Research Paper | Geography

Natural Environment Zoning of West Georgia for Identifying The Perspective Regions of Actinidia Chinensis Planch Culture Spreading

Seperteladze Zurab Kh. — Ivane Javakhishvili Tbilisi State University, Department of Geography, Chavchavadze Ave. 3, 0179, Tbilisi, Georgia

Davitaia Eter F. — Ivane Javakhishvili Tbilisi State University, Department of Geography, Chavchavadze Ave. 3, 0179, Tbilisi, Georgia

Aleksidze Tamar — Ivane Javakhishvili Tbilisi State University, Department of Geography, Chavchavadze Ave. 3, 0179, Tbilisi, Georgia

Memarne Guram — Batumi Shota Rustaveli State University, Institute of Phytopathology and Biodiversity

Khalvashi Neli — Batumi Shota Rustaveli State University, Institute of Phytopathology and Biodiversity, Chief Scientist of Division of Biodiversity Monitoring and Conservation

Gaprindashvili George — Ivane Javakhishvili Tbilisi State University, Institute of Geography, PhD student, Chavchavadze Ave. 3, 0179, Tbilisi, Georgia

ABSTRACT

The methods to estimate the agro-resource potential of a territory are developed and relevance of using the said method is identified. The regularities of spatial distribution of agroclimatic potential favorable for Actinidia Chinensis Planch (kiwi) culture in west Georgia are identified depending on the proximity to the standard model (hypsometric stages and types of landscape). By creating and processing numerous databases and by using GIS-technology, a large-scale landscape map was drafted.

KEYWORDS : Physical-Geographical zoning, multi-factorial analysis, standard model, landscape

Introduction

Estimation of the agro-resource potential of an area is much important to rationally grow some or other culture and identify the potential prospects to improve its productivity (harvest). The latter depends on many factors, with natural physical-geographical factor as one of the most important of them. This factor is multi-factorial and multi-dimensional. Application of a mathematical method allowing improving the geographical approach and providing a more objective and complex estimation of the area in this respect was considered by us as the most optimal way to solve this complex problem. This method also facilitates selecting and estimating the areas with their numerical values varying within a great range and with different dimensions.

By using the above-mentioned method by the authors (Agriculture of Georgia, 2011; Gökay Nemli, Hüseyin Kırcı et al. 2003), the present work accents the kiwi culture commonly spread in west Georgia in recent period. The experimental plantations of kiwi (Actinidia chinensis) are grown only in the low- and middle-mountainous landscape zones of Ajara-Guria segment, in west Georgia (even at 1200 m asl); however, the questions of optimal landscapes and zoning of the habitats of the given culture are not developed yet. With this thought in mind, we, a group of authors, in cooperation with agricultural technicians, who are practitioners, have developed and estimated the agroclimatic properties of kiwi culture, selected and identified the optimal natural conditions (without agricultural measures) (by designing a virtual standard model) and provided the landscape zoning of West Georgia by using GIS-analysis.

The topicality of the work also can be seen if considering important curative and preventive properties of kiwi culture (Papunidze 1998). As it is known, kiwi fruit contains a large amount of organic acids, sugar, protein, different vitamins (with the major content of vitamin C), etc. It is widely used in cookery, food and processing industry, as well as in treatment and prevention of blooding, tuberculosis, whooping cough. It is recommended in treating infectious diseases, intoxication, hepatitis, physical and mental fatigue, etc. Consequently, accenting the theoretical issues to select the optimal natural-geographical conditions to grow kiwi in Georgia is quite topical and in the first instance, needs a complex approach and multifactorial analysis, by using the mathematical apparatus and landscape approach. It should also be noted that in its home country (New Zealand) haivard type kiwi harvesty is average 25 tons per hectare. Under normal conditions, plant produce an average 400-600 units of the fruit, which equals the weight of 25-50 kg. Therefore the average yield for 1 hectare is 11-25 tons, but with good care and good weather conditions productivity increases 30-35 tons.

The major scientific novelty of the project is selecting and ranging the areas with the conditions optimal to grow kiwi by using a mathematical method, in particular, estimating (selecting and processing) the agroclimatic properties, designing a virtual standard model and providing the landscape zoning of the territory based on the proximity to the virtual standard model what will allow differentiating the territory for the given culture by considering its potential validity (Elizbarashvili E., Chavchanidze Z., et al. 2006).

Object of Research

West Georgia, with its major part occupied by the landscapes of humid subtropical Kolkheti valley has been known as a fertile and rich region since the ancient times. In addition to Kolkheti plain valley, it incorporates the landscapes of the Caucasioni in the north, Meskheti ridge in the south and piedmonts of Imereti plateau and adjacent low- and average-mountain landscapes in the east. With its peculiar geographical location and owing to the Caucasioni acting as a barrier, diversified relief forms, hypsometric extension, influence of the Black Sea and, most importantly, the resultant much favorable soil and climatic conditions (Elizbarashvili E. Elizbarashvili M. 2007), the region has rich and diversified nature (Seperteladze, Davitaia 2013; Seperteladze, Davitaya 2012) All these factors facilitate to develop subtropical gardening (citrus-growing and fruit-growing) successfully in the region.

A number of works is dedicated to the study of the agroclimatic conditions of Kolkheti (Meladze, Meladze 2012; Scott Frey R. A 2000) and there is a collection of works published in two volumes giving significant studies of the agroclimatic conditions of Kolkheti. It is established that the main factors contributing to the favorable growth and development of agricultural crops and high-quality and fertile harvest are heat and moisture.

The warm period of the year in west Georgia (with the average daily temperature of over 10°C) is quite long and constitutes 220-250 days (Elizbarashvili E. Urushadze T. et al. 2010). The sum of accumulated temperatures in this period (in the lowland) is over 4000-4500° (Table 1).

Table 1. Different provisions of sum of temperatures over 10°C

Average Sum	provisions %				
	95	75	50	25	5
4000	3700	3850	4000	4150	4300
4200	3900	4050	4200	4350	4500
4400	4100	4250	4400	4550	4700
4600	4300	4450	4600	4750	4900

The duration of a frost-free period in west Georgia is 230-210 days on average, while that of the periods with the risk of frost is minimal and reaches 60 days a year even over the slopes at 5 to 6 km above the sea. Sometimes, in winter, the air temperature along the sea coast and adjacent warm slopes rarely or never falls below 0°C (Table 2).

Table 2. Different provisions of the duration of frost-free periods (days)

Average Duration	provisions %				
	95	75	50	25	5
230	190	211	230	249	270
250	210	231	250	269	290
270	230	251	270	289	310
290	260	271	290	309	330
310	270	291	310	329	350

West Georgia is distinguished for abundant atmospheric precipitations (1200-2300 mm and over). Mean hydrothermal coefficient showing the relation between the heat and moisture varies between 1,5 and 3,5 and is minimal in the east part of the area (in Imereti), while reaches its maximum in Ajara-Guria region. Different provisions of the hydrothermal coefficient in the vegetation period are clearly shown in the table below (Table 3).

Table 3. Different provisions of the hydrothermal coefficient in the vegetation period

Average Value	provision, %				
	90	75	50	25	5
1,5	1,0	1,3	1,5	1,9	3,1
2,0	1,5	1,8	2,0	2,6	4,7
2,5	1,9	2,3	2,5	2,9	5,0
3,0	2,2	2,6	3,0	3,4	5,5
3,5	2,5	3,0	3,5	4,0	5,9

The soils in west Georgia are mostly formed in terms of humid subtropical climate. Owing to abundant atmospheric precipitations and peculiarity of the relief, there are boggy lands mostly spread along the coastline, subtropical podzolic soils, Alisols and Cambisols spread in the hilly areas and piedmont, and brown soils spread in the mountainous areas creating favorable conditions for kiwi plantations to grow. Exception is the boggy and podzolic soils not supporting kiwi plantations due to their heavy loamy properties.

According to the observations and the data obtained, for cultivation of Actinidia it is necessary following soil physical and chemical composition: stone-gravel - 10-15%, sand -60-70%, metallic compounds - 20-25%, clay -10-15%, PH-6-6,5%, organic mass - 3-4% permeability -30-50 mg/h, total nitrogen - 1,5-1,8%, digestive Phosphorus - 40-50 mg / g, potassium -100-160 mg / g, active lime - 5%, and etc.

It is very interesting to establish of maturity level and optimal time of picking of Chinese Actinide. It is known that fetal maturity level according to protopectine content - one of the most successful, but this figure refers only to indicate the minimum level and not at the top of the border. Initially the focus was made on dry substance and soluble dry matter content. From the dry matter of picking the first term does not change, while the soluble dry matter concentration starts to rise (picking the first term 17,7-10,0 %; picking a second term - 18,2-12,0 %. (Table 4).

Table 4. Dry substances and soluble dry substance content in Chinese Actinidia fruit during picking time

Value, %	Harvesting period			
	x ± s	I. x ± s	II. x ± s	III. x ± s
Dry substance	16.4 ± 0.2	17.7 ± 0.4	18.2 ± 0.5	17.9 ± 0.5
Soluble dry substance	9.4 ± 0.3	10.0 ± 0.2	12.0 ± 0.4	13.6 ± 0.6

Research methods and initial data

The agro-resources of some or other area can be estimated by using the multifactorial analysis. Therefore, it is important to use the method allowing most optimal selection of the right conditions (Arveladze 2006). In this respect, it is important to identify the leading factors and order them, by considering their functional priority. Consequently, in estimating the spreading area of kiwi culture, we think it relevant to fix the weighted distance from different points to the standard model by considering the priority of different factors (properties) and to group the objects depending on their proximity to the standard model (Nikolaishvili, Seperteladze 2013; Matchavariani L. 2012).

The research was organized in several stages:

1. Creating the database of the agro-resource potential.
2. By using software MATLAB, calculating the "weighted" distances from each object to the standard model with the coefficients of priority, ranging the calculated values and grouping them by using Sterges formula.
3. Zoning the landscape units with the agro-resource potential favorable for kiwi to grow (designing a large-scale landscape map), depending on the proximity to the standard model, based on GIS-analysis.

The research was based on six major parameters characterizing the agro-climatic potential of the area in the warm period of the year: absolute altitude of the location, sum of active temperature (>10°C), amount of atmospheric precipitations, hydrothermal coefficient and soil pH value and prognosis yield per ha.

Data processing was carried out with the mathematical models in several stages:

- Formation of Matrix $A = (a_{ij})_{n \times m}$, where

$$a_{ij} = K_j(O_i); i = \overline{1,n}; j = \overline{1,m} \quad (1)$$

$O_1, O_2, \ldots, O_n$ and $K_1, K_2, \ldots, K_m$

apropriately determine objects (territorial units) and selected quantitative characteristics in accordance with the aim of redistricting process.

– Data normalizing, because of range of numerical values variations corresponding to marks and features may differ from each other by several row.

.....

$$k_j(O_i) = \frac{K_j(O_i)}{K_j^*}, i = \overline{1,n}, j = \overline{1,m}, \quad (2)$$

where $K_j^* = \max\{K_j(O_1), K_j(O_2), \ldots, K_j(O_n)\}, j = \overline{1,m}$

– Composition of normalizing data matrix

$$B = (b_{ij})_{m \times n}, b_{ij} = k_j(O_i), i = \overline{1,n}, j = \overline{1,m} \quad (3)$$

– Determination of priority coefficient for i-characteristic $c_j, j = \overline{1,m}$, where

$$\sum_{j=1}^{m} c_j = 1, \quad (4)$$

– Formation of normalized values

$$e_i = \frac{E_j}{K_j^*}, j = \overline{1,m}, \quad (5)$$

Where E_j ($j = \overline{1,m}$) are the components of etalon-object E.

– Calculation of „weighed" distances from O_i object to E etalon-object in Euclid n dimension space:

$$d_i = \sqrt{\sum_{j=1}^{m} c_j (b_{ij} - e_j)^2}, i = \overline{1,n} \quad (6)$$

– Determination of full range of distance dispersion from the object to etalon $d_{\max} - d_{\min}$,

Where $d_{\max} = \max\{d_1, d_2, \ldots, d_n\}$,

$$d_{\min} = \min\{d_1, d_2, \ldots, d_n\}. \quad (7)$$

By Sturges formula $k = 1 + 3{,}222 \log n$ for n optimal amount of grouping of objects were determined and determination of verge of grouping intervals:

$$h = \frac{d_{\max} - d_{\min}}{k}, \quad (8)$$

– On the basis of complex characteristics the intervals for grouping of objects was defined:

$$(rd_{\min}, rd_{\min} + h), r = \overline{1,k}. \quad (9)$$

Based on the obtained, to take into consideration the entire complex of mark and features, in the first category r=1 are the objects that are most close to the etalon-object, but in category r=k-objects that are far from the most.

In some of the works (Arkhipov, Bladjko 1976), we may see a different approach to the complex evaluation problem solving of the territorial units. In this regard, our present model is specific and has a number of advantages, which can be grouped:

- The possibility of consideration of mark and features different nature (in regard with types and values of measurement and range variations of scales).
- The introduction of weighted measure by the priority coefficient of mark and features of the closeness value to the object.
- Model universality in the sense that it can be used as for the evaluation of separate agriculture so for the evaluation of complex agri-resource potential, when the problem of grouping and selection of the optimal objects is solved by simultaneous consideration of multiple criteria.

Time-consuming calculation should be considered as the faulty part of the model, especially with the increase of mark and features. However, it should be noted that by consideration of modern technologies and software capabilities, the current problem can be solved successfully.

The advantage of this method lies in the fact that it can be used in other similar multi-factored geographical analyses, such as selection of analogue objects and optimal conditions on the bases of several criteria, as certain the degree of anthropogenic transformation of the territory and other. However, the method has fault parts what for the first relates to agri resource potential with respect of assigning various ranks to almost equal importance objects. The most important role in achieving accurate results fulfils the correct selection of agri resource potential determining factors (Urushadze, Seperteladze 2012; Gogichaishvili G. Urushadze T. 2006) and their meanings as well as determining correctly their meanings (ranks).

By analyzing the natural agroclimatic conditions most optimal for kiwi (Actinidia chinensis) and with the recommendation of expert-specialists, a virtual standard model with the following properties was designed: absolute height – 400 m, sum of active temperature (>10°C) - 3500°, amount of precipitations (in the warm period of the year) – 1200 mm, hydrothermal coefficient - 3,0 and soil pH value – 6,0, Prognos yield per ha - 30 tons

The agroclimatic characteristics were designed for seven regions of Georgia: Ajara, Guria, Imereti, Samegrelo, Svaneti, Racha-Lechkhumi and Apkhazeti (Table 5). Basis on this it was allocated 11 type of landscape of optimal conditions of Actinide Distribution (proximity Etalon - model).

Table 5. Hypsometric distribution of agroclimatic properties in the warm period of the year

Region		Objects	Place Elevtion (m)	Sum of active temperatures, C0	Sum of atmospheric precipitation, mm	Hydrothermal Coefficient	Soil PH-indicator	Prognos yield per ton/ha
Adjara	I	Batumi, Kobuleti, Chakvi, Akhalsheni	30-400	4000-4500	1500	3-3,5	7-8	20–25
	II	Chakvistavi, Keda	400–700	3800-4300	1400-1500	2,4-4	5-6,5	10–15
	III	Khulo, Purtio, Gomarduli	700-1200	3100-3300	500-650	1,5-2	6-6,5	5–7

Region		Objects	Place Elevtion (m)	Sum of active temperatures, C0	Sum of atmospheric precipitation, mm	Hydrothermal Coefficient	Soil PH-indicator	Prognos yield per ton/ha
Guria	I	Ureki, Supsa	5-100	4100-4400	1200-1400	2,7-3,3	5-7	15–20
	II	Dablatsikhe, Anaseuli, Acana	100-500	4100-4200	950-1150	2,3-2,7	5-5,2	10–15
Imereti	I	Samtredia, Vani, Tskaltubo, Khoni, Sakara, Dimi	30-200	4500	600-1000	1,5-2	5-7,5	15–17
	II	Kharagauli, Sachkhere, Tkibuli	200-500	3500-4000	500-1000	2-3	5-7	10–12
Samegrelo	I	Abasha, Anaklia, Senaki, Kheta	0-100	4300-4600	800-1100	1,8-2,4	7-7,5	15–20
	II	Chkhorotsku, Martvili, Zugdidi	100-700	4000-4200	1000-1200	2,5-3	5-7	10–15
	III	Tsalenjikha, Mukhuri, Lebarde	700–1500	3000–3300	600–700	2–2,5	6–7	5–7
Svaneti	I	Khaishi, Lentekhi	300-1000	3300	760	2,3	7,0	4–5
	II	Mestia, Becho, Koruldashi	1000-1700	1750-2100	1700-2100	2,5-6,5	7-7,5	2–3
Racha-Lechkhumi	I	Khvanchkara, Chrebalo, Tsageri, Lentekhi	500-900	3000-3500	650-750	1,8-2,5	6,5-7	10–12
	II	Kharistvala, Oni, Ghebi, Shovi, Kherga	900-1900	1100-2200	750-1300	3,5-7,5	7,5	3–5
Aphkhazeti	I	Gagra, Gali, Gudauta, Gulripshi, Ochamchire, Sokhumi	30-300	4000-4500	850-1000	1,5-2,5	5-7,5	20–25
	II	Lata, Kvezani	300-500	3600-4000	750-1450	2,9-3,6	5-7	10–15

As the table 4 shows, closest to the standard model is the second hypsometric zone of Ajara, Apkhazeti, Guria, Imereti and Samegrelo (from 100 to 400-500 m); however, the I zone in Guria region (if ignoring a little too much abundant moisture in it) is quite close to the II zone with humid subtropical landscapes (see map zones: 2,3 - Figure 4) of a hilly-Terrace piedmont with Alisols, Cambisols and Raw humus Calcareous (the later type of soil is particularly widely spread in some parts of Samegrelo, Imereti and also in part of Apkhazeti) (Nikolaishvili D.A., Matchavariani L.G. 2010). As for Racha-Lechkhumi and Svaneti, their natural conditions are less favorable for kiwi to grow and develop, with the I zone (700-1000 m) with the Kolkheti humid subtropical mountain-forest landscapes with humid yellow-brown and Raw humus Calcareous soils being closest to the standard model (see map zones 4, 5), As for the rest hipsometriul zones (map # 6, 7, 8, 9, 10) are useless kiwi culture zones, therefore are away from Etalon-model (Figure 5).

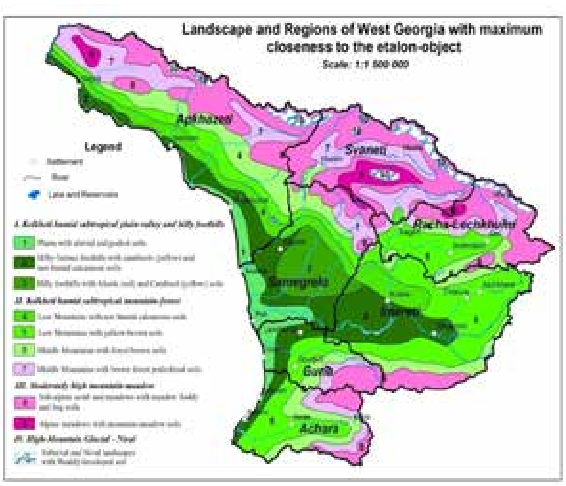

Figure 4. Landscape and Regions of West Georgia with maximum closeness to the etalon-object

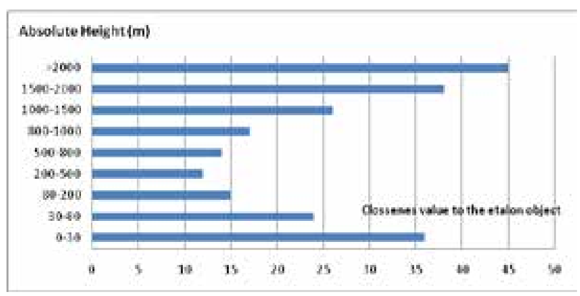

Figure 5. Closeness value to the etalon-object according to different altitudes in terms of resource potential

Conclusion

Several important results were gained as a result of the study:

- The methods to estimate the agro-resource potential of the territorial units were developed. The methods are based on the calculation of the weighted distances with a coefficient of priority of factors to the standard object.
- By using the said method, the regularities in the territorial distribution of Actinidia Chinensis Planch culture in west Georgia, hypsometric stages with high potential, landscape types and regions were identified. Detected different potential of Hypsometric area, landscape types and regions.
- Based on the database of the agro-resource potential and GIS-technologies, a large-scale landscape map of the territory of west Georgia was designed (figure 4).

Acknowledgments
This research would not have been possible without the support of many people and also without using many scientific researches done by the staff of the Geographical Department (Faculty of Exact and Natural Sciences) of Ivane Javakhishvili Tbilisi State University and Institute of Phytopathology and Biodiversity of Batumi Shota Rustaveli State University. The authors of the work express their gratitude to all them.

REFERENCES

Agriculture of Georgia (2011) Statistical publictaion. National Statistic Office of Georgia. | Arkhipov I.R., Bladjko N.I. (1976) Mathematical Methods in Geography. Kazan University, 352 p. | Arveladze G.A. (2006) Mathematical modeling of hydrometeorological processes yields formation of perennial crops and optimization of their cultivation technology, Tbilisi, p.p 64-69; | Elizbarashvili E. Urushadze T. Elizbarashvili M. Elizbarashvili SH, Schaefer M. (2010) Temperature Regime of Some Soil Types in Georgia, Eurasian Soil Science. Volume 43, No. 4, pp. 427-435. | Elizbarashvili E. Elizbarashvili M. Maglakelidze R. Sulkhanishvili N. Elizbarashvili SH. (2007) Specific Features of Soil Temperature Regimes in Georgia. Eurasian Soil Science. Volume 40, No. 7, pp. 761-765. | Elizbarashvili E., Chavchanidze Z., Elizbarashvili M. Maglakelidze R., Sulkhanishvili N. Elizbarashvili SH. (2006) Soil-Climatic Zoning of Georgia Eurasian Soil Science, Volume 39, No.10 pp. 1062-1065. | Gogichaishvili G. Urushadze T. (2006) Estimation of Erosion Lands of the Reclamation Fund in Georgia, Journal of Agriculture and Rurol Development in the tropics and Subtropics. Kassel University Press, vol. 107, #1. | Gökay Nemli, Hüseyin Kırcı BedriSerdar, Nurgül Ay, (2003) Suitability of kiwi (Actinidia sinensis Planch.) prunings for particleboard manufacturing, Industrial Crops and Products, Volume 17, Issue 1, P. 39–46. | Matchavariani L. (2012) Time Factor in Soils of Georgia – Mirror or Memory of Landscapes, Journal of Environmental Biology. Special Issue of JEB"Environment & Geography in the Mediterranean", 33(2), 393-400. | Meladze G., Meladze M., (2012) Agroclimatic resources of western regions of Georgia. Institute of Hidrometeorology at the technical university. Tbilisi. p. 248-426 | Nikolaishvili D.A, Seperteladze Z.K, Davitaia E.F, Kikvadze T.T, Donadze T.I. (2013) Evaluation of agri resource potential of georgia's landscapes by the use of mathematical methods, International Journal of Scientific Research, volume 2, Issue 12, December, ISSN 2277-8179, p.p. 251-256. | Nikolaishvili D.A., Matchavariani L.G. (2010) Humus Reserves and Their Distribution in the Landscapes of Georgia. Eurasian Soil Science, vol. 43, #1, 39-48 | Papunidze V. 1998, Kiwi. Publishing: Metsniereba (Science), 97 p. | Scott Frey R. A (2000) Glossary of Agriculture, Environment and Sustainable Development, Agricultural Experiment Station, Kansas State University Bulletin 661. ISSN 0097-0484, 112 pp. | Seperteladze Z., Davitaia E, Alpenidze M. (2013) Nature Management Zoning of Upper Svaneti Geographical Environment. Annals of Agpapian Science, Vol. 11, Nom. 2. 12-15 | Seperteladze Z., Davitaia E. Aleksidze T., Ruxadze N. (2012) Problems Landsscape Ecological and Natural Zoning. Vol.8, No. 6. 88-94 | Urushadze T., Seperteladze Z., Davitaya E. (2012) Natural Resource Potential of Western Georgia and Territorial Managment of Agro Landscapes. Bulletin Georgian National Academy of Sciences vol.4. no. 1. Tbilisi. 74-78. | |