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CREATION OF A DIGITAL MAP OF GEORGIA GIS SYSTEMS FOR FORECASTING WIND EROSION OF SOILS FOR ESTABLISHING THE SUSTAINABILITY OF FARMLAND TAKING INTO ACCOUNT CLIMATE CHANGE

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1. INTRODUCTION

Geopolitical map of the Caucasus Region (2008)

Regional Climate Model 4 (RegCM4) was used for the South Caucasus region34. This model belongs to the group of so-called "limited models", it uses large-scale meteorological parameters as initial and boundary conditions on the area limited by the user, on which high-resolution geographical information (such as: topographic elevations, land use, vegetation and so on) can be used in high-definition calculations. A simulation was done (N 40º30'-47º; W 39º25'-44º) with maximal horizontal resolution of 20km, admissible in the area. The area used for simulation includes the territory of Georgia as well as part of the territories of Armenia, Azerbaijan, Turkey and the Russian Federation. Initial and boundary conditions were taken from EH5OM (MPI, Hamburg), global model output data (existing from 1941-2100) and A1B socio-economic scenarios

2. METHODOLOGY

The methodology employed in the USAID-supported Institutionalization of Climate Change Adaptation and Mitigation in Georgian Regions (ICCAMGR) project and therefore in the Road Map closely follows the methodology described in the "ESPON (**European Spatial Planning Observation Network**) Climate: Climate Change and Territorial Effects on Regions and Local Economies Report" (2011)19. This methodological choice was made for several reasons: Georgia's national aspirations with regard to association with the European Union, Georgia's Eastern European geographical location, methodological soundness, a comparable set of indicators and approaches followed, the wide use of the methodology applied in this report by the climate change and impact research community and its applicability to Georgian realities in terms of data availability and other related issues.

The indicators employed in this study are also comparable with ones used in the "European Environmental Agency Report: Climate change, impacts and vulnerability in Europe 2012 (an indicator-based report)"20, a background document for elaboration of EU Strategy on adaptation to climate change.

3. Weights

- There can be various methods of weight allocation when indicators are from different sectors and require the setting of priorities. In the case of not allocating specific weights, equal weights are assumed during aggregation (when weights are 1/n). Due to the need to set priorities for decision-making, it is important to apply the most straightforward and practical methodology for weight allocation.
- In case of intra-sectoral weight allocations (for instance, two or more agricultural sensitivity indicators) the respective expert team member was requested to individually provide weights and justification arguments, validated on self-consistency interactively by the experts from other sectors. Results of the expert intrasectoral weight allocation are documented in each sectoral methodology description provided by each sectoral expert for each thematic dimension of this assessment.
- As for inter-sectoral weight allocations, the Delphi expert survey method was applied in this assessment, described briefly here. The survey for weight allocation among sectors/dimensions was conducted in two interactive rounds. First, all members of the expert group were asked to allocate percentages to each sensitivity dimension as well as to each component of the two ‘impact pairs’ of exposure-sensitivity. Each of these two estimations added up to a sum of 100% (which is equivalent to summation of weights to 1). In the second round, all experts were informed about the results of the first round and those who wished to do so and whose opinions differed significantly from the average scores of the first round were given the opportunity to adjust to more moderate scores. Two sets of weights were then recalculated from percentages to fractions of 1 for use in sensitivity and impact aggregate index calculations. The results of the intersectoral Delphi survey exercise is provided in Table 1 below. Results obtained were compared to similar figures given in ESPON (2011) in order to be compatible with similar international studies.

Table 1.
Weights resulting from the Delphi-based inter-sectoral expert survey

Delphi Survey	Agriculture	Tourism	Energy	SUM
Agriculture Team	45	15	40	100
Project Coordination Team	50	25	25	100
Report Reviewer/Editor	50	20	30	100
Tourism Expert	50	20	30	100
Industry Expert	40	20	40	100
Energy Team	40	20	40	100
GIS Analysis Team	40	20	40	100
AVERAGE	45	20	35	100

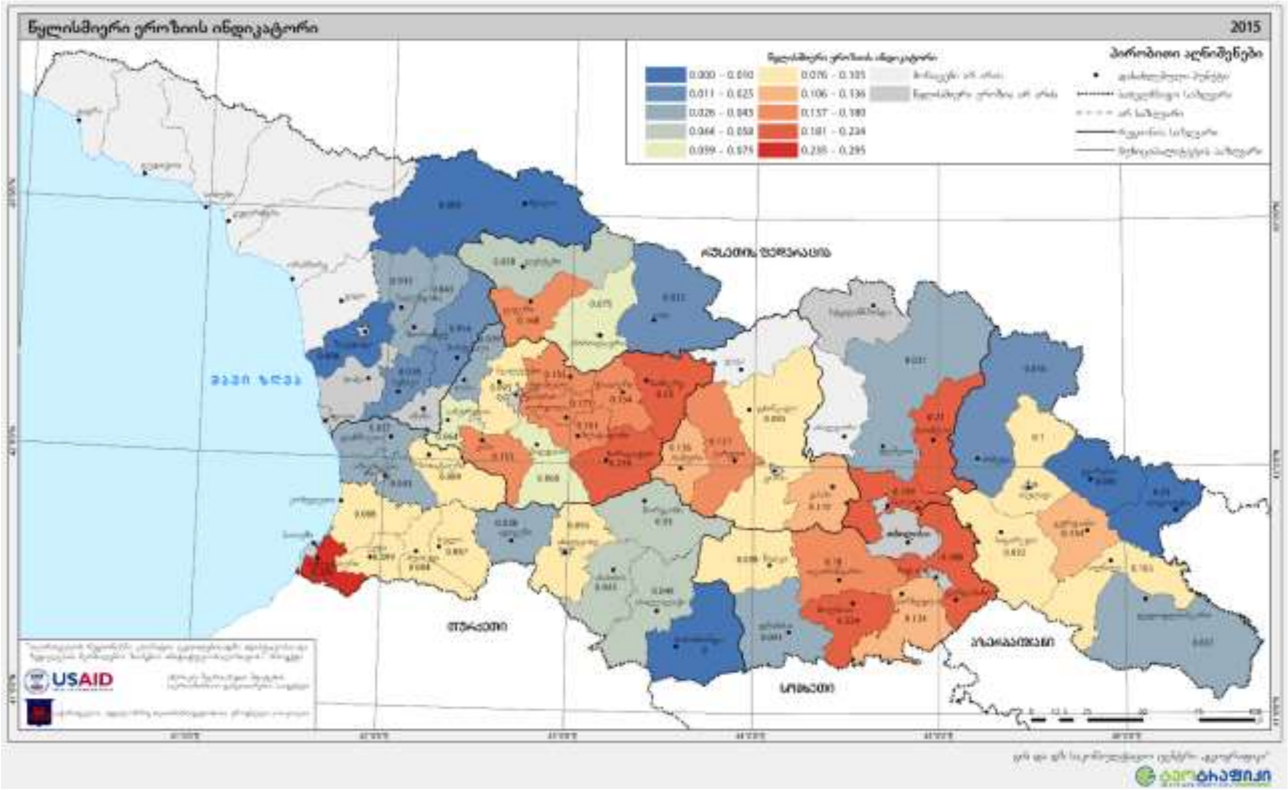
4. EROSION

- In Georgia110, 54.1% of cropland is located on sloping land with slope of 2º, 22.5% on slopes from 2º to 5º, 14% on slopes of 5º-10º, up to 6% on slopes of 10º-15º, and 3.4% on slopes exceeding 15º.
- The foregoing agricultural land factor, together with rainfall intensity, determines water erosion occurrence and development. When implementing irrigation measures, the same factor creates a negative phenomenon that is known as irrigation erosion on the soil surface.
- Sensitivity of agricultural lands to water erosion enhancement risk – water erosion arises from topsoil washing away during the irrigation of agricultural lands. One type of water erosion is linear erosion. This type entails erosion caused by concentrated runoff accompanied by scratching or scoring of the soil surface to various degrees. The runoff spreads across the soil surface during rainfall (i.e. when the infiltration rate has been exceeded) and may take various forms and degrees. The more humus the soil has and the lighter it is, the more permeable it is.
- At the Water Management Institute of the Georgian Technical University, based on half a century of research, the academic Ts. Mirtskhulava has developed a method for calculating the maximum allowable soil loss from erosion (G), the functional dependence of which has the following expression:

$$G = f\left(R, S, I, \Omega, M, Y\right) \qquad (1)$$

- Where R = amount and intensity of rainfall; S = the physical-mechanical properties of the soil; I = soil sloppiness and shape indicator; = share of area covered with vegetation; M = irrigation rate (to calculate the irrigation erosion), Y = eroded area indicator.
- In 1998-1999, the Water Management Institute of the Georgian Technical University reprocessed the abovementioned All-Union Standard, which served as the basis for preparing the 1999-2005 purpose-oriented state program aimed at protecting soil from erosion in Georgia.

Water-eroded areas of agricultural lands for each municipality in 2015

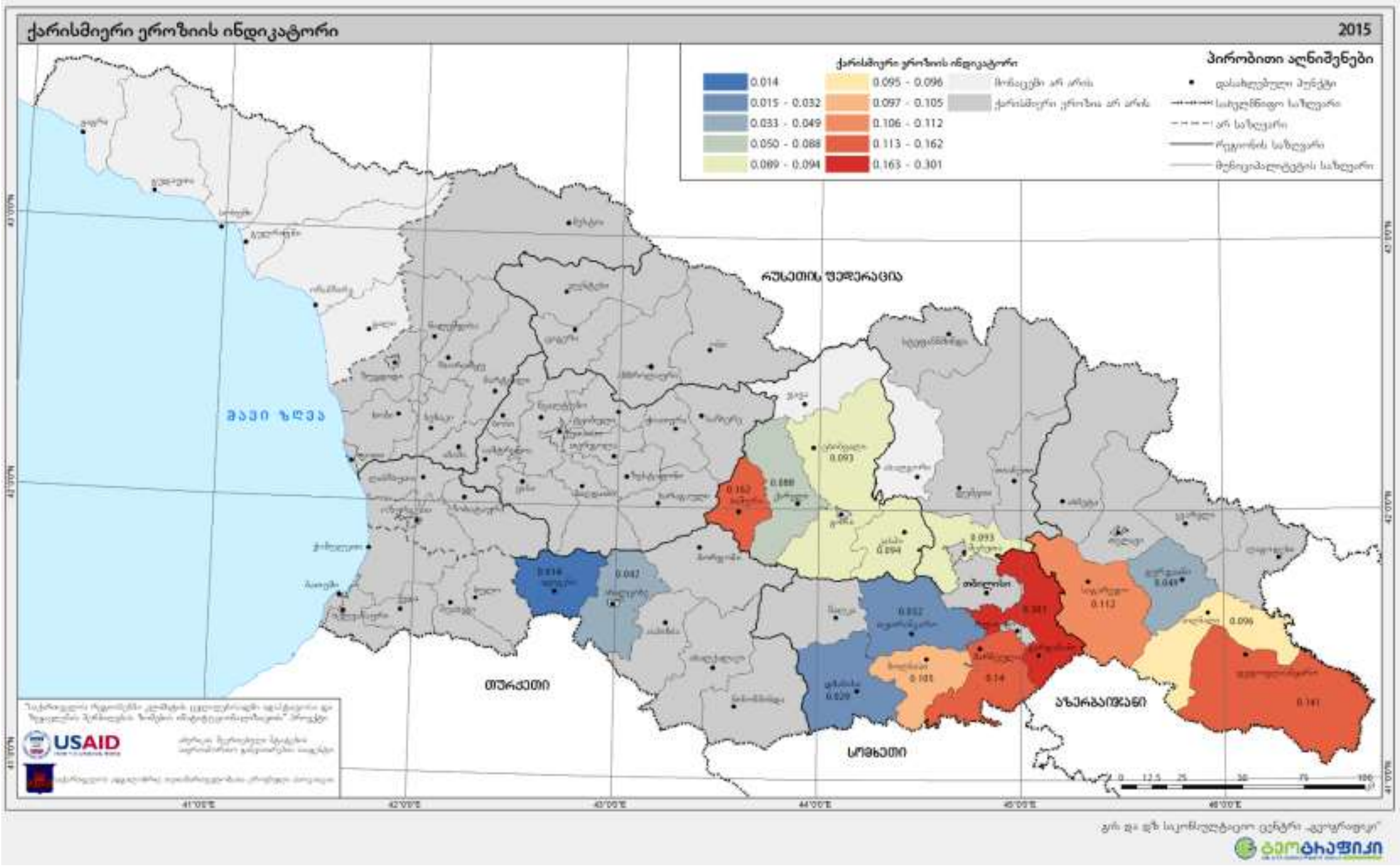


- Wind erosion (soil deflation) is conditioned by the deterioration and transportation of topsoil and its forming substances. Water and wind erosion are both more or less observable in almost all regions of the country. To forecast wind erosion, the knowledge of the direction and speed of hazardous winds is necessary so that erosion prevention measures can be properly planned113.
- In addition to climatic conditions, among other factors, wind erosion processes are also predetermined by the mechanical and aggregate composition of soil, the content of organic substances, structural stability, and the cohesion of soil aggregates.
- The intensity of the wind erosion process is determined by several factors including wind speed in the region and the existence of side shelterbelts. Wind erosion intensifies in winter and early spring, when vegetation covers and protects less agricultural land, therefore leaving the soil bare. The intensification of wind erosion is caused by deep tillage with plowing, as a result of which the topsoil layer reinforced with plants' root systems is inverted and mixed with the subsoil114.
- The value of the amount of soil deposited by wind erosion (G) represents a multifactor function:

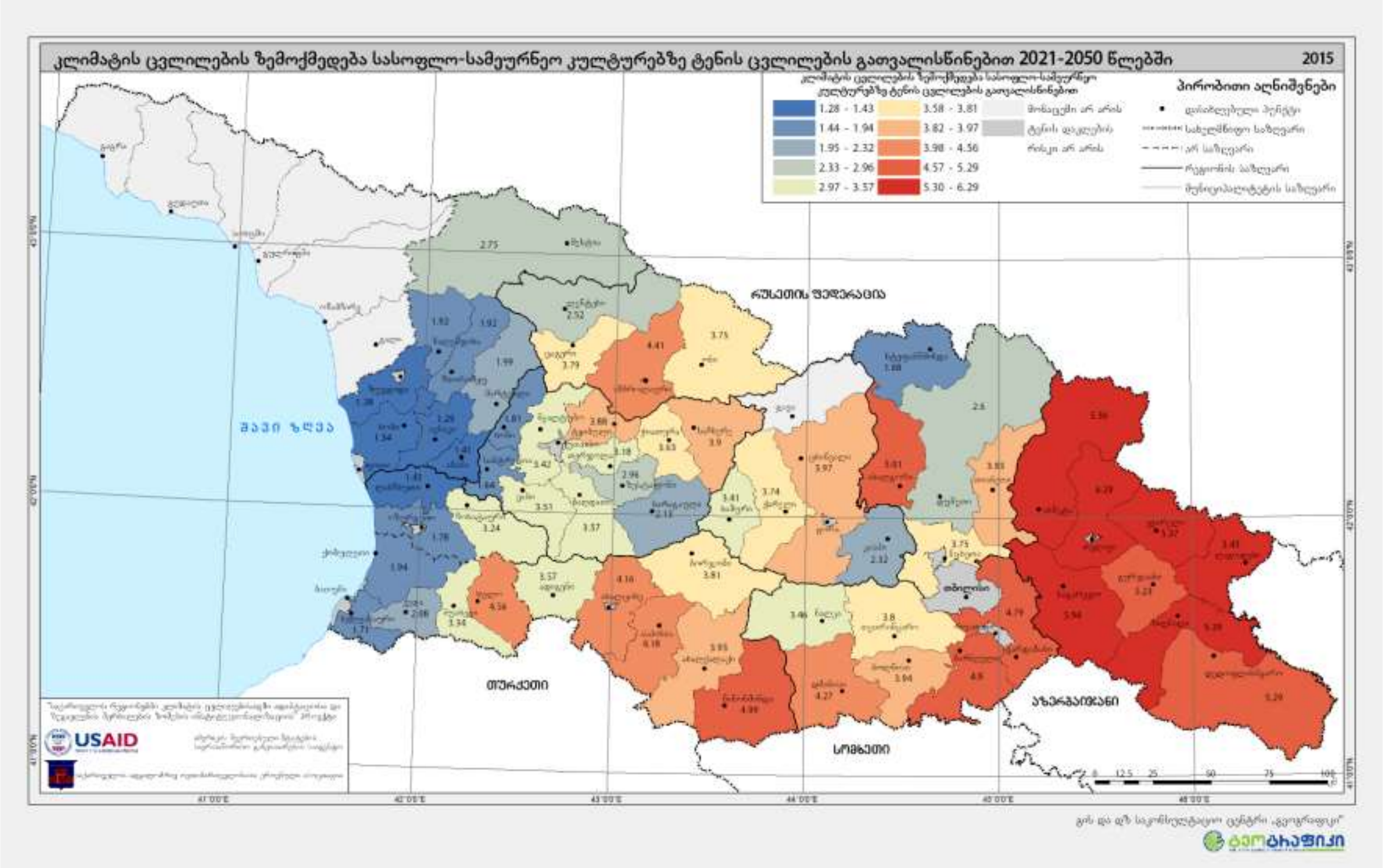
$$G = f\left(G_L, G_S, G_I, G_P, G_M, Y_w\right), \qquad (2)$$

Where G_L is the distance between windbreaks; G_S is the texture of soil, G_I is the soil surface inclination; G_P is the indicator of the vegetation cover impact on the topsoil; G_M is the climatic factor indicator. Taking into account each of these factors, the weight of the wind-deposited soil is calculated independently; Y_W is the wind-eroded area indicator.

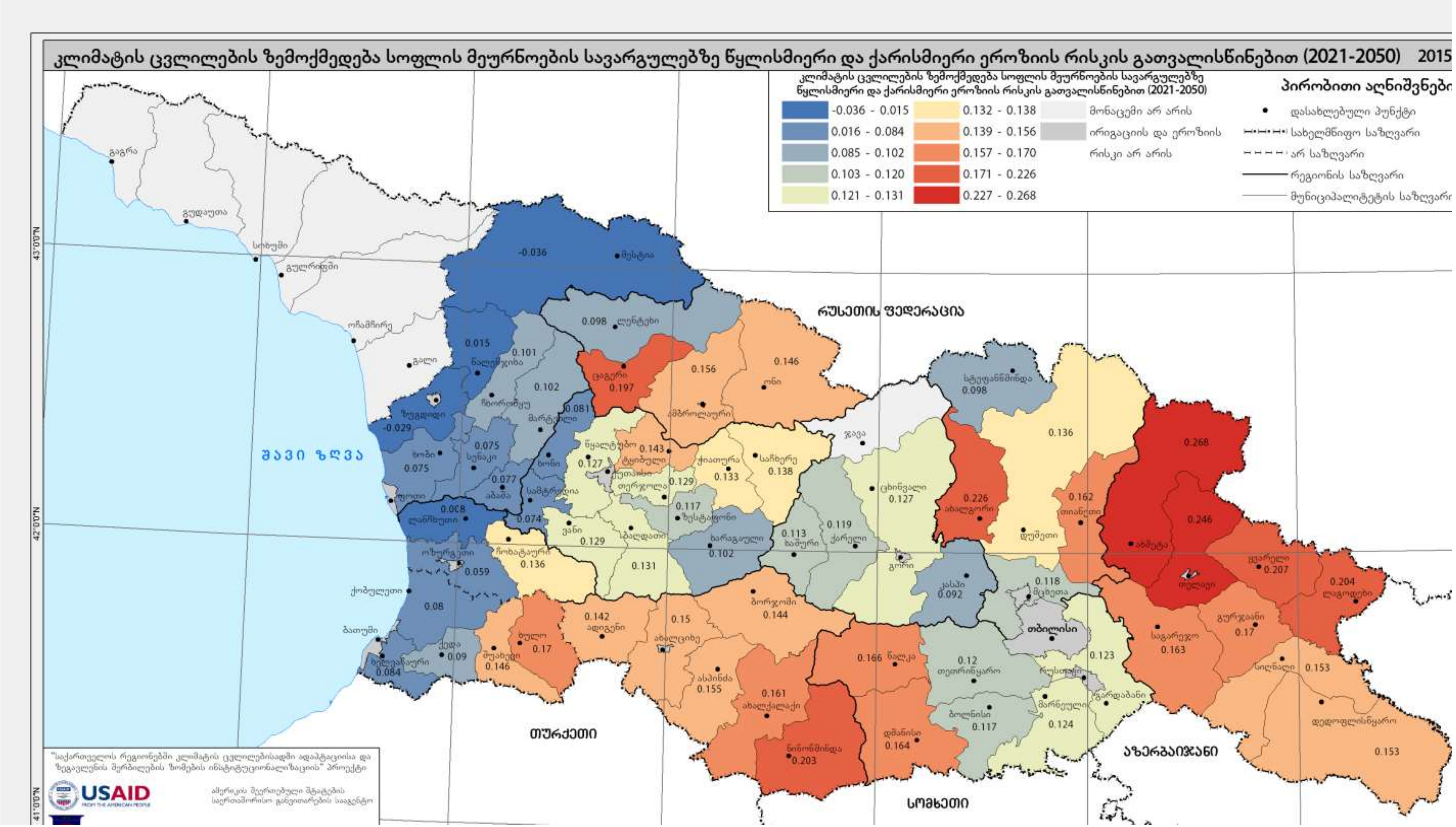
WIND-ERODED AGRICULTURAL LAND AREAS FOR EACH MUNICIPALITY IN 2015



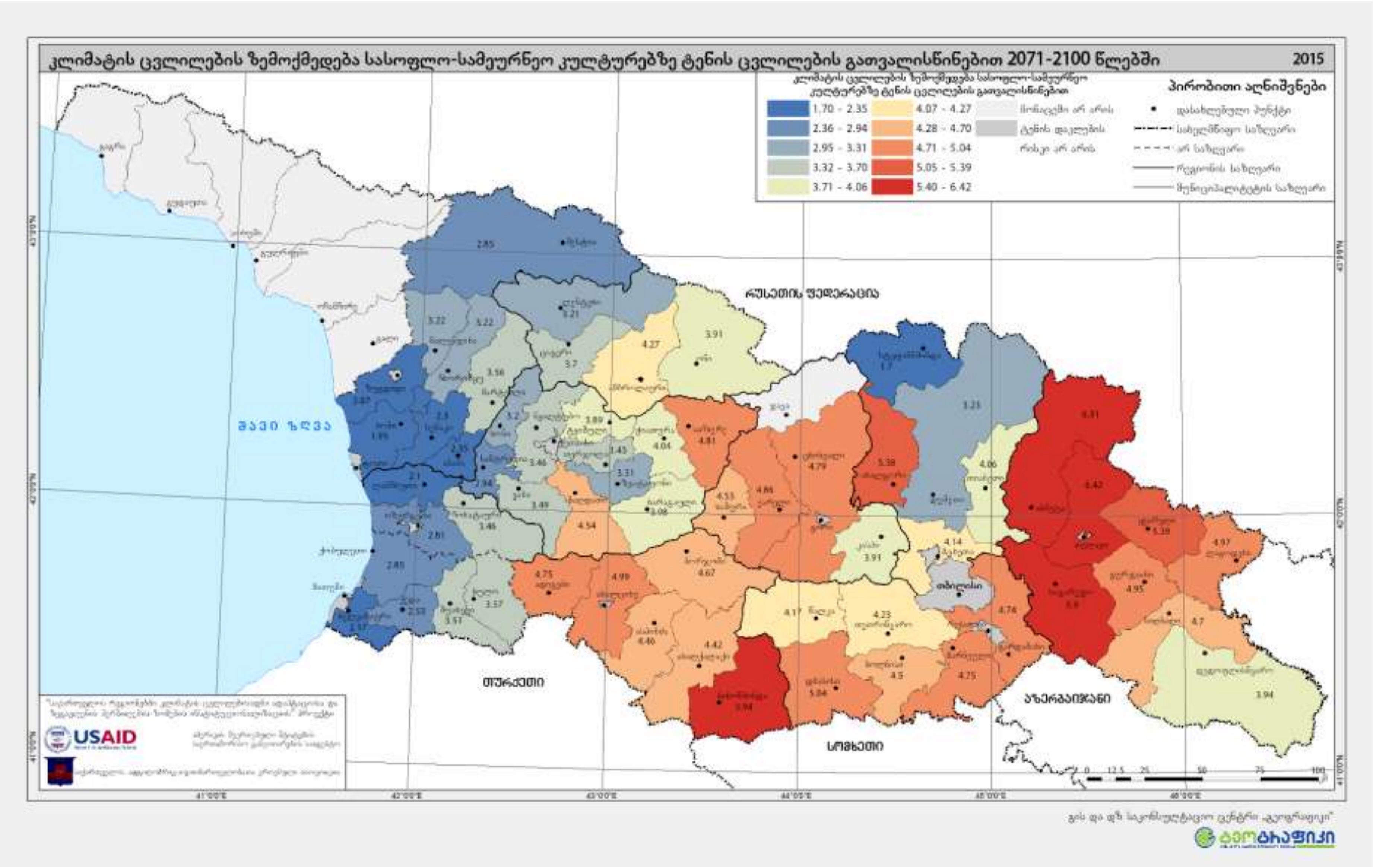
Climate change maps for Future 1 (2021-2050)



and Future (2050-2071)



and Future 2 (2071-2100)



Change in wind speed between two periods 1986-2010 and 2071-2100

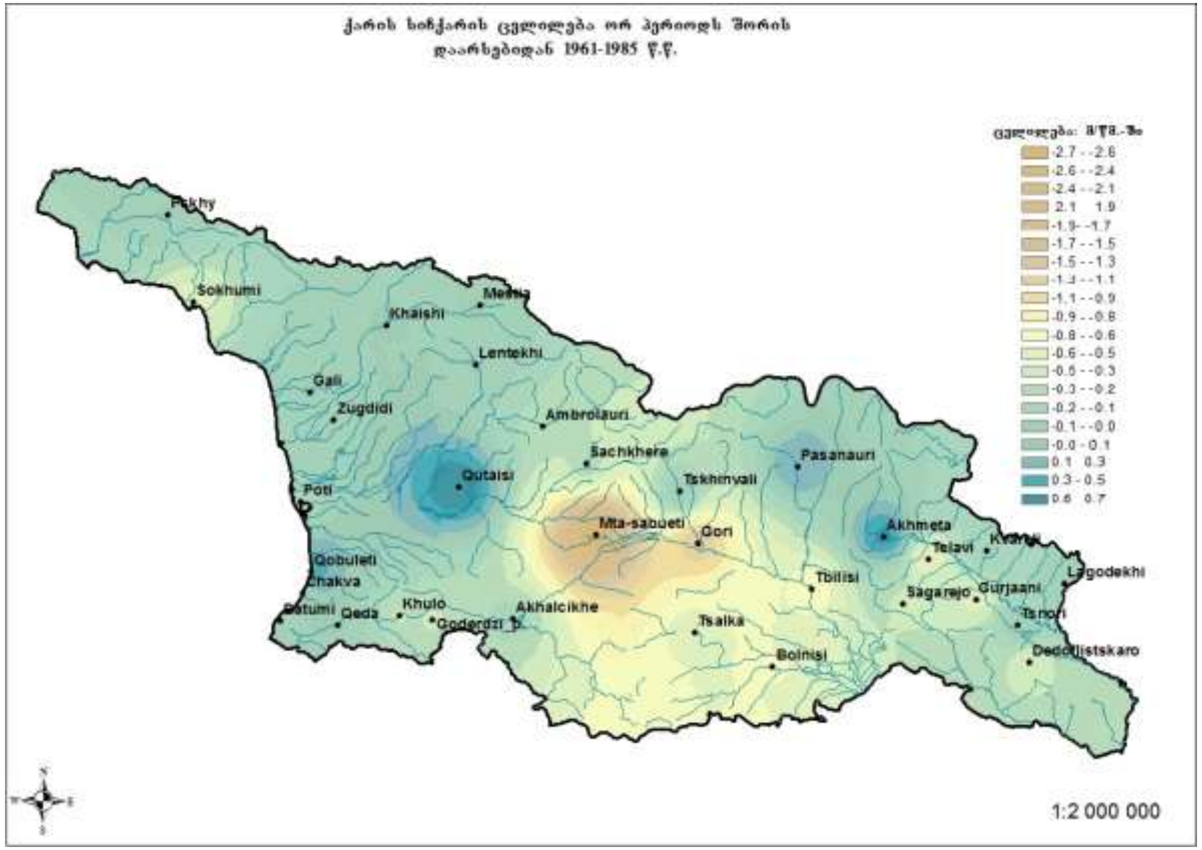


Fig. 1

Change in wind speed between two periods 1961-1985

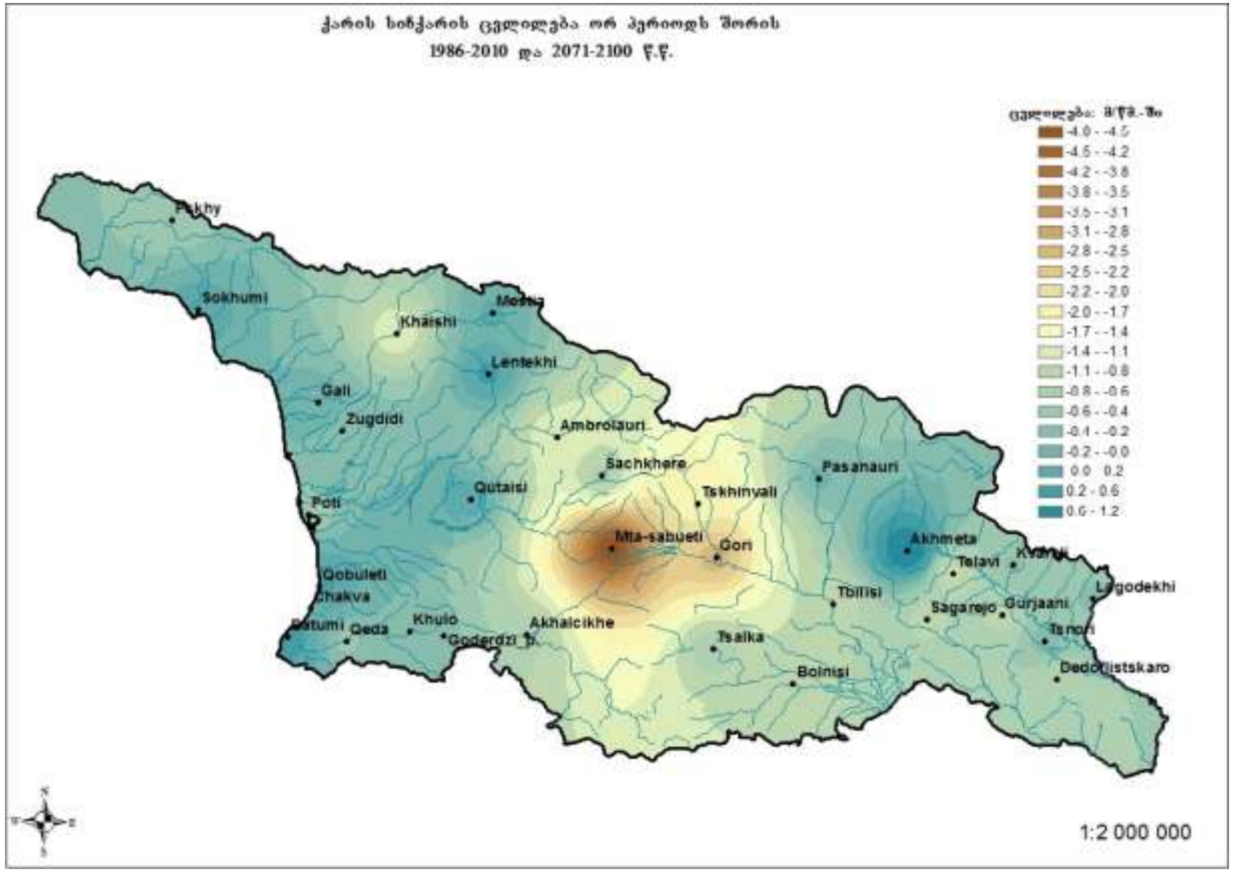


Fig. 2

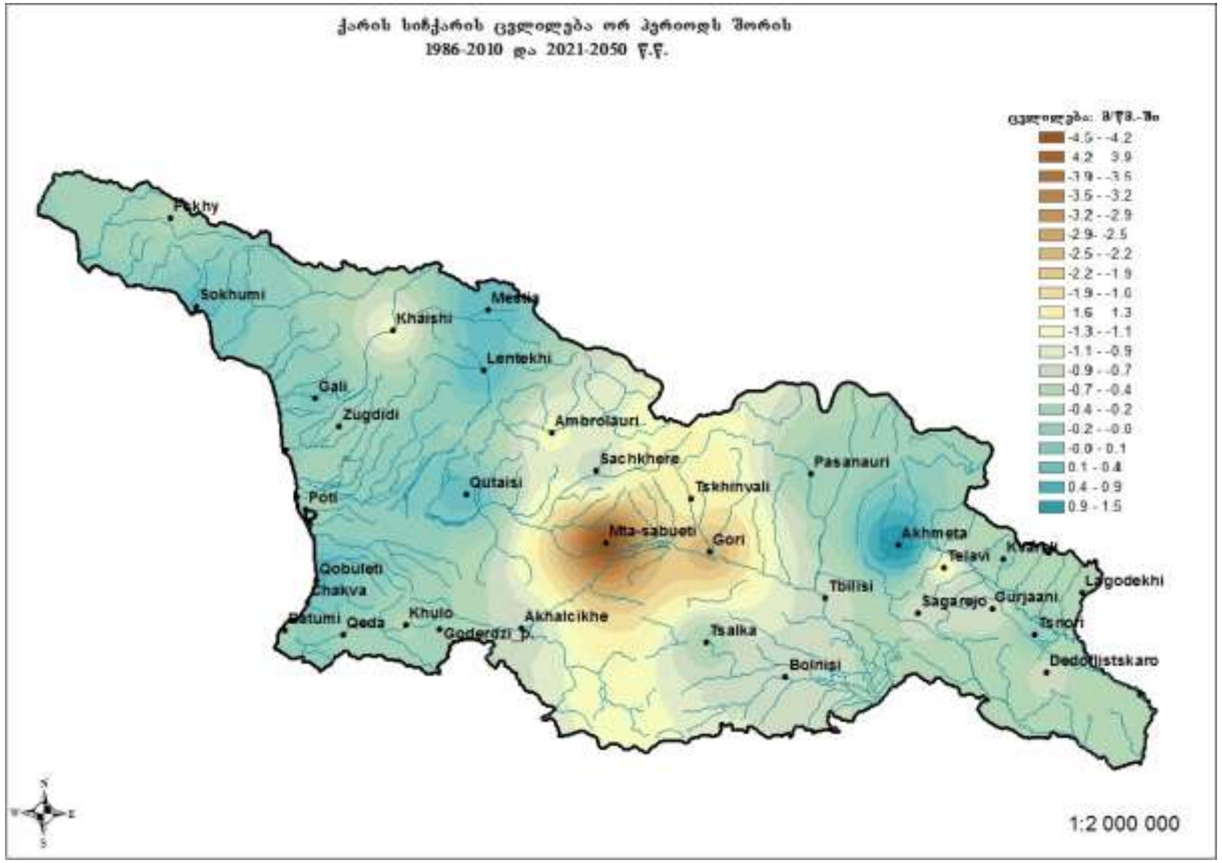


Fig. 3

Change in wind speed between two periods
1986-2010 and 2021-2050

Change in wind speed between two periods
1986-2010 and 2071-2100 гг.

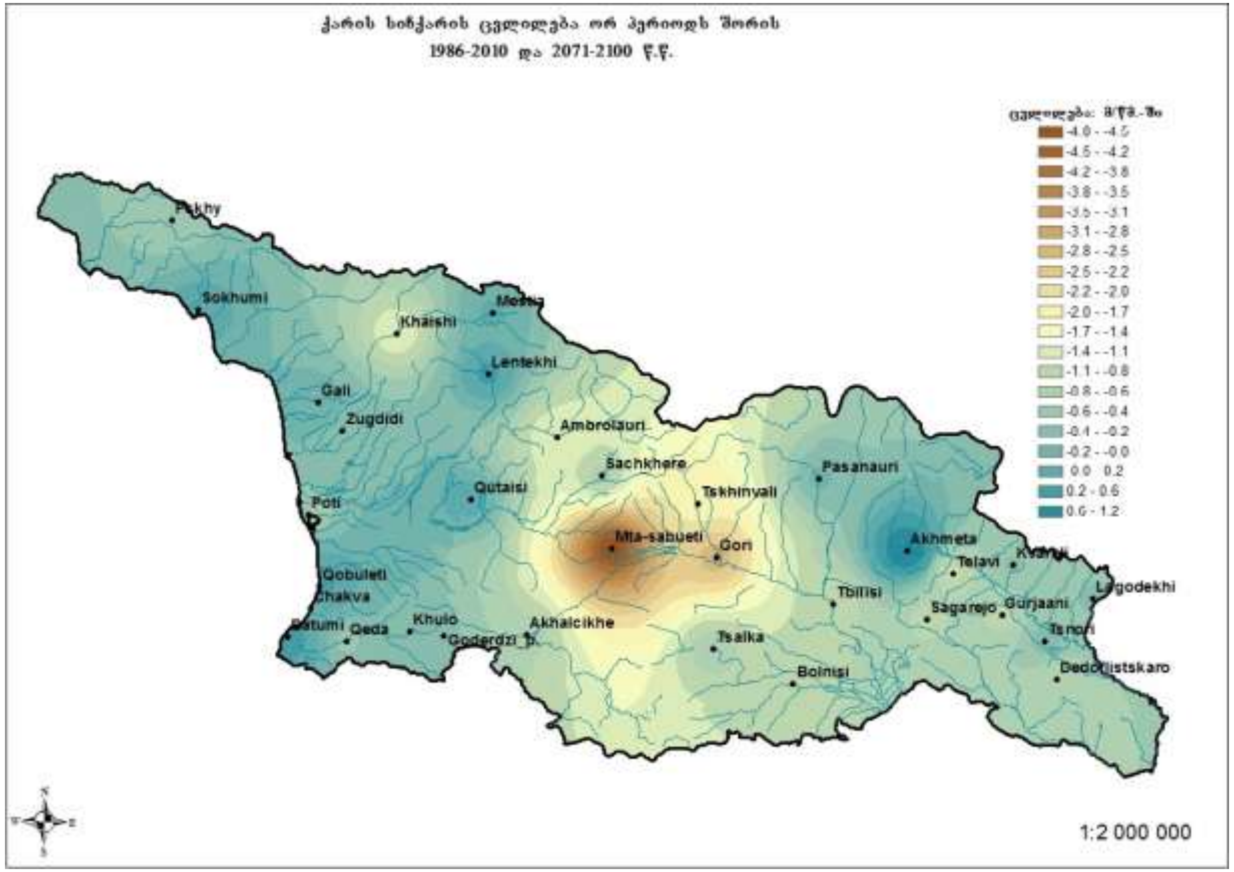
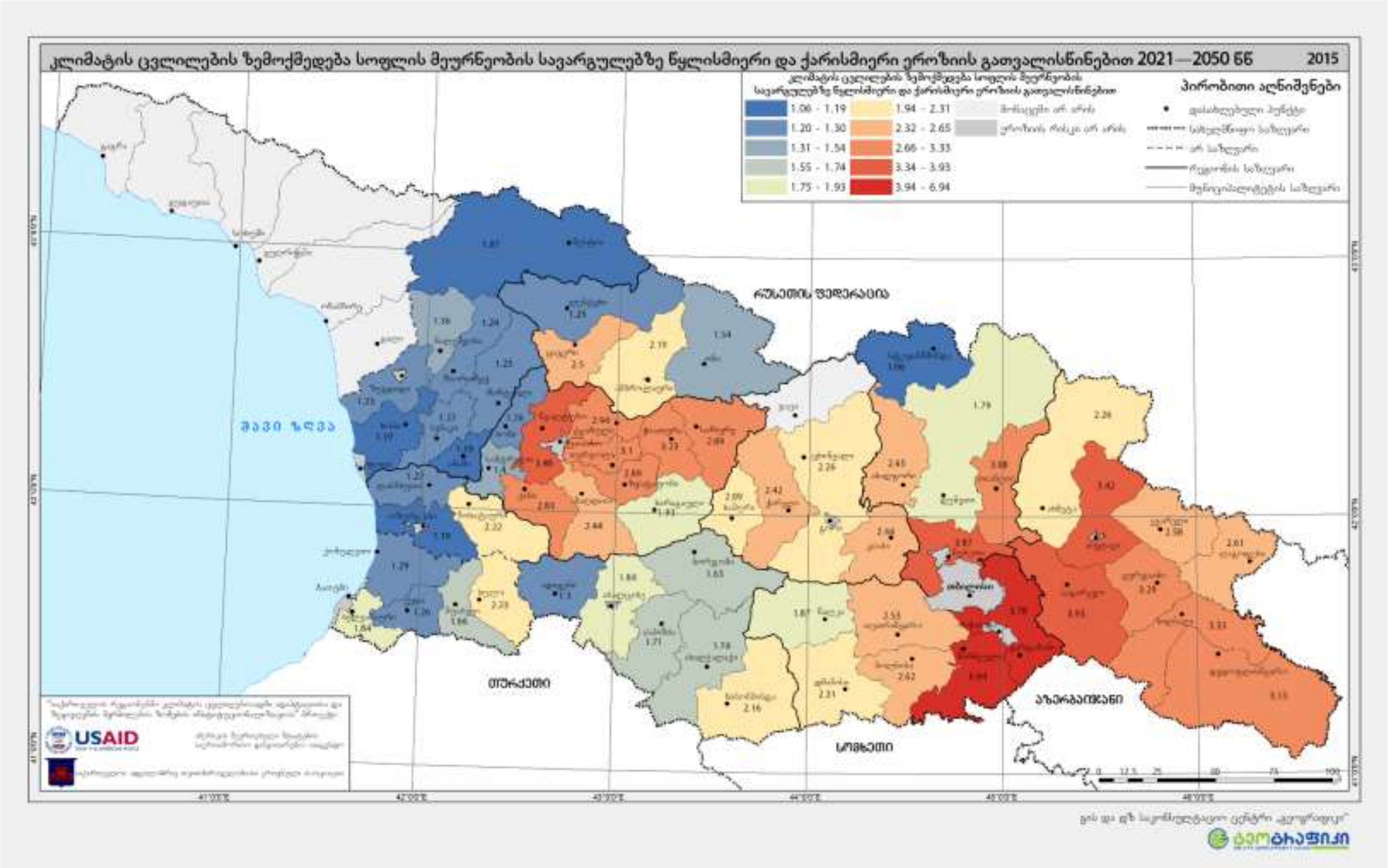
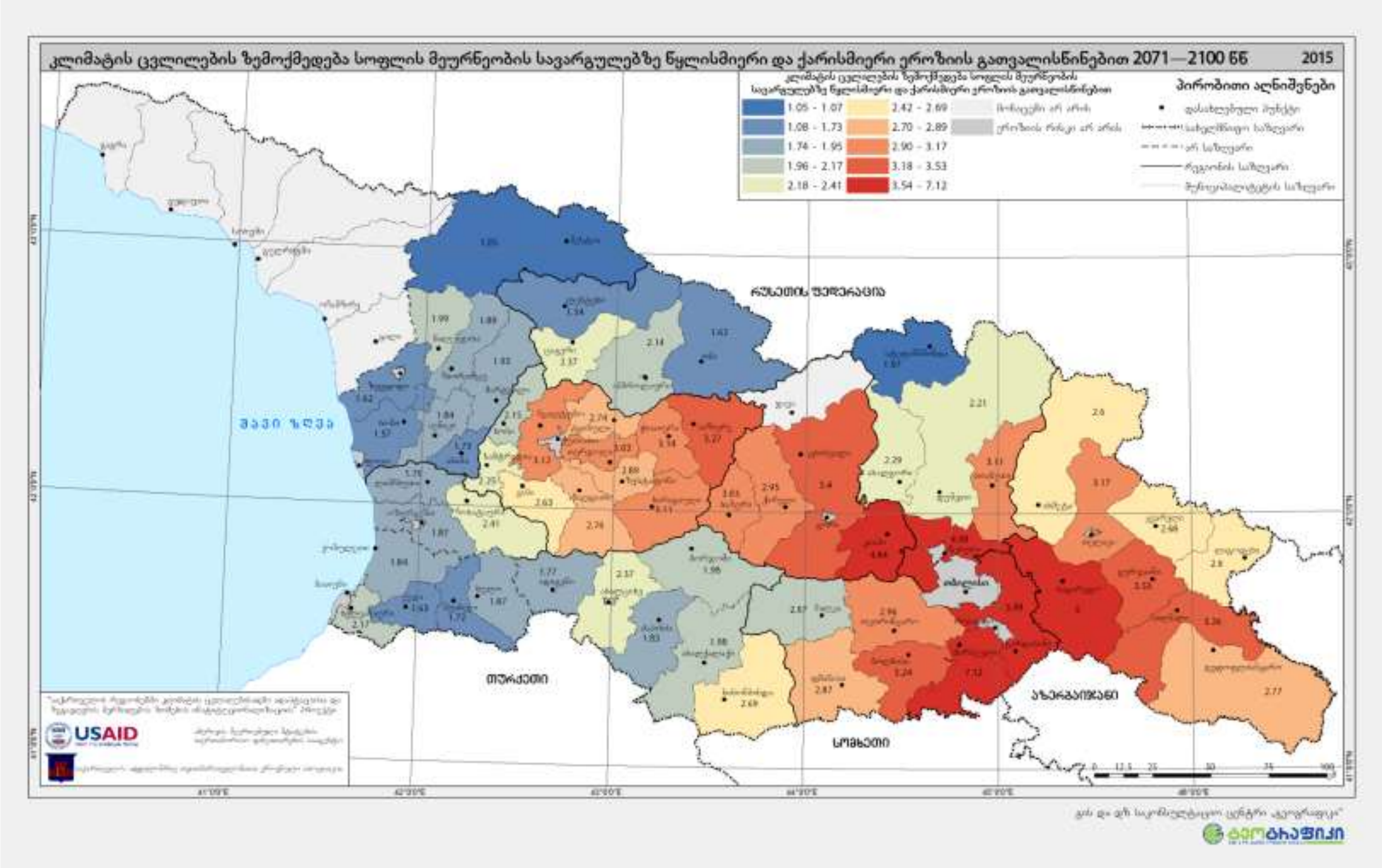


Fig. 4

In 2021-2050, the average risk of wind erosion, for Georgia is estimated at 0.22



In 2071-2100 the average risk of wind erosion, for Georgia is estimated to be 0,55

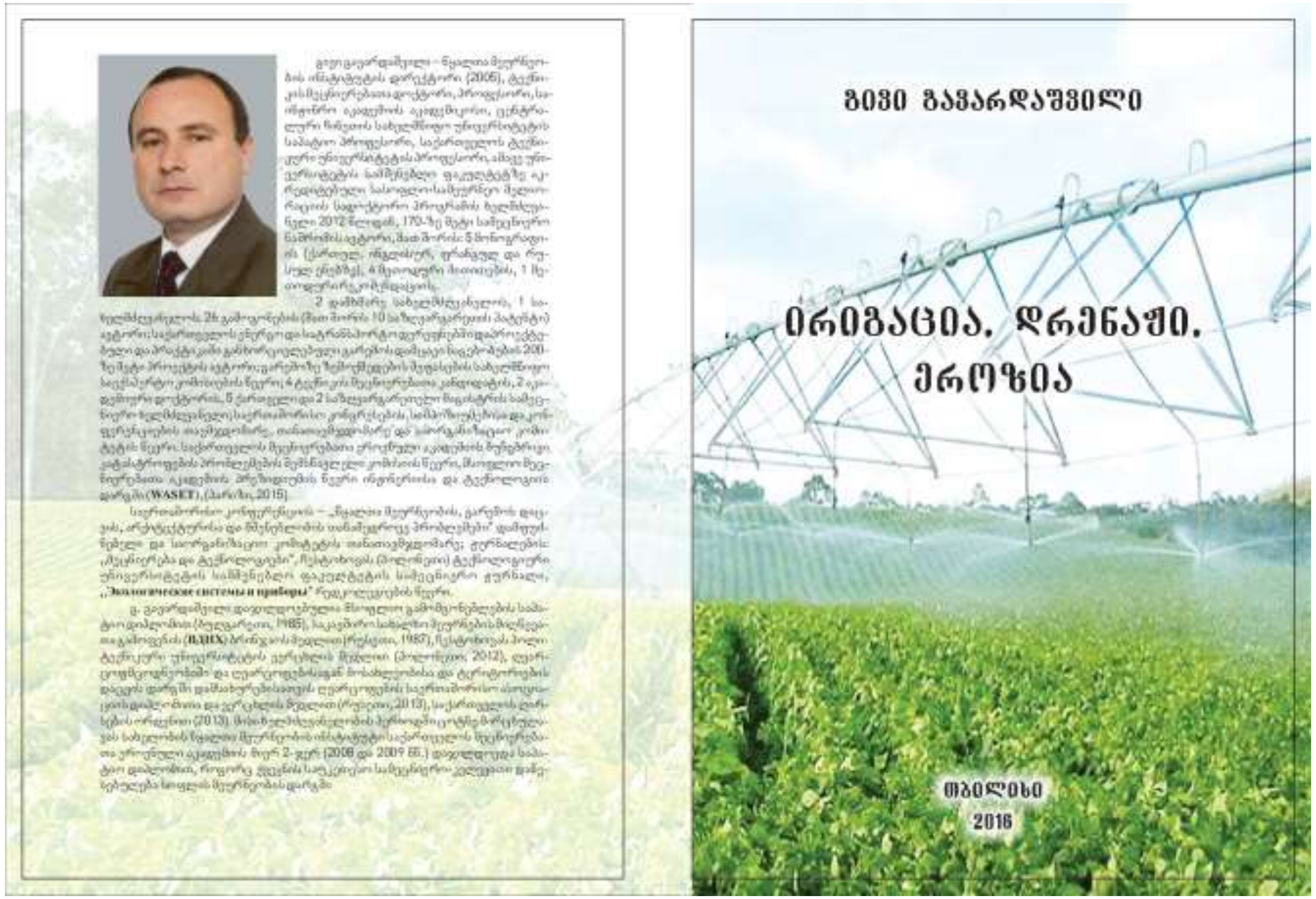


5. Conclusion

Based on the scientific-theoretical and field-expedition work carried out in 2010-2017, the following main conclusion can be drawn: In 2021-2050, the occurrence of wind erosion or an increase in the risk of wind erosion in the above periods is associated with changes in wind speed, precipitation decrease and air temperature rise . The average risk of wind erosion for Georgia is estimated at 0.22, and increases from 2071-2100 to an average of 0.55 in Georgia.

6. Manual for students

Irrigation, Drainage , Erosion
Tbilisi, 2016, 410 p



Thank you for your attention