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MATHEMATICAL MODEL FOR DETERMINING THE INDEX OF FINANCIAL BENEFITS FOR HIGH-MOUNTAIN, HARD-TO-REACH AND BORDER SETTLEMENTS

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Abstract.

The article presents a mathematical model designed to calculate the index of financial benefits for settlements nestled in utopian high mountainous regions, characterized by their near-inaccessibility and proximity to state borders. Unlike existing methodologies that solely rely on hypsometric indicators, this model introduces a novel approach by incorporating the multiplication of individual Complex Coefficients. By elucidating the limitations of current quantitative methodologies, particularly their reliance on qualitative factors, the article underscores the necessity for a more objective assessment of the problem.

Central to this model are three key complexity indicators: Height above sea level, Distance from central transport routes, and Proximity to the state border. The article delineates the research avenues pursued to ascertain these complexity coefficients, accompanied by tables presenting magnitudes derived from logical conclusions. This comprehensive framework not only enhances the accuracy of financial benefit assessments but also provides a standardized methodology for evaluating settlements in challenging geographical contexts.

Furthermore, the innovative approach illustrated in this article holds promise for informing policy decisions and strategic planning in regions characterized by geographical complexities. By elucidating the intricate interplay between geographical features and financial viability, the article offers valuable insights into optimizing resource allocation and fostering sustainable development in remote and borderland communities.

Keywords: complexity coefficients; Altitude; Proximity to state border; Distance from central transport routes.

Introduction.

in Georgia, in 2015, an updated law was adopted, which introduced certain financial benefits for high-altitude settlements. If the altitude above sea level exceeded 1500 m, financial benefits were provided for residents, such as an increase in wages and pensions, a reduction in taxes, etc.

The introduction of these privileges caused a desire in certain communities to broaden the territory where the privileges were distributed. As a result, the area has grown significantly and settlements lying below 800 m above sea level have been included there. In such a situation, the law lost its meaning and was suspended.

The reason is not only the desire of individual officials but also the wrong approach presented in the law - when compiling lists, they rely only on hypsometric indicators. Some of the villages may be located below 800 meters from sea level, but the remoteness from the central highways, the lack of movement on access roads, and in some cases the need to overcome high-altitude passes created many difficulties for the population. Such places include a large part of settlements in the following regions of Georgia: Racha, Lechkhumi, Guria, Adjara, etc.

In some cases, even a low altitude of 5-10 m above sea level creates great difficulties for residents. It becomes necessary to deal with swamps caused by high groundwater levels and slowly flowing surface water flows. Special engineering measures are required, the effectiveness of which requires continuous work throughout the year.

Such places include, for example, villages in the vicinity of the cities of Poti, Khobi and other places. We need a comprehensive indicator – an index that will become the basis for calculating financial benefits by certain quantitative criteriums.

Main part.

In our opinion, the complexity index for determining financial benefits should include three main factors:

1. Altitude, which in most cases determines the climatic conditions and the resulting difficulties in farming, especially in animal husbandry and crop production, as well as high heating costs during the long winter periods.

2. Distance from central highways, as well as the length and complexity of access roads. This factor can be expressed in terms of the operating costs of moving the most suitable and common type of vehicle in local road conditions, as well as the number and severity of road accidents in a given period (for example a year).

3. Proximity to the state border. This indicator, expressed in kilometers of length, determines the possibility of importing contraband and prohibited goods by field roads, as well as theft from villages in a neighboring country in peacetime. In times of political tension, the conditions of work and rest become more complicated, and in the period of the outbreak of hostilities, the evacuation of family members and the participation of those who remain in combat operations. It is in the interests of the country to have well-fortified places in the border area with appropriately motivated people.

To determine the complexity index, you can use the coefficient multiplication method, according to which the expression can determine the complexity index:

$$I = \prod_{i=1}^{n} Hi \cdot Li \cdot Bi$$

In which H_i - is the total value of the difficulty coefficients caused by altitude above sea level

$H_i = h_1 \cdot h_2 \cdot h_3 \cdots h_n$

h_n – Partial coefficient of complexity from factor "n"

Below are some examples of their definition

$h_1 = \frac{H}{H_{эт}}$

H - height above sea level of a given locality,

$H_{эт}$ - is the height limit under reference conditions. Eg. 1200m.

$h_2 = \frac{T°_{эт}}{T°}$

$T°_{эт}$ - is the average annual air temperature under reference conditions

T° - is the same indicator for the etalon locality in question

$h_3 = \frac{T_{сн}}{T_{эт}}$

$T_{сн}$ - duration of snow cover at the considered point, days

$T_{эт}$ - the same indicator for the reference conditions

L_i - is the final value of the complexity coefficients caused by the distance from the main road.

$L_i = l_1 \cdot l_2 \cdot l_3 \cdots l_n$

In which l_n is a partial coefficient of individual "n" complexity

$l_1 = \frac{l}{lo}$

l - distance of a given point from an intrastate highway, km

l_o – the same indicator for the etalon conditions. For example - l_o = 5 km

$l_2 = \frac{H}{Ho}$

H - is the height of the pass on the way to the settlement, m

H_o - is the height of the reference point. For example, 1200m

$l_3 = \frac{q}{qo}$

q - is the operating cost of the design vehicle (oil, rubber, etc.) given per 1 km

q_0 - similar costs for a reference point

B_i - the resulting complexity value caused by the proximity of the border

$B_i = b_1 \cdot b_2 \cdot b_3 \cdots b_n$

$b_1 = \frac{bэт}{b}$

b - distance of the settlement from the state border

bet – distance of the Etalon settlement from the state border. Eg. 50km

$b_2 = \frac{R}{R_{эт}}$

R - the complexity of the relief of the point under consideration,

$P_{эт}$ - complexity of the relief of the reference point; $R_{эт} = 1$

For complex terrain with large differences in elevation R=3 Mountainous terrain less complex R=2, rugged or hilly R=1.5

The number of the above-mentioned coefficients may increase in the process of further research, and the values of partial coefficients and their analytical expressions can also be clarified.

To determine the values of the complexity coefficients, it is possible to use the materials of the Institute of Geography of the Georgian Academy of Sciences on the natural conditions of Georgia [2]. Of particular interest are the maps issued by the General Staff of the Armed Forces of the former USSR in the last edition of 1980 on a scale of 1:200000, where, along with the relief and situation, military topographic descriptions of the terrain are displayed, the relief, climate, geology, hydrology, road network, dimensions of bridges and maximum loads are considered in detail. Features of the road network and development of settlements, the difficulty of moving through the seasons of the year, etc.

To determine the complexity coefficients, several problems need to be solved:

Determination of the parameters of the reference locality for the region according to the following indicators:

Altitude above sea level, distance from a road of domestic importance, distance from the state border.

Determination of partial coefficients for specific localities, considering natural and man-made factors, relief, hydrology, indicators of transport infrastructure development, etc.

Places of high complexity in Georgia can be considered high-mountain parts of Abkhazia, for example, villages located in the gorge of the Chkhalta River, in Svaneti - villages in the upper reaches of the Enguri River, in the mountainous Racha gorge of the Tskhenistskali and Rioni rivers.

In Khevi - the Terek gorge, in Khevsureti the gorges of the Argun and Asa rivers, in Tusheti along the tributaries of the rivers Khiso, Pirikita, Alazani, and others. All of them are characterized by a harsh climate, difficult terrain, remoteness from the central main roads, and proximity to the state border of Georgia. There are many places with favorable conditions, for example, villages located in the valley of the Alazani River in Kakheti and the valley of the Kura River in Kartli, in western Georgia, part of the settlements in the vicinity of the city of Zugdidi, etc.

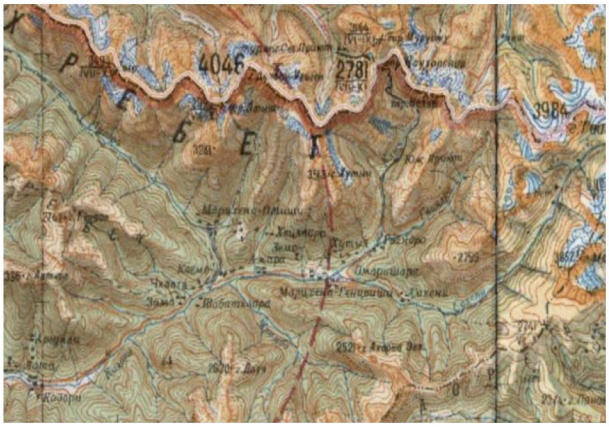

Fig. 1 An example of difficult conditions in Western Georgia (Abkhazia)

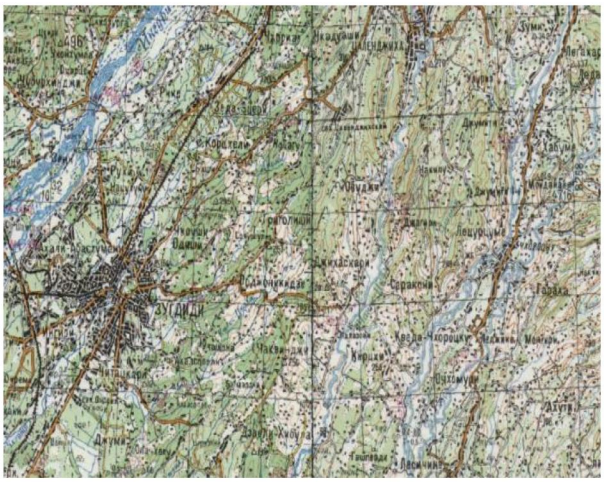

Fig. 2. Example of reference conditions in Western Georgia (villages of Zugdidi region)

Fig. 3. Example of difficult conditions in Eastern Georgia (Tushetia)

Fig. 4. Example of standard villages in Eastern Georgia (Kachreti region)

The implementation of the above-mentioned work will require a certain amount of time, financial costs, and the involvement of a group of qualified specialists in the fields of economics, geography, transport, sociology, etc.

To illustrate the practical use of the proposed method in the first approximation, tables compiled based on logical considerations can be used.

To a first approximation, the difficulty index can be set using three parameters with corresponding coefficients from the tables below.

Altitude from sea level

H_i, m	1200	1400	1600	1800	2000	2400	2600
h_1	1.0	1.17	1.33	1.5	1.67	2.0	2.17

Distance from the central highway

L, (km)	5	10	15	20	25	30	35	40	45	50
L_1	1	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45

Proximity to the state border

b, (km)	50	40	35	30	25	20	15	10	5	1
b_1	1.0	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.0

Below is an example of the calculation of the complexity index and the corresponding amount of financial benefits.

1. The settlement is located at an altitude of 1800 m above sea level, therefore $h_1 = 1.5$; It is 50 km away from the central motorway, $L_1 = 1.45$, distance to the state border is 5 km. $b_1 = 1.90$. From those parameters, we can determine the difficulty index - $1.5 \times 1.45 \times 1.90 = 4.13$, therefore, an adequate increase in pensions, salaries, etc. would be 4.13-fold.

2. The height of the settlement above sea level is 1600 m, so $h_1 = 1.33$. Distance from the motorway 25 km, $L_1 = 1.20$. Distance to the State Border 20 km, b1 = 1.60 Complexity index = $1.33 \times 1.20 \times 1.6 = 2.55$ Increase in pension, salary, etc. 2.55-fold.

The establishment of the complexity index for all settlements in difficult natural and man-made conditions can be made by ranking the settlements based on the final complexity coefficient. There are 4 categories of complexity: the highest; High; Average; and low

corresponding value of the introduction of financial benefits, for example, an increase in salaries and pensions by 5, 4, 3, or 2 times. A place where there are favorable conditions for living and family farming will have an index of 1. The initial value of the assignment of pensions, salaries, and other types of receipt of funds will be the amount intended for places with favorable conditions, with their further increase according to the indicator of complexity.
As a result of the analysis of the complexity of natural, social, and infrastructural indicators in terms of complexity, a table should be created, where data on financial benefits by the value of the final complexity index will be entered.

Conclusion.

To determine the coefficients of difficulty, it is necessary to solve several problems:

1. Selection of reference village parameters for East and West Georgia (or by regions) with the following indicators: height above sea level, distance from road, distance from the state border.

2. Determining the values of individual coefficients for etalon and given settlements, taking into account the indicators of natural and technogenic factors (relief, hydrology, transport, other types of infrastructure, etc.).

3. Determining the benefit index for all high-mountainous settlements and transforming the calculation formula of the difficulty of its use in an appropriate form, so that compared to the reference conditions, it would be possible to establish a certain amount of benefits. or by the decision of the government to introduce the corresponding coefficient (K<1) in the current financial year, taking into account the country's budget.

It is obvious that the execution of the works mentioned in the clauses requires a certain

amount of time, funding and a group of qualified specialists.

Reference

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