Application of Novel Technologies When Assessing and Modelling the Ecological Situation for In-region Migration of Local People

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Editorial

The conference "Environmental Change and Migration: From Vulnerabilities to Capabilities" was the first of a new conference series on "Environmental Degradation, Conflict and Forced Migration". It was organised by the European Science Foundation, the Bielefeld University and its Center for Interdisciplinary Research. The Center on Migration, Citizenship and Development (COMCAD), the Universities' unit responsible for scientific content and quality of the conference, has launched a COMCAD Working Paper Series on "Environmental Degradation and Migration". The new series intends to give conference participants the opportunity to share their research with an even broader audience.

The symposium focused on how environmental change impacts the nexus between vulnerabilities on the one hand and capabilities on the other hand, and how this relationship affects mobility patterns. Although the conference organizers chose to include all kinds of environmental change and types of migration, climate change figured prominently among the submissions to the conference. Therefore, the conference aimed to bring together the perspectives from climate change, vulnerability, and migration studies, and to draw conclusions about the political implications of the knowledge scientists currently have available. Toward that goal, the conference was structured along three pillars. The first concentrated on climate change and the vulnerability of certain regions and groups. It covered case studies as well as different approaches for making climate change projections and assessing the likelihood of vulnerability. The second pillar focused on empirical research on environmentally induced migration from a vulnerabilities perspective, but acknowledged the occasionally strong elements of capability within it. In this way, the aim was to learn about approaches and options to support existing capabilities. The third pillar was concerned with the opportunities and pitfalls of policy options in dealing with the future challenge of climate induced displacement, and with the analysis of dominant public discourses within the field.

The researchers invited represented a wide range of disciplines, including sociology, social anthropology, migration, conflict, gender and development studies, geography, political science, international law, and climate and environmental science. The conference was also well balanced in terms of geographic origin, gender, and academic status of the participants. The conference programme and full report can be found at www.esf.org/conferences/10328.

Bielefeld, February 2011 Jeanette Schade and Thomas Faist

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Abstract

The aim of accomplishing investigation is to get maps, which may help us to choose new areas during inner migrations, which have more ecological favorable conditions, and the second, to move people from the areas which have bad conditions to the areas which have better ecological conditions.

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1. Introduction

A steadily increasing impact of the man upon the nature as a result of increase in population and scientific and technical progress brings not only to ecological, but also to social consequences. Undesirable social aftereffects include food deficiency at a global scale, rising disease incidence in cities, outbreaks of local ecological conflicts induced by creation of enterprises ecologically unsafe from the viewpoint of local population and finally ecological migration of the population.

Under critical situations connected with land degradation, drought and other unfavorable changes in living conditions of humans a problem arises of migration of people from ecologically harmful zones. For instance, Degradation of pastures under intense overgrazing makes the populace migrate to sites more suitable for traditional cattle-raising. However, so as to make in-region migration coordinated and efficient, it is necessary to preliminary select optimal areas having high ecological potential and ecosystems' biota to avoid origination of new ecological concerns. In Syunik marz, in-region migration of local people is connected also with unfavorable ecological conditions and natural disasters. Natural and man-made disasters are known to induce total unexpected migration of people. So, in such a case relevant governmental efforts are needed to prevent origination of additional ecological problems resulting from home migration by ecological and other reasons (social, economic, political, war-caused), and finally to efficiently manage the situation and keep control over it.

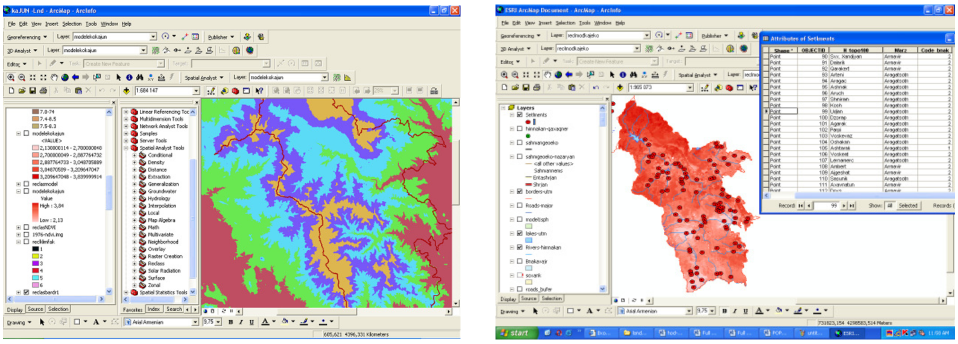
This supports a necessity to build a site-specific information basis, evaluate and model general state of a territory so as to reveal sites with relatively favorable ecological conditions that could minimize the consequences of adverse man-made impacts and maximize ecological potential and stability.

Models suggested by us provide a general ecological picture of territories that may be helpful in management of the noted and other relevant issues.

2. Materials and Methods

Regional ecological studies for in-region migration of local people are underpinned by collection, systematization and consequent arrangement of information on environmental components. Such an opportunity is provided by geographic information systems (GIS) (Mkrtchian 2006:5, Muradyan & Khoetsyan 2008: 6, Muradyan 2009: 7). Geographic information systems or geospatial information systems is a set of tools that computers, stores, analyzes, manages, and presents data that are linked to location(s). In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology (Figure 1). Modern GIS technologies use digital information, for which various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium through the use of a computer-aided design program, and geo-referencing capabilities (Abler 1987:1).

Figure 1. Interface of GIS package ArcGIS



GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

Syunik marz (province) situated in the southeast of Armenia is characterized by specific natural and economic conditions and covers an area of some 45,060 sq.km which makes 15 per cent of the entire territory of the country (Figure 2). Syunik marz includes the reservoir of upper and mid streams of the rivers Vorotan and Voghchi and the eastern slopes of the Zangezour mountain-chain. It is the highest mountain-chain after the Mets (Big) Caucasus in Trans-Caucasus.

Figure 2. A map of position of Armenia in the South Caucasus

Syunik marz occupies Zangezour country, which is a part of historical Syunik (Sisakan) situated in the southern part of Armenia. Syunik marz is formed in 1995. It includes the former districts of Kapan, Goris, Sisian and Meghry.

The population of Syunik marz makes about 4 per cent of Armenian population and with number of urban population is the second after Yerevan (Table 1). With its geographical position, rich natural resources and big industrial potential, especially during the formation of independent Armenia, Syunik marz has got particular strategic and geographic-political importance.

Table 1. Several demographic indices of Syunik marz

Urban communities	7
Rural communities	102
Towns	7
Villages	127
Population number as of January 1, 2009	152.9 ths. persons
including:	
urban	103.7 ths. persons
rural	49.2 ths. persons
Share of marz population size in RA population size, 2008	4.7. %
Share of urban population size	67.8%

In mountain regions similar to Syunik marz ecological and migration problems are sharply manifested. This region is a separate, complicated natural system, which stands out for a variety of natural elements and its uniqueness, with a unique combination of heat, humidity and soil types. The primary ecological factor to the region is the relief.

The ecological situation in Syunik marz is substantially impacted mainly by mining production which share makes 90.2 per cent of overall industrial production of the region, and by boundary, poorly populated land lacking settlements which share makes 76 per cent.

RA Syunik marz occupying strategic and geographic political important position, having rich resources of natural raw materials, industrial big capacity and being one of the biggest administrative and economic regions of the republic, at the same time is remained as a one of not enough inhabited and economically developed marzes, which is connected with a big distance from the capital and lack of alternative modes of transport communication.

The diversity of the region's natural conditions and high sensibility of natural and territorial complexes to man-made intervention is seen in their poor and unstable ecological state.

As a software while preparing a ecological-migration GIS, we employed a GIS package ArcGIS 9.2, ArView GIS 3.3 with expansion moduli 3D Analyst 1.0, Spatial Analyst 2.0 (ESRI Inc.) and ERDAS Imagine 9.1 (Leica Geosystems Inc.).

The ecological analysis of Syunik marz was performed through 4 underlying parameters:

1. Evaluation of ecological potential of mountain landscapes

2. Evaluation of ecological stability of mountain landscapes

3. Evaluation ecological load of mountain landscapes

4. Evaluation of ecological tension of mountain landscapes

The values of basic parameters of the ecological analysis were calculated as sums of respective indices expressed in scores and multiplied by their significance reflecting coefficients. Conversion of natural unit measurement indices to a single score system was implemented through division of a natural value (minimal to maximal) segment into a quantity of equal-size segments (Gorelov, 2000), corresponding to the quantity of single-scale scores (PACH II-7.01-96 1996: 10 , PACH II-6.01-96 1996: 11, Region planning 1986: 9, Poghosyan 1986: 8).

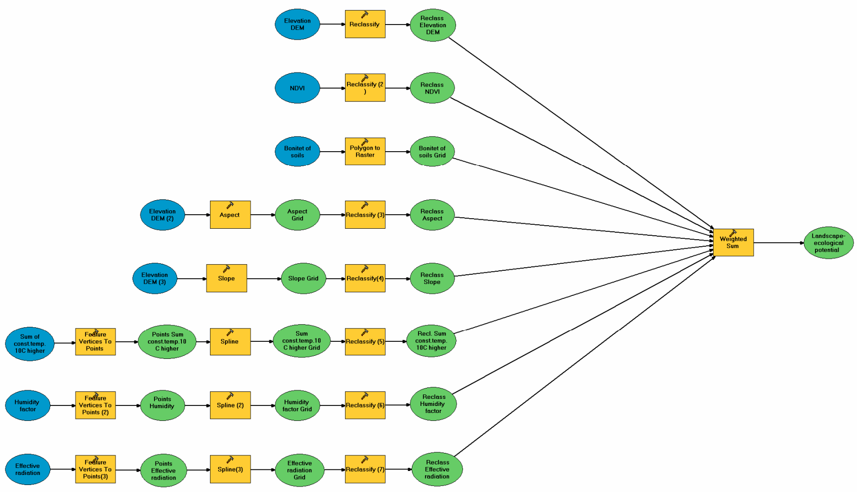
To obtain compatible collation units by different indices, a single score scale was assumed (1-5). Then produced were chains of significance of diagnostic indices (from most to less significant) in a complex index. According to the methods (Kolomits 1998: 2) the sum of all weight factors of one complex index does not exceed a unit. In agreement with that rule, a formula was derived of calculation of basic indices of ecological analysis (ecological potential, stability, load and tension):

$$M_{int} = K_1*(F_1)+ K_2*(F_2)+ K_3*(F_3)+.... +K_n*(F_n),$$

where Mint- is an integral assessment of basic indices of ecological analysis; F1...Fn –values of under-consideration indices in scores; n – the number of factors; K1..Kn – corresponding weight factors.

Subsequently, those factors were integrated by “Model Builder” in ArcGIS 9.2 applying “Weighted Sum” functions. The produced maps enabled us to assess general ecological conditions for in-region migration of local people(Figure 3).

Figure 3. Model of the estimation of the ecological situation of Syunik marz



3. Result and Discussion

One of fundamental concept of the landscape-ecological theory of man-nature interaction is the landscape – ecological potential (EP), i.e. a set of conditions necessary for life activity and reproduction of organisms populating the given territory i.e. satisfaction to this or that extent the need of the man in all necessary (primary) manufacture-irrelevant conditions of existence: the air, light, heat, drinking water, food sources adding natural conditions for labor, leisure, and spiritual development (Isachenko 2004: 3).

Every component or element of landscape separately, e.g. climate as a whole or wind only, the relief, vegetation cover etc. can serve as an object for ecological assessment that pursues indication of the level of adverse or beneficial impacts upon human life. However the ecological effect of any natural factor depends on its coupling with other factors. So, evaluation of natural ecological factors should be complex, covering thus a complexity of factors expressed in the notion of ecological potential. A comprehensive characteristic of ecological potential demands consideration of hundreds of indices, however its comparative assessment can be underpinned by 2 determining factors – heat and humidity, which in the first instance biological productivity depends (Isachenko 2004: 3).

For this particular research 8 factors were selected that would underlay general evaluation of ecological potential:

1. the annual sum of constant temperature 100C and higher
2. humidity factor
3. effective radiation
4. elevation of relief
5. slope exposition
6. normalized differences in vegetation index
7. soils bonitet
8. angle of slope .

Treating the noted methods as a base, the following formula was derived:

EP= 0,16 (Fsum of temperatures)+ 0,15 (Fhumidity factor)+ +0,14 (Feffective radiation)+ 0,13(F elevation of relief)+ +0,12 (Fslope exposition)+ 0,11 (Fvegetation cover)+ +0,10 (Fsoils)+ 0,09 (Fangle of slope), Fsum of temperatures, Fhumidity factor, Feffective radiation, F elevation of relief, Fslope exposition, Fvegetation cover, Fsoils, Fangle of slope– the values of the considered scored indices.

Subsequently, those factors were integrated by Model Builder in ArcGIS 9.2 using Weighted Sum functions (Figure 4).

Figure 4. A map of ecological potential of Syunik marz.

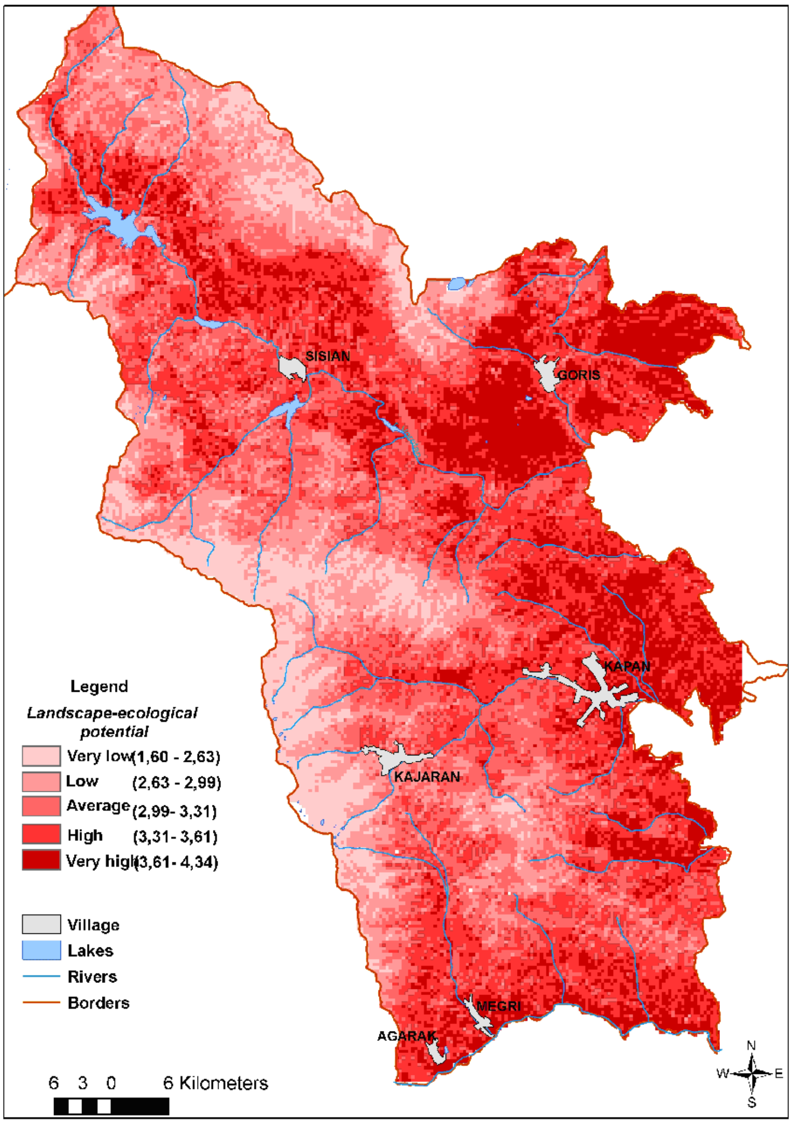


Figure 4. shows that the highest ecological potential EP is common to mid- and low-mountain territories of Goris region, low-mountain parts of Sisian and eastern section of Kapan regions and separate territories of River Meghri valley.

It should be noted that in Syunik marz social and economic activities fall predominantly on territories with high ecological potential. In particular, over 80% of hayfields and perennial plantations of Goris and Sisian regions are distributed on landscape territories with high and very high ecological potential, whereas low-potential landscapes stretch out predominantly on the region's highland parts.

The analysis of spatial distribution of EP of the Syunik marz territory indicates that high- and very high- potential landscapes make 29.61 and 18.23, and those with low- and very low- potential – 18.17 and 8,86 per cent, respectively.

A picture of integral ecological situation in Syunik marz should be obtained with regard for natural stability of landscapes and ecological load on the same landscapes. The sum of such indices the level of ecological tension (ET) of the territory. The values of natural stability and ecological loads were calculated as sums of corresponding indices expressed in scores and multiplied by coefficients that reflect their significance under natural stability or man-made impacts.

For this research 29 factors were selected that would underlay a general assessment of ecological stability (ES) and load (EL):

1. altitude of the relief
2. slope steepness
3. bioclimatic factor
4. humidity factor
5. sum of temperatures above 0^0C.
6. summary radiation
7. precipitation
8. evaporation rate
9. biomass
10. protected areas
11. granulometric structure of soils vs. erosion
12. granulometric structure of soils vs. man-made pollution
13. pH of soils
14. soils humus
15. annual runoff layer
16. suspended alluvia runoff
17. soil exploitation
18. geology
19. pollution zones
20. mine, tailing repository
21. roads
22. settlements
23. farmlands
24. population
25. soil erosion
26. mudflows
27. landslips
28. vertical dissection
29. distance from erosion net

Finally, we obtained the following formulas

ES= 0.11 ($F_{\text{altitude of the relief}}$) + 0.10 ($F_{\text{slope steepness}}$) + 0.09 ($F_{\text{bioclimatic factor.}}$)+ 0,09 ($F_{\text{humidity factor}}$)+ 0,08 ($F_{\text{sum of temperatures}}$)+ 0,08 ($F_{\text{суммарная радиация}}$)+ 0,06 ($F_{\text{precipitation}}$)+ 0,06 ($F_{\text{evaporation rate}}$)+ 0,05 ($F_{\text{biomass}}$)+ 0,05 ($F_{\text{protected areas}}$)+ 0,04 ($F_{\text{granulometric structure of soils vs. erosion}}$) + 0,04 ($F_{\text{granulometric structure of soils vs. man-made pollution}}$)+ 0,04 ($F_{\text{pH of soils}}$)+ 0,04 ($F_{\text{soils humus}}$)+ 0,03 ($F_{\text{annual runoff layer}}$) + 0,02 ($F_{\text{suspended alluvia runoff}}$)+ 0,01 ($F_{\text{soil exploitation}}$)+ 0,01($F_{\text{geology}}$).

EL= 0.13 ($F_{\text{pollution zones}}$) + 0.12 ($F_{\text{mine, tailing repository}}$)+ 0.11 ($F_{\text{roads}}$)+ 0,10($F_{\text{settlements}}$) + 0,09 ($F_{\text{farm-lands}}$)+ 0,09 ($F_{\text{soil exploitation}}$)+ 0,08 ($F_{\text{population}}$)+ 0,07 ($F_{\text{soil erosion}}$)+ 0,06 ($F_{\text{mudflows}}$)+ 0,05 ($F_{\text{landslips}}$)+ 0,04 ($F_{\text{slope steepness}}$)+ 0,03 ($F_{\text{vertical dissection}}$) + 0,03 ($F_{\text{distance from erosion net}}$),

where

ES- is ecological stability,

EL- ecological load,

$F_{\text{altitude of the relief}}$, $F_{\text{slope steepness}}$ $F_{\text{bioclimatic factor}}$, $F_{\text{humidity factor}}$, $F_{\text{sum of temperatures}}$ …. – values of the considered indices in scores.

Then those factors were integrated with help of Model Builder in GIS package ArcGIS 9.2 employing functions of Weighted Sum.

Finally, through GIS modelling maps of ecological stability and ecological load (Figure 5) were produced, which were then integrated as a map of ecological tension of the territory of Syunik marz (Figure 6).

Figure 5. Maps of ecological load (a) and stability (b) of Syunik marz.

а **б**

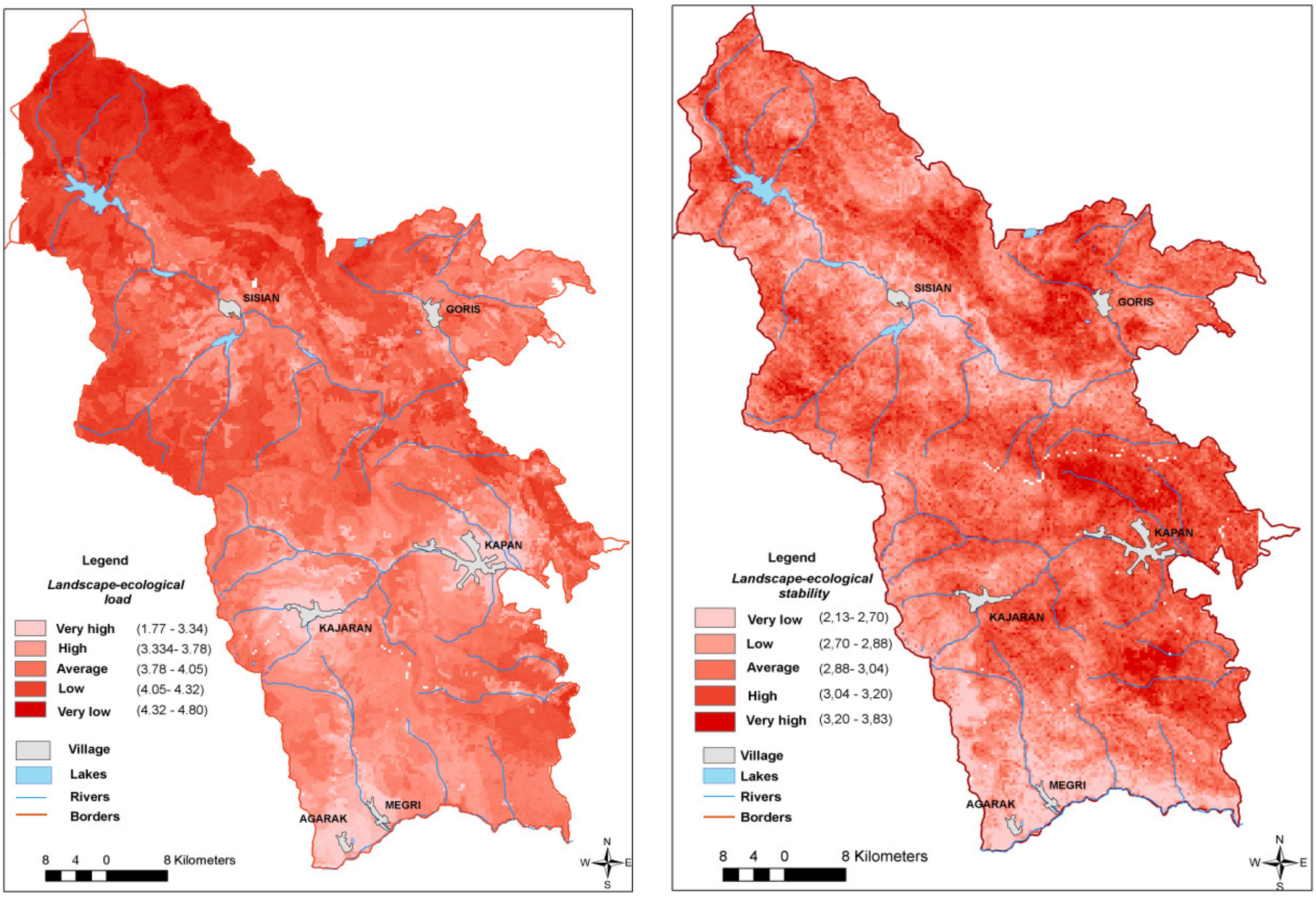
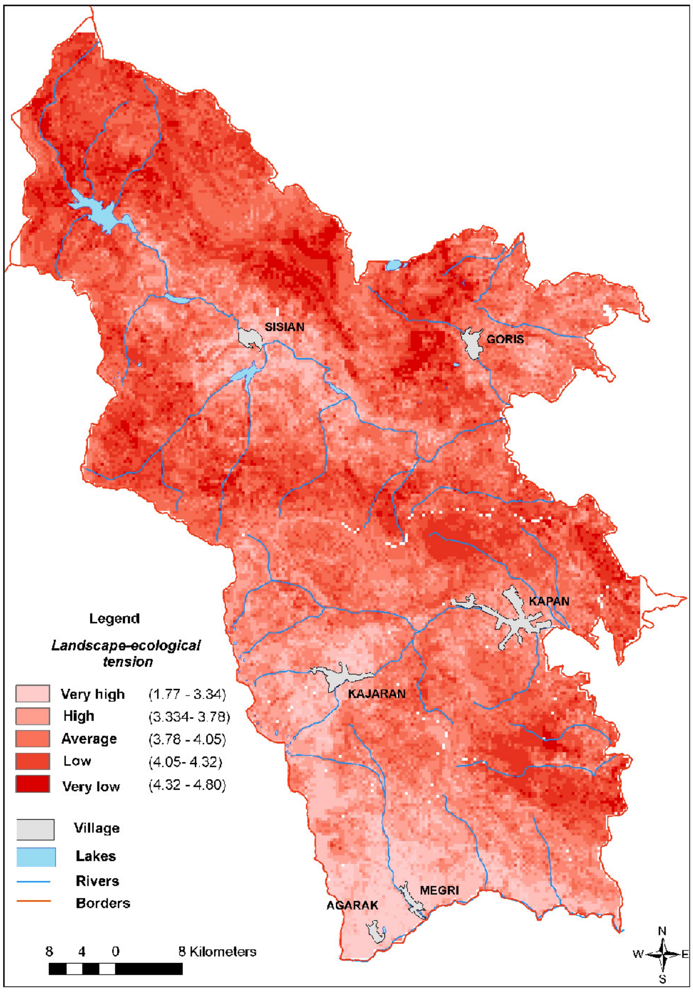


Figure 6. A map of ecological potential of Syunik marz



As seen from Figure 6., the most unfavorable territories lies predominantly on River Voghchi valley, separate sites – on the valley of Rivers Meghri and Araks, lowland parts of Sisisan region, the share of such vast areas in marz making some 41per cent (Table 2).

Favorable and relatively favorable territorories occupy 695,4 and 865,7 sq.km, respectively, and stretch mainly on highland parts of the region, on meadow-steppe and forest land-scapes.

Table 2. Evaluation of landscape-ecological tension of the area of Syunik marz

Landscape-ecological tension in scores	**Area**	
	sq. km	**%**
Favorable (4.01-5.00)	695,388	15,77
Relatively favorable (3.51-4.01)	865,702	19,64
Unfavorable (3.01-3.51)	1026,31	23,28
Specially unfavorable(2.00-3.01)	1441,44	32,7
Completely unfavorable (1.00-2.00)	379,553	8,61

The obtained research outcomes – the results of processing of evaluation methods of Syunik marz' ecological potential, stability, load and tension which included technological procedures of relevant database processing, creation of case-specific maps and GIS modeling, enabled us to indicate the ecological situation of the studied territory and separate optimal territories for probable in-region migration of local people.

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