Adam Senetra

Methodology for developing survey questionnaires based on recreation planning analyses in the region of Warmia and Mazury

Acta Scientiarum Polonorum. Administratio Locorum 10/2, 83-94

2011

Acta Sci. Pol., Administratio Locorum 10(2) 2011, 83–94

METHODOLOGY FOR DEVELOPING SURVEY QUESTIONNAIRES BASED ON RECREATION PLANNING ANALYSES IN THE REGION OF WARMIA AND MAZURY

Adam Senetra

University of Warmia and Mazury in Olsztyn

Abstract. Questionnaires are a popular tool in surveys assessing the value and availability of space. The correctness of survey results has to be analyzed during the statistical processing of questionnaire data. This study proposes a paired comparison method for evaluating natural and anthropogenic resources that support recreation planning in the region of Warmia and Mazury. The gathered data have been analyzed in view of the consistency coefficient of individual questionnaires and the coefficient of concordance determined for the entire group of experts. The proposed methodology relies on statistical formulas developed by Kendall. A list of key attributes for recreation planning in the analyzed area has been developed. Statistical methods were deployed to validate the analysis of consistency and concordance of questionnaire data.

Key words: assessment, questionnaire, expert, comparison, consistency, concordance

INTRODUCTION

An assessment of planning functions assigned to space requires a set of attributes that are characteristic of the intended purpose of the evaluation. Questionnaires are a popular tool in planning surveys assessing the value and availability of space. A list of attributes is presented to the respondents, questionnaire results are processed and every attribute's impact on rating results is determined. The correctness of the questionnaire method is often overlooked at this stage of the analytical process. This aspect will be analyzed in this study which investigates the relations between tourist

Adres do korespondencji – Corresponding author: Adam Senetra, Katedra Planowania i Inżynierii Przestrzennej, Uniwersytet Warmińsko-Mazurski w Olsztynie, ul. Romana Prawocheńskiego 15, 10-724 Olsztyn, e-mail: adam.senetra@uwm.edu.pl

and recreational behaviors, natural assets and the spatial aspects of recreation planning on the example of the region of Warmia and Mazury.

A list of natural assets and infrastructure elements that contribute to a given area's recreational attractiveness has been compiled based on the results of a questionnaire survey involving experts. The investigated attributes were divided into three principal groups:

1. Natural assets – scenic value, water bodies, forests, phenomena of animate and inanimate nature, species diversity of fauna and flora, trees and shrubs, permanent grasslands, marshes, peatlands, land relief.
2. Technical infrastructure – roads, sewer networks, water supply networks, power grids, gas supply networks, telecommunications networks, road transport, car parks, mobile telephone networks.
3. Recreational facilities and tourist services – tourist accommodation (year-round and seasonal), nautical and sports facilities, bathing areas, horseback riding facilities, private recreational facilities, restaurants, retail and service outlets.

The above attributes have been selected and grouped in view of their contribution to recreation planning in rural areas in north-eastern Poland [Senetra 2001].

QUESTIONNAIRE DEVELOPMENT METHODOLOGY

According to Krupowicz [Prognozowanie gospodarcze… 2008], an expert is a person who is asked to participate in a survey on account of his/her knowledge, personality, broad horizons, etc. Experts are persons who have a future-oriented approach and who are recognized authorities in their respective fields. The main criteria for expert selection include: formal education in the field of spatial planning, wide age spread, versatile and individualistic outlook for the future. This set of attributes ensures the adequacy of the formulated judgments. Out of the total number of 95 mailed questionnaires, responses were elicited from 64 participants, mostly academic staff of universities and doctoral students, including seven spatial planning professionals and four tourism professionals. The quality of the survey was further enhanced by the fact that the respondents were residents of the analyzed area (with thorough knowledge of the region) who actively searched for recreational opportunities (on a daily and seasonal basis) in the vicinity of lakes. Therefore, the respondents were both experts and prospective recipients of tourist services [Senetra 2001].

Heuristic methods are based on the assumption that the validity of group judgments is higher than the reliability of individual judgments. Group responses regarding the object of the survey are at least as valuable as the judgments formulated by individual members of the group. An individual expert's broad and unique knowledge in a given field may compensate for the ignorance of other experts who demonstrate a high level of knowledge in other fields [Prognozowanie gospodarcze... 2008].

The questionnaire has been developed in the form of an evaluation matrix (Fig. 1) which supports paired comparison. When objects are ranked in view of a given attribute, the respondents can be presented with a pair of objects in all possible configurations.

Objects considered to be more attractive for a given planning function are selected separately for every pair of compared objects (or attributes, landscapes, images, phenomena, etc.). This method delivers more reliable results than evaluations in which all attributes are evaluated collectively by all judges [Ferguson and Takane 1989]. The total number of paired comparisons is equal to the number of pair combinations *k*:

$$\frac{k(k-1)}{2} \tag{1}$$

The use of arrows in marking the selected option is a convenient solution (in particular for the respondent). By marking one of the two compared elements with an arrow, the respondent indicates that the selected option is more important (more attractive) for the analyzed function (in this study – the area's suitability for recreation planning). If the respondent concludes that element X_2 is more attractive than X_1, the above choice is denoted as $X_1 \rightarrow X_2$, and when element X_1 is more attractive than X_2 – as $X_2 \rightarrow X_1$.

When questionnaire data are processed, every evaluated element is assigned a numeric value resulting from the paired comparison procedure. This value is an expression of every attribute's impact on the attractiveness of space. All fields in the evaluation matrix have been assigned a constant numeric value of 1. The total value of a single evaluation matrix is equal to the total number of possible pairs (cf. 1), and it is also expressed as:

$$\frac{k(k-1)}{2}.$$

In a paired comparison, an element that is deemed to be more attractive (marked with an arrow by the expert) is assigned the value of 1, and the less attractive element is assigned the value of 0. The numeric values of all elements are summed up, and their sum total equals the evaluation matrix total. A matrix format is very convenient because the respondents fill out the questionnaire only in the top part above the diagonal line. The corresponding numeric values are entered into the fields under the diagonal line by the researcher (tab. 1). The matrix format contributes to the ease of questionnaire filling, and it minimizes the possibility of error.

Table 1. Model responses to a paired comparison
Tabela 1. Wzór odpowiedzi dla porównań parami

	X_1	X_2	X_3	Sum of rows – R Suma wierszy – R	$(R - R_{av})^2$
X_1	**X**	1	1		
X_2	0	**X**	1		
X_3	0	0	**X**		

Source: Own compilation based on Kendall [1970]
Źródło: Opracowanie własne na podstawie Kendalla [1970]

In the paired comparison method, the consistency of the respondents' choices has to be checked. Let us use three hypothetical elements, X_1, X_2, X_3. The respondent's choice is consistent if the expert prefers X_1 over X_2 and X_2 over X_3. If the expert prefers X_3 over X_1, the last choice is inconsistent with the previously selected options. The sequence $X_1 \rightarrow X_2 \rightarrow X_3 \rightarrow X_1$ forms an inconsistent triad of propositions. An expert could make an inconsistent choice because he is unable to differentiate between objects, he makes accidental choices or he voluntarily changes the imposed choice criteria during the survey [Bajerowski et al. 2007]. The consistency of choices made by individual experts has to be analyzed to eliminate accidental preferences that could significantly affect the quality of the survey. In this study, the consistency of the experts' choices was evaluated using the consistency coefficient K and statistical formulas developed by Kendall.

CONSISTENCY COEFFICIENT K AND ITS SIGNIFICANCE

The choices made by the experts in a paired comparison were recorded in table form. If alternative X_1 was described as more attractive than X_2, the value of 1 was entered in the field at the intersection of row X_1 and column X_2 above the diagonal line. The opposite value, 0, was entered in a respective field that corresponded to row X_2 and column X_1 below the diagonal line. The same method was applied to tally the remaining choices (tab. 1).

The number of inconsistent triads can be determined for every set of objects k, and it is used to calculate the consistency coefficient characterizing the respondents' choices. If the respondents were unanimous in their choices, the total ranks from each row would amount to 0, 1, 2, ..., k – 1, although the above sequence is not always preserved. The presence of inconsistent choices is determined by the decreasing variation, i.e. the repeatability of total ranks. If total ranks are marked as R, the mean value of total ranks would amount to:

$$R_{śr} = \frac{\sum R}{k}.$$

and it is equal to:

$$\frac{k-1}{2}.$$

The sum of squared deviations from all rows is:

$$\sum (R - R_{śr})^2 = \sum R^2 - \frac{k(k-1)^2}{4} \qquad (2)$$

Special attention should be paid to the highest and the lowest sum of squared deviations. $\Sigma\ (R - R_{śr})^2$ reaches the highest value when the evaluation matrix contains no inconsistent choices, and it is equal to:

$$\frac{k(k-1)^2}{12}.$$

The lowest value of $\Sigma\ (R - R_{śr})^2$ is determined by whether k is an odd or an even number. If k is an odd number, then the lowest value of $\Sigma\ (R - R_{śr})^2$ is 0. If k is an even number, the lowest value is $k/4$.

Consistency coefficient K (3, 4, 5) is defined as:

$$K = \frac{Z - NM}{NW - NM} \tag{3}$$

where:
Z – observed sum of squared deviations,
NM – lowest value of the sum of squared deviations,
NW – highest value of the sum of squared deviations.

If k is an odd number, then:

$$K = \frac{12\sum(R - R_{śr})^2}{k(k^2 - 1)} \tag{4}$$

and if k is an even number, then:

$$K = \frac{12\sum(R - R_{śr})^2 - 3k}{k(k^2 - 4)} \tag{5}$$

Coefficient K is referred to as Kendall's consistency coefficient. Its anticipated value is *0* when respondents make random choices, which is the case when there is no overall agreement among the respondents, or *1*, when the respondents are completely unanimous in their choices [Kendall 1970]. Coefficient K is interpreted as follows: the number of inconsistent triads of propositions $X_1 \rightarrow X_2 \rightarrow X_3 \rightarrow X_1$ is marked with the symbol d (6, 7). Its value is related to coefficient K. If k is an odd number, then:

$$d = \frac{k(k^2 - 1)(1 - K)}{24} \tag{6}$$

and if k is an even number, then:

$$d = \frac{k(k^2 - 4)(1 - K)}{24} \tag{7}$$

The significance of the consistency coefficient is determined based on the distribution of the number of triads when the respondents make random choices. Kendall [1970] developed a table of probabilities which shows that a given value of d is reached or exceeded when k ranges between 2 and 7. He also demonstrated that the χ^2 test (8) can be used to determine approximate probability when $k > 7$. The value of:

$$\chi^2 = \frac{8}{k-4}\left(\frac{1}{4}C_3^k - d + \frac{1}{2}\right) + df \tag{8}$$

has the rough distribution of χ^2 where the number of degrees of freedom is expressed by the following formula:

$$df = \frac{k(k-1)(k-2)}{(k-4)^2}$$

The expression C_3^k in formula (8) is the number of combinations of objects k in groups of three, i.e. $k!/3!(k-3)!$. In this test, the required probability that d will be equal to or greater than the value resulting from random choices complements the probability of χ^2.

COEFFICIENT OF CONCORDANCE W AND ITS SIGNIFICANCE

Questionnaire results have to be processed to assess agreement among the experts. The resulting observations contribute to survey quality, and they validate the suitability of the verified data for further spatial analyses. The degree of agreement among the respondents has been determined with the use of Kendall's coefficient of concordance W and the methods proposed by Kendall [1970].

If various sets of ranks exist, and each set is generated by a different expert, the concordance between various ranks has to be determined by identifying the degree of correlation between the set of ranks n concerning objects k. The value of coefficient W ranges from 0 (no agreement) to 1 (total agreement), and it is expressed on an ordinal scale. A highly significant value of W indicates that the experts are in agreement as regards the criteria used to rank a given sample. Coefficient W is a useful tool only when evaluation criteria are used by the experts in a reliable manner and if the ranks are assigned independently. A high value of W does not automatically imply that the ranking of compared elements yields correct results. The experts may deploy false criteria to arrive at concordant opinions, therefore, a high degree of unanimity does not testify to the accuracy of the criterion used by the respondents to make independent judgments [Brzeziński 2010].

Coefficient W is determined for data expressed on the ordinal scale where the responses given by experts n have to be ranked. Rank 1 is assigned to the element which is considered to be optimal in view of the evaluated criteria. In this study, rank 1 was given to the object which was most frequently chosen by experts in paired comparisons.

The least desirable element was assigned rank k. A computational table with n (number of experts) rows and k (number of compared objects) columns was created (tab. 2). The ranks given by all experts were entered in table fields. The sum of ranks given to the evaluated objects was calculated and entered into row R_j. Partial sums were added, and the result was divided by the number of evaluated objects k. The value in row R_j was subtracted from the mean, and the result was entered in the following row. The value of squared deviations was entered in the last row of the table. The sum of squared deviations was marked with the symbol S.

Table 2. Model table for calculating the coefficient of concordance W
Tabela 2. Wzór tabeli pomocniczej do obliczania współczynnika zgodności W

Objects (k) – Elementy (k) Judges (n) – Sędziowie (n)	1	2	3	4	K	Σ
1						
2						
3						
N						
R_j						
$(R_j - M)$						
$(R_j - M)^2$						S

R_j – total ranks assigned by the judges to the j-th object – suma rang przypisana przez sędziów j-temu elementowi

$\sum_{i=1}^{k} R_j$ – total of partial sems R_j – suma sum cząstkowych Rj

$M = \left(\sum_{i=1}^{k} R_j \Big/ k \right)$

Source: Own compilation based on Brzeziński [2010], Ferguson and Takane [1989]
Źródło: Opracowanie własne na podstawie Brzezińskiego [2010], Fergusona i Takane [1989].

If the respondents were completely unanimous, they would assign rank 1 to the same object, rank 2 to the following object, etc., all the way down to rank k. In this case, total ranks would amount to n, $2n$, $3n$, $4n$,..., kn. The value of total ranks k given by judges n is:

$$\frac{nk(k+1)}{2}.$$

and the mean value of total ranks is:

$$\frac{n(k+1)}{2}.$$

The degree of agreement between the judges is expressed by the variation of total ranks. The highest variation is observed when the judges are unanimous. The value of total ranks is less varied when the judges' responses are more random, therefore, total ranks are more or less equal when the respondents are in greatest possible disagreement [Ferguson and Takane 1989].

Let us assume that R_j represents the total ranks given to the j-th object. The sum of squared differences between every R_j and the mean value of $(\Sigma R_j/k)$ for k objects is:

$$S = \sum \left(R_j - \frac{\sum R_j}{k} \right)^2 .$$

The value of total ranks is the highest when the judges are unanimous, and it equals:

$$\frac{n^2 \left(k^3 - k \right)}{12} .$$

The coefficient of concordance W (9) is defined as the ratio between S and the highest possible value of S:

$$W = \frac{12S}{n^2 \left(k^3 - k \right)} . \qquad (9)$$

If the test statistic W=1, then all the judges have been unanimous, and if W=0, then there is no overall trend of agreement among the respondents. With a correction of tied ranks (if any), the formula for coefficient W becomes:

$$\sum_{i=1}^{n} T_i ,$$

where:

$$T_i = \frac{\sum \left(t^3 - t \right)}{12}$$

t – number of tied ranks.

The final formula for coefficient of concordance W (10) is:

$$W = \frac{S}{\frac{1}{12} n^2 \left(k^3 - k \right) - n \sum_{i=1}^{n} T_i} \qquad (10)$$

The correction for ties increases the value of W. If the number of tied ranks is low, the correction has an insignificant effect. If there are no tied ranks, the correction equals zero, and the formula shown in (18) is deployed.

The mean value of Spearman's rank correlation coefficient has to be calculated between all possible pairs of the rankings to determine the percentage of variation in the respondents' judgments over which W is calculated:

$$\bar{\rho} = \frac{nW - 1}{n - 1}.$$

The value of $\bar{\rho}$ is squared and multiplied by 100% to produce the total percentage of variation expressed by the given value of W. The remaining percentage of variation accounts for individual differences in the respondents' judgments, etc. [Ripley 2004, Brzeziński 2010].

The values of W required for a significance level of 5 and 1 percent $k \leq 7$ at have been compiled in table form by Friedman (cf. Siegel, Kastellan 1988). If $k > 7$, the distribution of W can be approximated based on the distribution of χ^2 with degrees of freedom $df = k - 1$ according to the following formula:

$$\chi^2 = n(k-1)W.$$

The criterion for the selection of the optimal object is the value of R_j. The best object is characterized by the lowest value of R_j.

RESULTS AND DISCUSSION

A questionnaire survey was carried out in accordance with the presented methodology to evaluate the investigated region's attractiveness for recreation planning. The resulting data supported the formulation of conclusions for subsequent parts of the study. The consistency of the respondents' choices was analyzed. Consistency coefficient K and the number of inconsistent triads of propositions d were determined for each questionnaire. The significance of consistency coefficients was determined to eliminate incorrectly filled out questionnaires [Silverman 2006].

Four questionnaires were eliminated due to an excessive number of inconsistent triads of propositions. The remaining questionnaires were filled in correctly. The rejected questionnaires were characterized by χ^2 values at a significance level of $\alpha = 0.02$ to $\alpha = 0.06$. Although selected rejected questionnaires were marked by higher consistency than random responses, the values of χ^2 at a significance level of $\alpha = 0.01$ were adopted as the correctness criterion due to a high number of incorrect questionnaires.

At the following stage, Kendall's coefficient of concordance was determined to assess the degree of agreement among all experts participating in the survey (having rejected incorrectly filled-in questionnaires). This analysis produced very high values of Kendall's W for individual questionnaires, and the noted values were regarded as highly significant. The values of χ^2 at a significance level of $\alpha = 0.01$ were adopted as the correctness criterion.

The ranking revealed the order in which the tested attributes were regarded as significant for recreation planning and spatial analyses. The adopted procedure does not support the determination of correlations between individual attributes and their effect on the survey results. The aim of the discussed analysis is to determine the correctness of choice criteria as well as the correctness of the questionnaire survey. The results yielded by the proposed method are shown in Table 3. The attributes described as most conducive to recreation planning in the region of Warmia and Mazury have been divided into three groups.

Table 3. The results of processed questionnaires
Tabela 3. Wyniki opracowanych ankiet

Most attractive attributes according to the respondents Elementy najatrakcyjniejsze zdaniem ekspertów	Number of compared elements Liczba elementów porównywanycdh	Grading scale Skala punktacji	Average grade Średnia punktacja	Rank Ranga
Natural assets Walory środowiska przyrodniczego				
Landscape Walory krajobrazowe	18	0–17	16,03	1
Water bodies (with tourist access) Wody powierzchniowe (dostępne dla turystów)	–	–	15,25	2
Older forests Lasy starsze	–	–	14,22	3
Land relief Rzeźba terenu	–	–	13,78	4
Technical infrastructure Elementy infrastruktury technicznej				
Road networks Sieć dróg	12	0–11	9,42	1
Sewer networks Sieć kanalizacyjna	–	–	8,38	2
Water supply networks Sieć wodociągowa	–	–	8,33	3
Recreational facilities and tourist services Elementy infrastruktury rekreacyjnej i usługowej				
Year-round accommodation Całoroczne obiektuy noclegowe	11	0–10	8,95	1
Nautical infrastructure Infrastruktura nautyczna	–	–	8,42	2
Private recreational facilities Indywidualna zabudowa rekreacyjna	–	–	7,92	3

Source: Own compilation
Źródło: Opracowanie własne

CONCLUSIONS

The experts' responses were marked by a very high degree of consistency, indicating that the paired comparison method delivers reliable results. This study validates the usefulness of the paired comparison method for spatial assessment. The surveyed technique delivers more reliable results than evaluations in which all attributes are evaluated collectively by all judges. Paired comparison analyses minimize the subjectivity of responses because experts choose one of the two presented options. The results of the survey indicate that the expert group had been successfully selected. Nearly all respondents made consistent choices, and the test investigating the level of concordance among the experts delivered results that were above expectations. The results were undoubtedly influenced by the matrix form of questionnaires and the arrow marking system which enabled the respondents to focus on their choices without having to control the correctness of zero/one items. The processed results support the unanimous and highly probable determination of spatial attributes that are most conducive to recreation planning in rural areas in north-eastern Poland. This study validated the usefulness of the proposed methodology for spatial analyses.

REFERENCES

Bajerowski T., Biłozor A., Cieślak I., Senetra A., Szczepańska A., 2007. Ocena i wycena krajobrazu. Wybrane problemy rynkowej oceny i wyceny krajobrazu wiejskiego, miejskiego i stref przejściowych. Red. T. Bajerowski. Educaterra, Olsztyn.

Brzeziński J., 2010. Metodologia badań psychologicznych. Wydanie 5. PWN, Warszawa.

Ferguson G., Takane Y., 1989. Statistical analysis in psychology and education. McGraw-Hill, Inc.

Kendall M., 1970. Rank Correlation Methods. Charles Griffin and Co, London.

Prognozowanie gospodarcze. Metody i zastosowania. 2008. Red. M. Cieślak PWN, Warszawa.

Ripley B.D., 2004. Spatial statistics. John Wiley & Sons, 2-nd ed., New York.

Senetra A., 2001. Zagospodarowanie rekreacyjne jako element rozwoju przestrzeni wiejskiej na przykładzie regionu warmińsko-mazurskiego (rozprawa doktorska). UWM, Olsztyn.

Silverman D., 2006. Interpreting qualitative data. SAGE Publications Ltd, London.

Siegel S., Kastellan J., 1988. Nonparametric statistics for the behavioral sciences. New York, McGraw-Hill.

PROPOZYCJA METODYKI OPRACOWANIA ANKIET NA PRZYKŁADZIE ANALIZY ZAGOSPODAROWANIA REKREACYJNEGO REGIONU WARMII I MAZUR

Streszczenie. W analizach dotyczących oceny i waloryzacji przestrzeni bardzo popularną metodą badawczą jest metoda ankietowa. Podczas statystycznego opracowania wyników ankiet należy przeprowadzić analizę prawidłowości badań ankietowych. W pracy przedstawiono możliwość zastosowania metody porównywania parami do oceny walorów naturalnych i antropogenicznych przestrzeni sprzyjających rozwojowi zagospodarowania rekreacyjnego w regionie Warmii i Mazur. Jakość materiału ankietowego oceniono poprzez zastosowanie współczynnika spójności pojedynczych ankiet oraz współczynnika zgodności całej grupy ekspertów. W zaproponowanej metodyce posłużono się formułami statystycznymi opracowanymi przez Kendalla. Część wnioskowa prezentuje listę cech uznanych za najważniejsze z punktu widzenia zagospodarowania rekreacyjnego rozpatrywanego obszaru. Potwierdzono ponadto zasadność badania spójności i zgodności materiału ankietowego z wykorzystaniem metod statystycznych.

Słowa kluczowe: Ocena, ankieta, ekspert, porównanie, spójność, zgodność.

Zaakceptowano do druku – Accepted for print: 21.03.2011