e-journal: **Information Technology for Economics & Management**
ITEM, *Volume 4, No 1, 2008, Paper 2*
ISSN 1643-8949

Calculation method of streams of tourists centers visitors using „modified gravitational" model on the base of fuzzy logic

Vyklyuk Yaroslav, Lyakhov Serhiy

This paper is about modified gravitational model improvement using fuzzy logic. New model was used to make calculation visitors' quantity tourism recreation systems, new results were compared with old ones and were shown advantages using new modified gravitational model.

Development of tourist industry in Ukraine will assist to the development of international and market relations, will decrease the quantity of unemployed persons, partly will protect the natural and historical-culture inheritance. It needs the large capital investments to develop tourist industry in a whole region simultaneously, therefore it is necessary to define places which will attract most of visitors.

There is vagueness in the models of functioning of the recreation tourist systems, from one side by absence of exact description of systems functioning processes, from other by impossibility to estimate proper conditions of the systems that's why sometimes it is impossible to use of exact quantitative methods.

Purpose of this paper is improvement with fuzzy logic the "gravitational" model which calculates quantity of potential clients in tourist-recreation centers.

Actuality. Determination of visitors' quantity is the important constituent of investment analysis. After estimation of visitors' quantity it is possible to optimize business-processes, predict an income, charges, profitability, to plan which services could be offered to visitors etc.

To forecast the potential visitors' quantity in the tourism recreation systems (TRSs) we applied the modified gravitational model, which allows to take into account the impact of distance from demand locality, price policy, seasonality and main "attractiveness" factors [1]. After this model the potential amount of visitors is determined as:

$$K_{ij}^{cat}(T) = k \times \left(1 + \frac{\sum_{l=1}^{n} Att_l^{TPC} Att_l^{cat}}{n_{Att}} \right) \times \frac{(D_{cat\,i} m_i)^m n_j^n}{r_{ij}^r} \times P_{cat}(T) P_{TPC}(T) \times \left(1 - \frac{\sqrt{\left| B_{TPC}^2 - B_{cat}^2 \right|}}{n_{price}} \right) \tag{1}$$

where

K_{ij}^{cat} – the number of the guests in *j-th* TRS who arrived from an *i-th* demand locality;

m_i^m – quantity of population in the *i-th* demand locality;

n_j^n – maximum capacity of the j-th TRS;

r_{ij}^r – distance between the *j-th* TRS and *i-th* demand locality;
k – empirical "gravity" (attractiveness) factor;
m, n, r – empirical factors;
$D_{cat\,i}$ –the proportion of the "cat" category people in the *i-th* demand locality;

$P_{cat}(T)$ – probability that the "cat" people will have their vocation in the time T;

$P_{TPC}(T)$ – probability that the given TRS will work in the time T;

B_{TPC} – TRS price category;

B_{cat} – the desired TRS category for the visitors of the "cat" category;

n_{price} – the normalizing factor which is equal to the degree of the B_{TPC} and B_{cat} rating scale;
l – the "attractiveness" type;

Att_l^{TPC} – the rating grade of the *l-th TRS* "attractiveness";

Att_l^{cat} – the grade defining the impact oh the *l-th* "attractiveness" for the "cat" category visitors

n_{Att} – the maxim value of Att_l^{TPC}.

All the factors in (1), except *k, m, n, r,* have statistical nature and were defined by expert assessments performed by the leading experts in this field.

Lack of this model is determination of general index of attractiveness in (1):

$$Atr(trs,cat)=\left(1+\frac{\sum_{l=1}^{n}Att_l^{TPC}Att_l^{cat}}{n_{Att}}\right). \qquad (2)$$

For calculation of this multiplier were used 28 indexes of attractiveness, which were determined by the expert evaluations [1]. Almost all attractiveness indexes for different TRSs are similar in values. Other indexes which considerably differ one from other can not substantially affect on multiplier (2). In such case values of almost all indexes of all TRSs are situated near some value, and the value of the multiplier (2) is schematically represented on fig. 1. The values range of multiplier (2) is [1;2] and value 1,value 2 and nearby are «dead values», it means that attractiveness of any TRS will differ from each other on 0,4–0,8, that can not substantially affect on final results. Also it is not so easy to evaluate qualitative indexes of attractiveness with high exactness what prevent using of classic mathematical methods.

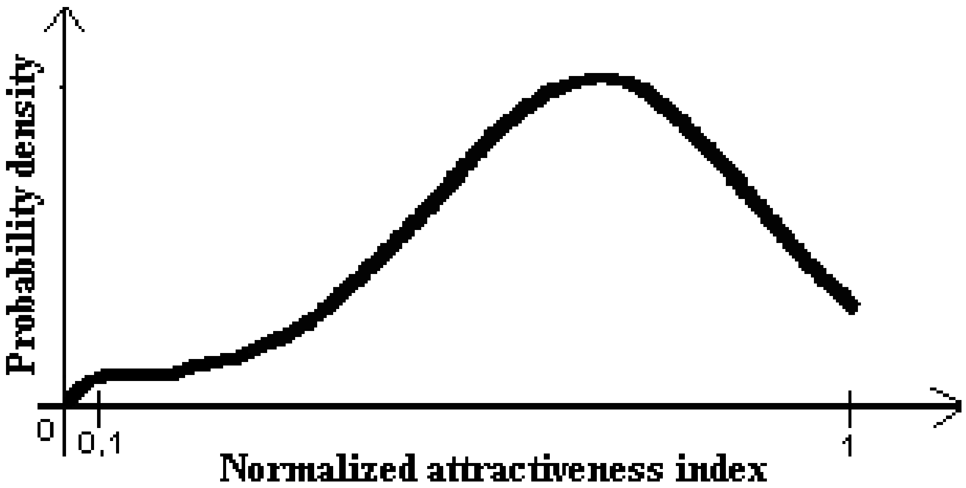


Fig 1. Schematic sketch of normalized attractiveness index distribution

It is better to use fuzzy logic for modeling attractiveness of any region or TRS. It will give possibility to determine the general index of TRS attractiveness on wider range and also it will be better to calculate other indexes of attractiveness. As shown in practice fuzzy modeling very often allows more adequately describe objects with some vagueness and gives the best results in comparison with the determined or probabilistic-statistical models [2]. Efficacy of using fuzzy logic in tourist industry researches was proved in papers [2–8]. In particular, work [4] is devoted for modeling and creation of consulting model of hotel choosing. Forecasting in tourist industry using fuzzy logic and neuronets is described in [5, 6].

Therefore we suggested to use instead multiplier (2) other index – ***Atr(trs,cat)fuzzy,*** which is calculated using fuzzy logic model

Fuzzy Set Theory was formalised by Professor Lofti Zadeh at the University of California in 1965. What Zadeh proposed is very much a paradigm shift that first gained acceptance in the Far East and its successful application has ensured its adoption around the world. A paradigm is a set of rules and regulations which defines boundaries and tells us what to do to be successful in solving problems within these boundaries.[9].

The main point of fuzzy sets is **membership function** which usually denoted *MFc(x)* and represent fuzzy set C and it is a generalization of the indicator function in classical sets. For an element *x* of *X*, the value *MFc(x)* is called the *membership degree* of *x* in the fuzzy set *C*. The membership degree *MFc(x)* quantifies the grade of membership of the element *x* to the fuzzy set *C*. The value 0 means that *x* is not a member of the fuzzy set; the value 1 means that *x* is fully a member of the fuzzy set. The values between 0 and 1 characterize fuzzy members, which belong to the fuzzy set only partially.

Unclear and linguistic variables are used for description of fuzzy sets.

An unclear variable is described by the set *(N,X,A)*, where *N* – it is the name of variable, *X* – universal set (region of reasoning), *A* – fuzzy *set* on X. Unclear variables can be the linguistic variable values, that is a linguistic variable is found high-level, than unclear variable. Every linguistic variable contain:

- the names;
- sets of the values, that is also called base term set *T*; the elements of base term set are the names of unclear variables;
- universal set *X;*
- syntactic rule *G, which is used for new terms generation from natural or formal language;*
- semantic rule *P*, which dedicate every linguistic variable to fuzzy subset of set *X*.

There are over ten typical forms of curves of membership functions. Most used are three-cornered, trapeze and gaussian membership functions.

The basis of fuzzy conclusion is a set of rules, that contains the unclear utterances in the form "*IF-THEN*", and membership functions for the proper linguistic terms. Further conditions should be present:

1) there is even one rule for every linguistic term of output variable;
2) for any term of initial variable should be even one rule in which this therm will be used as pre-condition (the left part of rule).

In the opposite case the incomplete base of unclear rules takes place.

Lets in the base of rules is *m* rules like:

$$R_1\text{: IF } x_1 \text{ is } A_{11} \text{ ... And .. } xn \text{ is } A_{1n}\text{, THEN } y \text{ is } B_1$$

.

$$R_i\text{: IF } x_1 \text{ is } A_{i1} \text{ ... And ... } x_n \text{ is } A_{in}\text{, THEN } y \text{ is } B_i$$

.

$$R_m\text{: IF } x_1 \text{ is } A_{i1} \text{ … And ... } x_n \text{ is } A_{mn}\text{, THEN } y \text{ is } Bm$$

where xk, $k=1..n$ – initial variables; y – output variable; A_{ik} –fuzzy sets with the membership functions.

The result of fuzzy conclusion is exact value of variable y^* that based on the set of exact values of x_k, $k=1..n$.

In the general mechanism of the logical conclusion flaw has four stages: introduction of fuzzification, fuzzy conclusion, composition and defazzification (Fig.2).

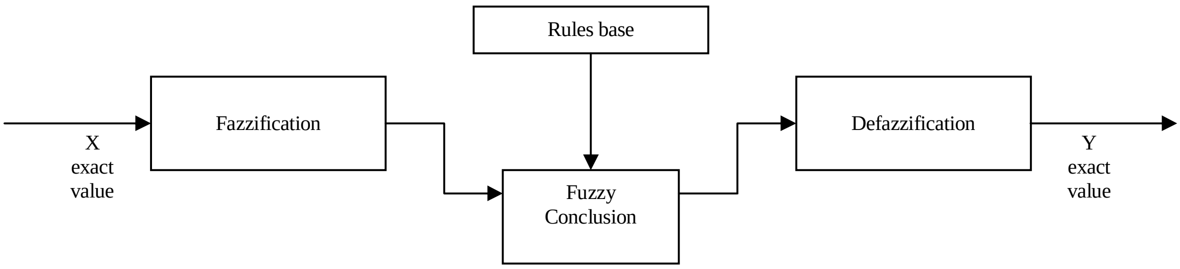


Fig. 2. Logical conclusion flaw.

Fuzzy conclusion algorithms differ from each other by the type of used rules, boolean operations and defazzification methods. Most popular algorithms are Mamdani, Sugeno, Larsen’s.

In [10] was stated the possibility of using algorithms Mamdani and Sugeno for determination of recreation potential. It was shown, that the received results not stringly differ and well correlate with experts estimations. Therefore in subsequent computations we used one of these algorithms – algorithm Sugeno with the three-cornered membership functions. We choose this algorithm because it is the basis of ANFIS (Adaptive Neuro-Fuzzy Inference System) and we could use these systems in future researches [11].

For fuzzy conclusion Sugeno we need unclear knowledge base:

$$(x_1 = \tilde{a}_{1j}\ \Theta_j\ x_2 = \tilde{a}_{2j}\ \Theta_{j\ldots}\ \Theta_j\ x_n = \tilde{a}_{nj}) \rightarrow y=b_{j0}+b_{j1}x_1+b_{j2}x_2+\ldots+b_{jn}x_n,\ j=1,m; \qquad (3)$$

where, $b_{j0}, b_{j1}, ..., b_{jn}$ – real numbers.

The conclusions of rules are set by a linear function from the inputs:

$$dj = b_{j0} + \sum_{i=1,n} b_{ij} x_i \qquad (4)$$

Degree of belonging of entrance vector $X^*=(x_1^*, x_2^*, \ldots, x_n^*)$ to the values $dj = b_{j0} + \sum_{i=1,n} b_{ij} x_i^*$ are calculated as follows:

$$\mu_{dj}(X^*)= \mu_j(x_1^*)\ \chi_j\ \mu_j(x_2^*)\ \chi_j\ \ldots\ \chi_j\ \mu_j(x_n^*),\ j=1,m. \qquad (5)$$

Result of conclusion according to the input vector X^* is the fuzzy set $\tilde{y}$:

$$\tilde{y} = \left(\frac{\mu_{d1}(X^*)}{d_1}, \frac{\mu_{d2}(X^*)}{d_2}, \ldots, \frac{\mu_{dm}(X^*)}{d_m}\right) \qquad (6)$$

For getting output result $\tilde{y}$ should be defazzificated, it is made by calculating balanced sum:

$$y = \sum_{j=1,m} \mu_{dj}(X^*) d_j\,. \qquad (7)$$

In this paper we use the Sugeno method of 0-th order, when the logical conclusion is a constant:

$$(x_1 = \tilde{a}_{1j}\ \Theta_j\ x_2 = \tilde{a}_{2j}\ \Theta_{j\ldots}\ \Theta_j\ x_n = \tilde{a}_{nj}) \rightarrow y=dj,\quad j=1,m. \qquad (8)$$

In accordance with experts' opinion [1] the most ponderable groups of attractiveness indexes are: Ecological condition, Infrastructure (with sub-groups Hotel infrastructure and Public infrastructure), Service factors, Locations. For estimation of output indexes following input parameters were proposed by experts for every group and sub-group (table 1):

Table 1. Description of linguistic variables and their therms for all groups of attractiveness indexes

Group	The linguistic variable	Variable description
E (Ecological conditions)	E_a E_b E_c E_d	Radiation Air Water Green planting of territory
I_a (Hotel infrastructure)	I_{a1} I_{a2} I_{a3} I_{a4}	Developed hotel infrastructure for different consumption segments Developed network of TV communications Developed infrastructure of sporting building and possibilities of sport activity Developed entertainments infrastructure on TRS

		territory
I_b (Public infrastructure)	I_{b1} I_{b2} I_{b3} I_{b4}	Developed infrastructure of transport communications: roads, air-ports, railway, marine and river ports Developed system of public food consumption Developed system of public transport Developed entertainments infrastructure near TRS territory
S (Service factors)	S_a S_b S_c S_d	Cost Original local food Developed industry and production of souvenirs Developed trade network. Presence of commodities groups especially attractive in a price-quality category
L (Location)	L_a L_b L_c L_d	Distance from villages Distance from cities and towns Providing with access roads for cars Providing by rails

For computation of the aggregated index of attractiveness we suggested to use the hieratic fuzzy system. Recreational potentials are calculated for each group using algorithm Sugeno. Its are input parameters for aggregated fuzzy expert system, which determines the coefficient of TRS attractiveness (fig. 3). Offered approach allows considerably decreasing the necessary quantity of production rules.

For calculation aggregated index of TRS attractiveness and take into account importance of intermediate indexes for every population group (middle class, students, businesspeople class and

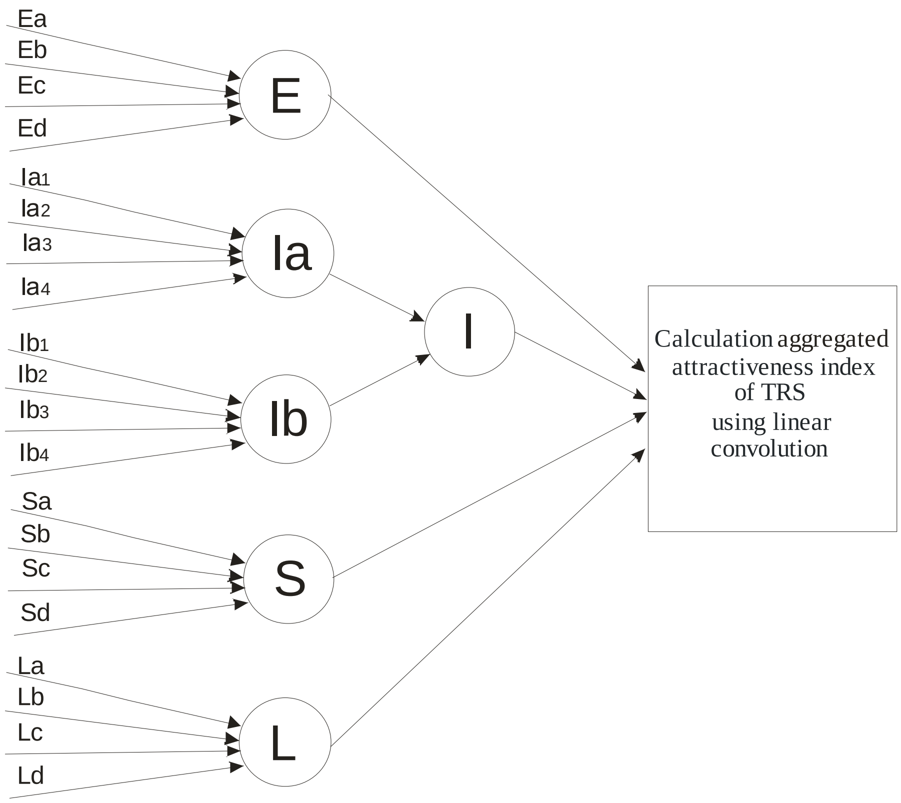


Fig. 3. Calculation schema of attractiveness index using fuzzy model.

children) the method of linear convolution was applied, that well prove itself in papers [2, 12].

$$Atr(trs,cat)_{fuzzy} = \sum_i Att(trs)_i \frac{Imp(cat)_i}{\sum_j Imp(cat)_j} \quad (9)$$

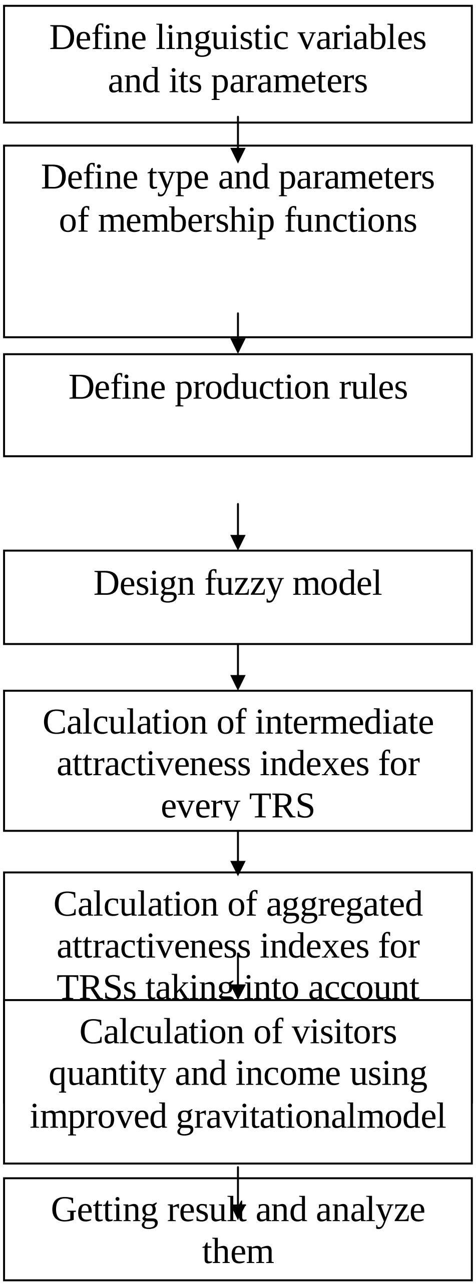
where ***Atr(trs,cat)***$_{fuzzy}$ – aggregated index of TRS attractiveness for the definite population category;

Att(trs)$_i$ – intermediate index of TRS attractiveness;

Imp(cat) – importance of intermediate attractiveness index for the definite population category.

Algorithm of computation

We offered to apply following algorithm for computation general index of TRS attractiveness:



Pic 4. Algorithm for computation general index of TRS attractiveness.

Computer experiment

For development of fuzzy logic model we used MatLab and Fuzzy Logic extension. Terms of linguistic variables definite in table 1 are present in table 2. For construction of unclear expert's production rules we used the generally accepted international abbreviations for the function parameters (Z – zero, close to the zero, PS – positive small, PM – positive middle, PB – positive large) [13, 14].

Table 2. Description of terms of linguistic variables for all groups of attractiveness indexes

Group	Linguistic variable	Function parameters	Parameter descriptions
E (Ecological condition)	Ea	PB PM Z	Radiation contamination is absent The level of radiation contamination meets possible for the life standards The level of radiation contamination exceeds radiation norms
	Eb	PB Z	Ecologically clean water without filtration Water from public cleansing service
	Ec	PB PM Z	Ecologically clean air (Healthy) City air Muddy air
	Ed	PB PM Z	Presence of health types of plants Enough greenery planting without the health types of plants Few greenery planting
Ia (Hotel infrastructure)	Ia1	PB PM Z	Enough rooms quantity for all consumptions segments Enough rooms quantity for few consumptions segments Insufficient rooms quantity for any level of consumption
	Ia2	PB Z	TV communications network is well developed Poorly developed or not developed TV communications network
	Ia3	PB Z	Well developed infrastructure of sporting building and possibilities of sport activity Almost absent possibility of sport activity
	Ia4	PB Z	Well developed entertainments infrastructure Badly developed entertainments infrastructure
Ib (Public infrastructure)	Ib1	PB PM Z	Presence of all types of transport communications Middling developed transport infrastructure Poorly developed transport infrastructure
	Ib2	PB Z	Well developed public food services Poorly developed public food services
	Ib3	PB Z	Well developed system of public transport Poorly the developed system of public transport
	Ib4	PB Z	Enough quantity entertainments centers Poorly developed infrastructure of entertainments
S (Service factors)	Sa	PB PM Z	The best correlation in price-quality A price is some overpriced Ever-higher price and bad service
	Sb	PB	Present original local food

		Z	Absent original local food
	Sc	PB Z	Well developed industry and production of souvenir goods Poorly or not developed industry of souvenir goods
	Sd	PB Z	Well developed trade network Poorly or not developed trade network
R (Location)	Ra	PB PM Z	High-quality roads near TRS Roads are located from TRS at some distance Bad roads and its are located far from TRS
	Rb	PB Z	The railway station is located from TRS, not far away The railway station is located far from TRS
	Rc	PB Z	TRS is located in or near village Villages are located far from TRS
	Rd	PB Z	TRS is located in a town or close to its Towns are far from TRS

Group indexes are described by terms: Z – low, RM – middle; PB – high; the complex index of attractiveness is described by terms: Z – low, PS – below than middle, PM – higher than middle, PB – high.

For computations with fuzzy model three-cornered membership functions were used. The three-cornered membership function is determined by three numbers *(a,b,c)*, and it's value in the *x* point is calculated according to a formula:

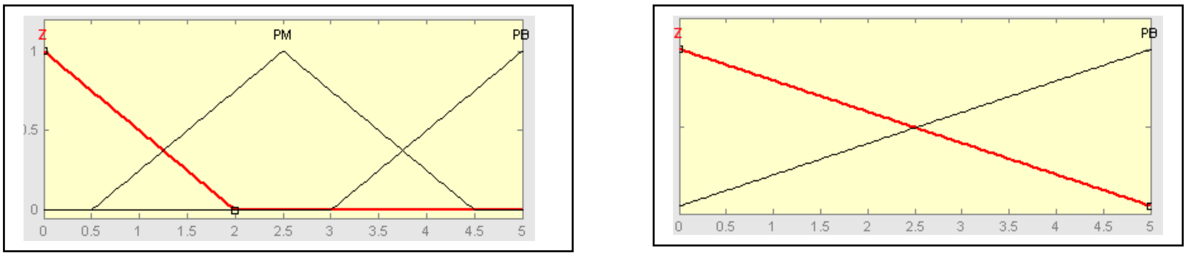
$$MF(x) = \begin{cases} 1 - \dfrac{b-x}{b-a}, a \le x \le b, \\ 1 - \dfrac{x-c}{c-b}, b \le x \le c, \\ 0, in\_other\_cases. \end{cases} \quad (10$$

At *(b-a)=(c-b)* we have the case of symmetric three-cornered membership function, that can be simply set by two parameters from three *(a,b,c)*. Gaussian membership functions gave less adequate results.

Parameters and type of membership functions are present in tab. 3 and on fig.5:

Table 3. Parameter specification of membership functions for construction of model in the MatLab system

Linguistic variable	**Term**	**Parameters of membership functions**
E_a E_b E_d I_{a1} I_{a3} I_{a4} I_{b2} S_a R_c (pic. 5 a)	**PB** **PM** **Z**	[3 5 7] [0.5 2.5 4.5] [-2 0 2]
E_c I_{a2} I_{b1} I_{b3} I_{b4} S_b S_c S_d R_a R_b R_d (pic. 5 b)	**PB** **Z**	[0 5 10] [-5 0 5]
E, I, S, P	**PB** **PM** **PS** **Z**	5 3.33 1.67 0



(a) (b)

Fig. 5. Three-cornered membership functions with three (a) and two (b) parameters (table 3).

Base of unclear production rules for the formal reflection of empiric knowledge, was got as a result of expert estimations given by tourism department of Chernivtsi regional state administration.

On the basis of the above-mentioned unclear production rules and structure fuzzy model in the system MatLab was developed. It evaluates intermediate attractiveness indexes for each TRS.

Using expert estimations of attractiveness indexes, computations of intermediate indexes of attractiveness for TRS Migovo, Boucovel and Nimchich were executed.

Table 4. Expert estimations of attractiveness indexes.

	Migovo	Boucovel	Nimchich
Ecological conditions			
Radiation	5,00	5,00	5,00
Water	5,00	5,00	4,20
Air	4,60	5,00	5,00
Greenery planting of territory	5,00	5,00	5,00
Infrastructure			
Hotel Infrastructure			
High-quality hotel infrastructure for different consumption segments	3,60	5,00	2,40
Developed network of TV communications	3,80	4,60	1,80
Developed infrastructure of sporting building and possibilities of sport activity	4,00	5,00	0,60
Developed entertainments infrastructure on TRS territory	3,80	5,00	1,60
Public infrastructure			
High-quality infrastructure of transport communications	3,80	4,20	1,00
Developed system of public food consumption	4,60	5,00	1,80
Developed system of public transport	3,80	4,20	0,40
Developed entertainments infrastructure near TRS territory	3,80	5,00	1,60
Service factors			
Cost and quality of service	5	4	3

Original local food	3,80	4,20	3,60
Developed industry and production of souvenir goods	2,80	3,80	2,60
Developed trade network	3,40	4,00	2,60
Location			
Providing with access roads for cars	4,20	4,80	0,40
Providing by rails	2,20	2,40	0,60
Distance from villages	3,80	4,60	3,20
Distance from cities and towns	3,80	4,40	1,60

Importance of intermediate attractiveness indexes for different population groups is determined by experts after a 6-point rating scale (5 – it is important, 0 – it is not important). Using (8) and attractiveness indexes, which are present in table 5, intermediate indexes of attractiveness were calculated for each TRS (table 6).

Table 5 . Importance of attractiveness indexes for different population categories.

	Middle class	Students	Businesspeople	Children
Ecological conditions	5	4	5	5
Hotel infrastructure	3	1	5	2
Public infrastructure	4	3	2	3
Service factors	2	1	5	1
Location	3	3	4	0

Table 6. Intermediate indexes of attractiveness on TRS.

	Migovo	Boucovel	Nimchich
Ecological conditions	**5**	**5**	**4,73**
Hotel infrastructure	**3,87**	**4,87**	**1,29**
Public infrastructure	**3,73**	**4,73**	**0,67**
Service factors	**3,33**	**4**	**2,93**
Location	**3,27**	**3,8**	**0,7**

All the regional centers of Ukraine and the cities with the population above 100 000 were taken as the points of demand for recreation. In order to analyze visitors flows and develop recommendations for increasing visitors numbers, we analyzed the expediency of allocating TRSs and the places which already have functioning TRSs specialized in mountain skiing.

TRS price category was assessed on 5-point rating scale, where resort of the highest quality „deluxe" class assessed on „1"; resort of medium class as „3". Resorts of the lowest price category were rated as „5". According to expert estimations, businessmen will prefer „delux" class resorts, i.e. class "1". Middle class will prefer the resorts rated „3". Children will use „4" and students will like inexpensive class „5" TRSs.

Probability of TRS work on monthly basis and also monthly probability of the use of recreation services by population categories is given in tables 7 and 8 [2]:

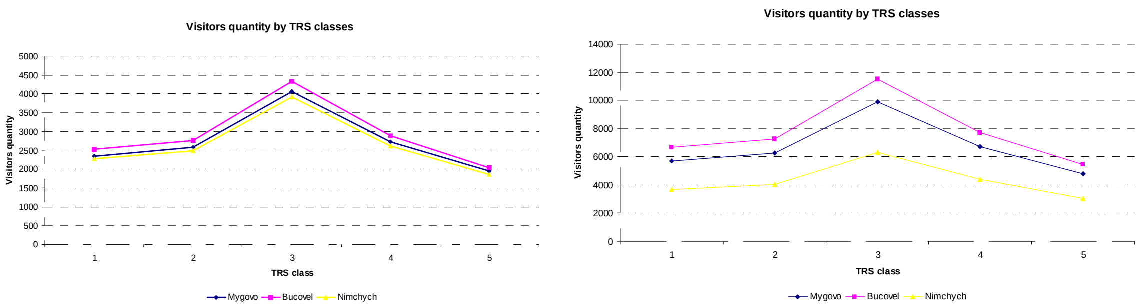
Table 7. Probability of TRS work.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nimchich	1	1	0,6	0	0	0	0	0	0	0	0	0,4
Bucovel	1	1	0,8	0,2	0	0	0	0	0	0	0	0,6
Migovo	1	1	0,8	0,2	0	0	0	0	0	0	0	0,6

Table 8. Probability of the use of recreation services by population categories.

Population categories	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Students	0,8	0,4	0,1	0,1	0,3	0,9	0,9	0,9	0,1	0,1	0,1	0,5
Middle class	0,9	0,9	0,3	0,3	0,5	0,9	0,9	0,9	0,7	0,5	0,3	0,9
Businesspeople	0,9	0,9	0,5	0,5	0,5	0,9	0,9	0,9	0,9	0,5	0,3	0,9
Children	0,4	0,1	0,4	0,1	0,1	0,9	0,9	0,9	0,1	0,1	0,4	0,1

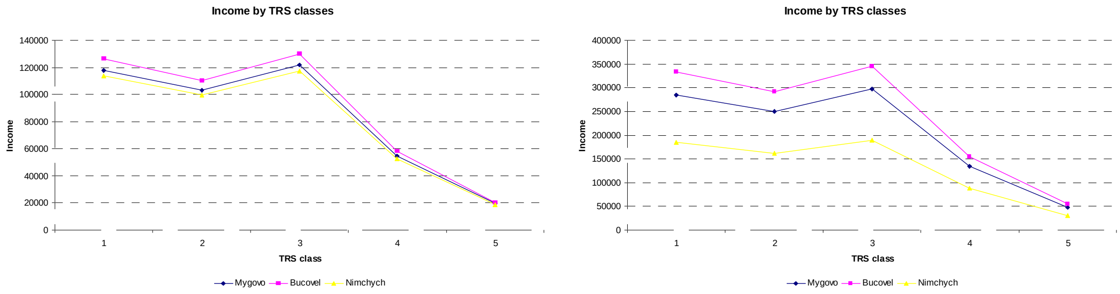
Calculation of possible visitors and income on TRSs in Prykarpattya region were made using data from tables 6, 7 and 8, results are represented on fig.6 and fig. 7 [15].



(a) (b)

Fig.6. Visitors quantity by TRS classes without fuzzy model (a) with fuzzy model(b).

As you can see on pictures, visitors' quantity and income distribution after TRS classes is almost the same as with using model without fuzzy logic. Difference between calculations is expressed in remaining behind TRS Nimchich (yellow line fig. 6 (b), 7 (b)) from TRS Migovo and Boucovelyo, that is more adequate reflection of reality, even that Nimchich is functioned since Soviet Union times and is enough known on Western Ukraine.



(a) (б)

Fig.7. Income by TRS classes without fuzzy model (a) with fuzzy model (b).

From the above-mentioned computations we could make conclusions, that using model with fuzzy logic gave us possibility to get results that are close to real ones, in spite of we use fuzzy logic only for one multiplayer from (1). It give as possibility more real estimate all kind of tourist activities and develop the realistic plan for forming and development of tourist infrastructure both in regions and for a whole country.

Using fuzzy logic for all multipliers of gravitational model will be next steps in our researches.

Conclusions

In this paper we showed lacks of the modified gravitational model and offered mechanism of their removal.

Adequacy of using model with fuzzy logic for determination of aggregated attractiveness index of TRS on a wide range and real estimation of all other attractiveness indexes were shown.

Stepping algorithm which describes realization of computations was developed.

Executed experiment showed adequacy of using fuzzy logic for computation of visitors' quantity. Got results represent basic economic-statistical indices of TRS more adequate than computations after a classic gravitational model (1).

Developed method give a possibility to forecast visitors quantity and income in TRSs, what will be useful for optimizing the complex of services given in any TRS and give possibility more effectively to choose territory for placing hotels or optimum choose the object of investing for investors.

It was offered to calculate all indexes from (1) using models with fuzzy logic ащк future researches (1).

Literature:

[1] Development of region tourist business: Monograph/By red. Dr. of economic sciences, Professor Shcola I.M. – Chernivtsi: Books - XXI, 2007. – 292 p.

[2] Shengquan Ma, Jing Feng, Huhua Cao. Fuzzy model regional economic competitiveness in GIS spatial analysis: Case study Gansu,Western China // Fuzzy Optim Decis Making, 2006. – #5, p.99–111

[3] Cathy H.C. Hsu, Kara Wolfe, Soo K. Kang. Image assessment for and destination with limited comparative advantages // Tourism Management, 2004. - #25., p.121–126

[4] E.W.T. Ngai, F.K.T. Wat. Design and development fuzzy expert systems for hotel selection // Omega, 2003. - #31, p.275 – 286

[5] Chao-Hung Wang, Li-Chang Hsu. Constructing and applying an improved fuzzy time series model: Taking tourism industry for example // Expert Systems with Applications, 2007. In Press

[6] Chao-Hung Wang. Predicting tourism demand using fuzzy time series and hybrid grey theory // Tourism Management, 2004. - #25, p. 367–374

[7] Tsung-Yu Chou, Mei-Chyi Chen, Chia-Lun Hsu. And fuzzy multi-criteria decision model for international tourist hotels location selection // International Journal Hospitality Management. In Press

[8] Wen-Bao Lin An empirical service quality model from viewpoint management // Expert Systems with Applications, 2007. - #32, p.364–375

[9] Lotfi And. Zadeh "Fuzzy Sets" // Information and Control, 1965. – #8.

[10] Vyklyuk Ya.I. Construction fuzzy-model for determination of recreation potential euro region „overhead twig” // Bulletin NTU "KPI". Bulletin of science papers. "System analyze, information management systems". - 2007. - № 41. - p. 191-203.

[11] Vyklyuk Ya.I. Use of fuzzy logic for determination of recreation potential of territory // Announcer of National University «Lvov politehnici» the «Informative systems and networks.» 2008 in printing.

[12] A.N. Sidorenko. The Logic-linguistic method of rate calculation of discounting for decision making in portfolio management. // Systems radio and computer electronic. – 2006. - №6 s.15-20.

[13] V.P.Dyakonov, V.P.Kruglov *MATLAB 6.5 SP1/7/7 SP1/7 SP2 Simulink 5/6 Instruments of artificial intelligence* // Seris «Biblioteka proffesionala». – M.:SOLON-PRESS, 2006.–456p.

[14] A.V. Leonencov Fuzzy modeling in MATLAB // SPb.: БХВ-Petersburg, 2005. – 736 p.

[15] Bogolyobov V.S., Orlovscaya V.P. Tourism economic // M.: Academy, 2005. – 192 p