quality was determined by the ratio of sums of the products $k_i q_i$ and the sum k_i.

$$Q_l = \frac{\sum_{j=1}^{4} k_j q_j}{\sum_{j=1}^{4} k_j}$$

To put the results in order, the values of Q can be classified by using the universal scale of states (Kolman, 2009). The values are classified into 10 quality classes, of which class 0 is the highest, and class 9 includes objects for which $Q < 0.1$.

Criteria determinants were determined for each of the 50 streets in accordance with previously set rules, based on the available cartographic data and on-site reconnaissance. The determinants were used to determine the quality of the routes in a quantitative manner. To illustrate the results, classes of routes were determined based on the universal class scale. The final classification of the routes is illustrated in the town map (Fig. 1).
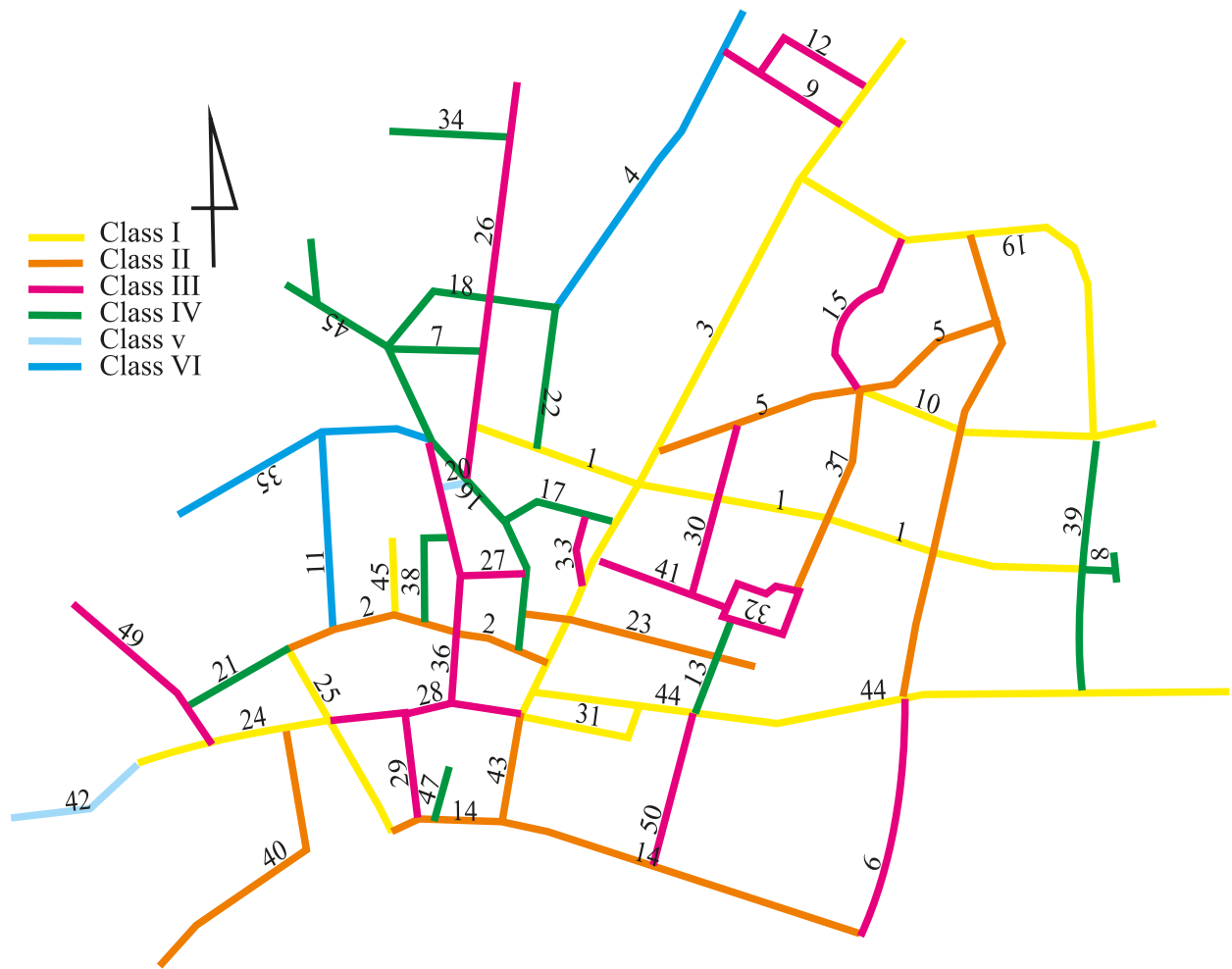
Fig. 1. A map of classification of pedestrian routes of the central part of the town of Giżycko

Source: Own study

After listing all the 50 analysed pedestrian routes, the authors focused on selecting the feature which had the greatest reducing effect on the quality level of each route. To this end, the *R* index was calculated, whose values for individual features (by identifying the highest value) allow one to select the features which are significant for a decrease in route quality.

$$R_i = k_i q_{max} - k_i q_i$$

Table 5. Values of criteria determinants corresponding to a specific feature

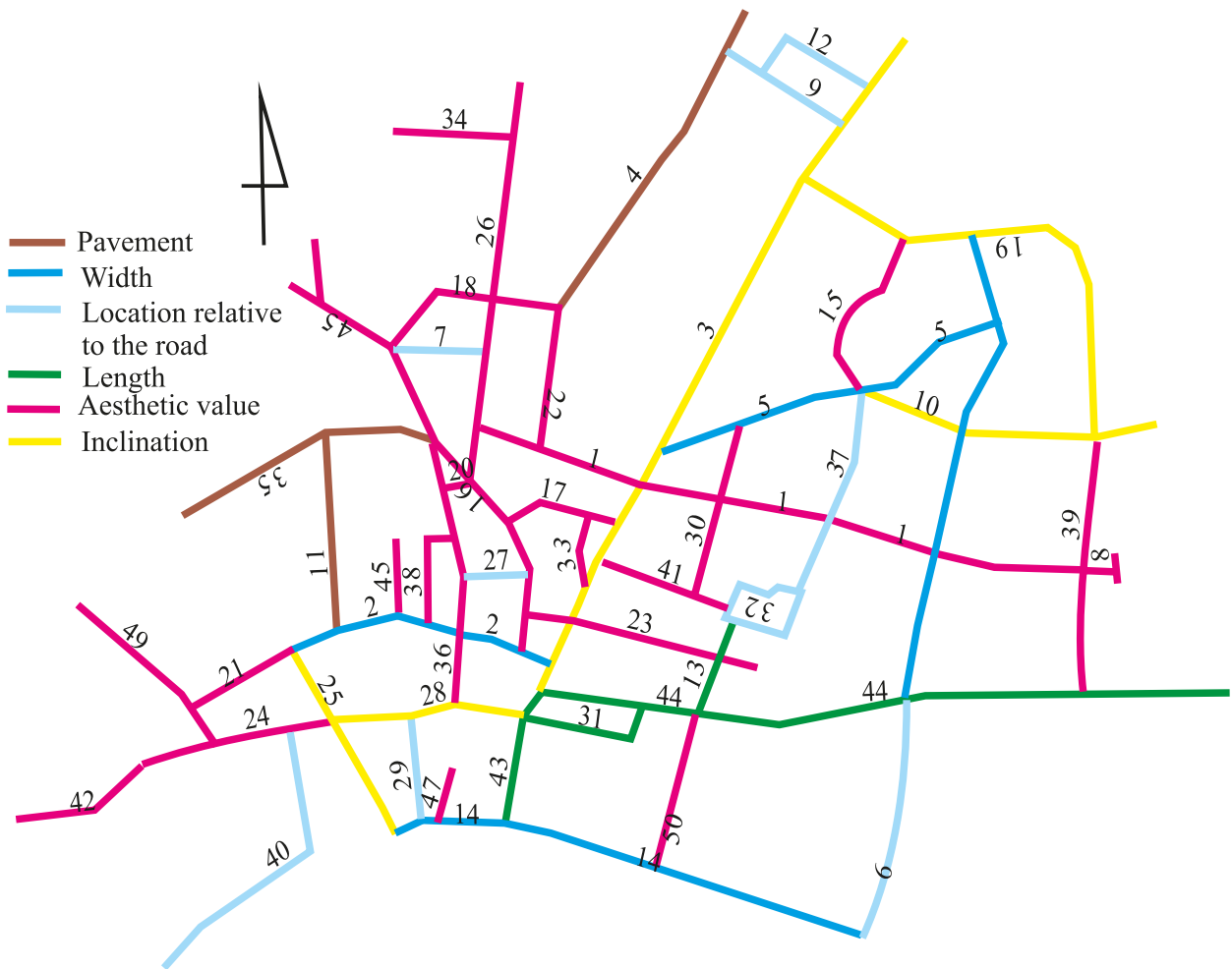| No.	Street name	length	C1	C2	C3	C4	C5	C6	Qi	Ri C1	C2	C3	C4	C5	C6
1	I Dyw. Im.	1320	0.9	0.9	0.9	0.9	0.7	0.8		0.00	0.00	0.00	0.00	0.42	0.16
	3-go maja	570	0.9	0.5	0.9	0.5	0.7	0.8	0.82	0.00	0.51	0.00	0.40	0.42	0.16
…	….	370	0.9	0.5	0.3	0.3	0.7	0.8	0.72	0.00	0.51	1.13	0.60	0.42	0.16
…	….	….	….	….	….	….	….	….	….	….	….	….	….	….	….

Source: Own study

Fig. 2. A map of corrective indications for the pedestrian communication system in the central part of the town of Giżycko

Source: Own study

Based on the analysis of the value of the *R* index, a map of corrective indications has been developed, which shows routes with specific shortcomings (Fig. 2).

6.   Summary of the study results

Quality is a fundamental concept which is difficult to define and nearly impossible to measure. Quantitative determination is difficult because, in fact, quality is not measurable, and the space around us is defined by an infinite number of features which make up its final quality. However, with a view to space optimization, it is important to seek methods which enable quantification of immeasurable concepts, mainly including quality. Such methods are used by qualimetry, which develops principles of numerical determination of quality. This also applies to such fragments of space as pedestrian systems, all the more so because their utility function is, in fact, a reason for their development, and (as in the case of many utility products) the quality can be measured by qualimetry.

The study results have shown that such interdisciplinary combination of knowledge from different fields of science about the surrounding space and the study methods used to determine quality in a quantitative manner opens up a new opportunity for solving research problems. The procedure of assessment of pedestrian routes proposed in this paper obviously requires improvement, but its modification is relatively simple, its results are clear, and

they provide a measurable picture, which is its significant advantage. The application of the method of quantitative valuation of quality to an assessment of pedestrian routes in the central part of the town of Giżycko also provides clear guidelines for optimizing the system.

It is noteworthy that the utility function of space is the basis for its fragments that are typical of a cultural landscape. Being a space developed specially to satisfy human needs, it should be treated as a creation with a specific quality. Determination of its quality in a numerical way provides broad opportunities for its description and optimization.

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