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Subtropical-Humid Agro Landscape Zoning of Adjara Region by Multifactor Approach

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Abstract: Physical and geographical factor are the main for Agro-Resource Assessment, which is multi-criterion and multidimensional. We considered a multi-faceted approach to optimal solution for solving this task. It has been possible to improve geographical (complex) research, agro landscape zoning of territory, optimal evaluation of natural conditions, assignment and assessment of places with different range and dimensional numerals. The methodology for assessing the agro-resource potential of the territories has been elaborated and the regularities of spatial distribution (hypsometric stages and types of landscapes) of the agro-cultures spread in the Adjara region are established. Based on the creation and development of numerous databases, large-scale landscape zoning has been carried out using GIS-technology.

Keywords: Agro-landscape, Multi-factor Approach, Humid, Hydrothermal Coefficient, Moisture Deficiency

1. Introduction

One of the most widespread modification in the class of cultural landscapes is agricultural, agricultural ecosystems, area of which on our planet already exceeded area of forest. These systems are mainly formed at irrigation, non-irrigation and pasturage areas and by their functional peculiarities represent a special category of anthropogenic landscapes and therefore it is not only the most widely distributed category also it is the oldest type of anthropogenic landscapes, which emerged approximately 7-8 thousand years ago.

One of main priorities for economic development of Georgia are agricultural ecosystems, which are represented in diversity on the territory of Georgia [1; 2] and it's natural, as local nature preconditions optimal development of multi-field agricultural, including subtropical cultures (in Western Georgia).

Anthropogenic – agricultural ecosystems are open systems with constant rotation of substances and energies as within systems also in neighboring systems and their spatial structure is predetermined in the first place by natural factors, that's why its effectiveness and productivity mainly depends on resource potential of landscape [3; 9] due to a quite high quality of anthropogenic influence on the nature agricultural ecosystems enhance surface and linear erosion, deflation of soil, facilitate simplification of terrace lines, activation

of exodynamic processes and finally leveling and vanishing of micro and nano-forms. This process is proportional to areas of arable plots of lands [5].

As to sustainability of agricultural ecosystem, it depends on multiply factors and still is disputable and unsettled. However, there is an opinion that landscapes, which have experienced agricultural influence are less sustainable or practically unstable [2; 8], which in our opinion along with many other factors is mainly dependent on sustainability of agricultural crop.

As compared to natural landscapes, structure of agricultural ecosystems is simplified as well; in particular, phyto component is changed. Here will be one vegetation culture (monoculture), however, naturally it changes some features of the soil. It should be noted that cultural vegetation is greedily absorbing organic and chemical substances and hampers reduction process, which is characteristic for damp subtropical hilly, shrubbery landscapes.

Based on the above, further adaptation and intensification of agricultural resources requires in-depth study of agricultural ecosystem and scientific analysis of intensity of ongoing natural processes and mapping, which shall promote system sustainability and keep natural balance, as well as introduction of cultural vegetation cultures and elaboration of successful agrotechnical measures. All the above shall represent a reliable ground for increase effectiveness of agriculture production.

For spreading of subtropical cultures in Georgia, especially against the background of global climate change, reaction of landscapes towards the problem is very important [4; 14]. In addition, reaction of humidified landscapes in Western Georgia is different from reaction of semiarid and arid landscapes in Eastern Georgia. Namely, the tendency of decrease of precipitations in humidified landscapes in Western Georgia, minor increase of air temperature and other negative natural processes should be considered during determination of plantation and frost resistance of citrus plants. Notwithstanding restricted climate conditions citrus planting in Georgia is considered to be high-intensity and commercial field. Among citrus cultures, tangerine is on the first place the area of spreading and importance, which is preconditioned by its significantly high frost resistance and profitability. As to Feijoa Sellowiana, it came to Georgia from the beginning of the 20th century and at that time, its amount was 200 shrubs. Afterwards area occupied by the culture increased and currently Feijoa occupies about 500 hectares.

Feijoa is a plant with a long span of life. It is confirmed by 48-50 years plants, which have no sign of aging. In Georgia, requirements of the crop for development and fruit-bearing are completely satisfied by physical-geographical, namely agricultural and climatic conditions of Adjara, Guria, Abkhazia, Imereti and Samegrelo regions.

Among agricultures of humid-subtropical zone feijoa seliowiana is distinguished by its taste, its nourishing and medical features. Thus, introduction of feijoa of South American origin in European, Mediterranean countries, USA, New Zealand, Crimea and the Black Sea coast in Caucasus, namely in Georgia may be considered only as a positive event.

Trial plots of feijoa culture have been functioning over the years in one of Georgian regions – Adjara, where a group of authors [14; 15] successfully supervises the culture; however, these plantations do not comply with corresponding requirements, which is caused by diversity of sort and inefficiency of agrotechnical measures and apart of that, in our opinion it is caused by unintended corresponding environment and ecology (plant requirement to environment conditions).

We consider the following agro-chemicals as agricultural climate index for widespread of Feijoa Sellowiana culture:

(1) Sum of active temperatures – 2500-3000°
(2) Hydrothermal coefficient - 2,5-3
(3) Annual precipitation -1800-2500 mm
(4) Average minimum of absolute minimal temperature - -6°
(5) Average annual temperature - 12-13°
(6) Average temperature of coldest month - 3-50
(7) Highest hypsometric level - 700 m. (where temperature of the coldest month is positive)
(8) Fruit ripening period (from blossoming to ripening) – 120-170 days
(9) Soil PH-factor – 5,5-7,6

Sandy light and alluvial soils are optimal and best condition for high yield of feijoa (also it easily gets used to and grows well in oxyphilous, less oxyphilous and red soil with alkaline reaction, subtropical podsol and turf-carbonate soils [10; 17].

One of main geomorphological factors of optimal conditions for spreading feijoa is inclination and decomposition of relief, exposition and hypsometry. Area for spreading feijoa is represented by hilly, shrubbery landscapes to the South, South-West and South-East plateaus, total area of which in the research region makes up to 41% (figure 1). Feijoa may also be planted on 5-10°, 10-15°, and 15-25° inclination plateaus, total area of which amounts to 88% (figure 2). Under optimal plantation of feijoa it should be also considered that relief of hilly, shrubbery areas is divided by gorges, that's why for planting we should use foothills and not bottom of gorges and plains.

It is known that spreading and fruit bearing of agricultural crop is firstly determined by warmth and humidity, namely: correlation of temperature indices and coefficient of humidity, i.e. hydrothermal coefficient (table 1), however along with that, other physical-geographical conditions (hydrographic and edaphic) play an important role as well.

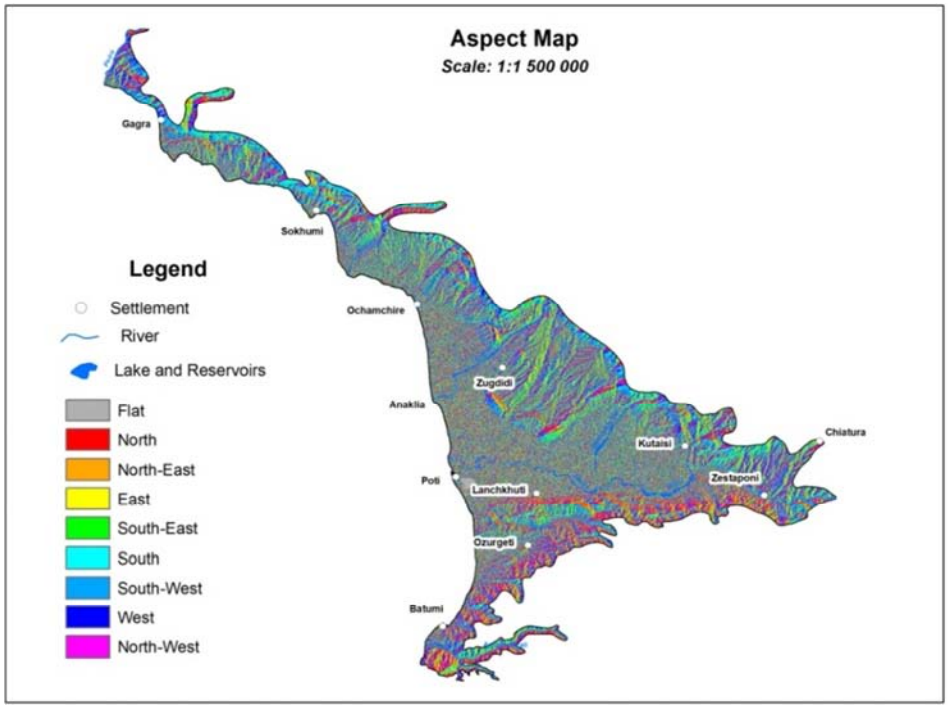

Figure 1. *Aspect map.*

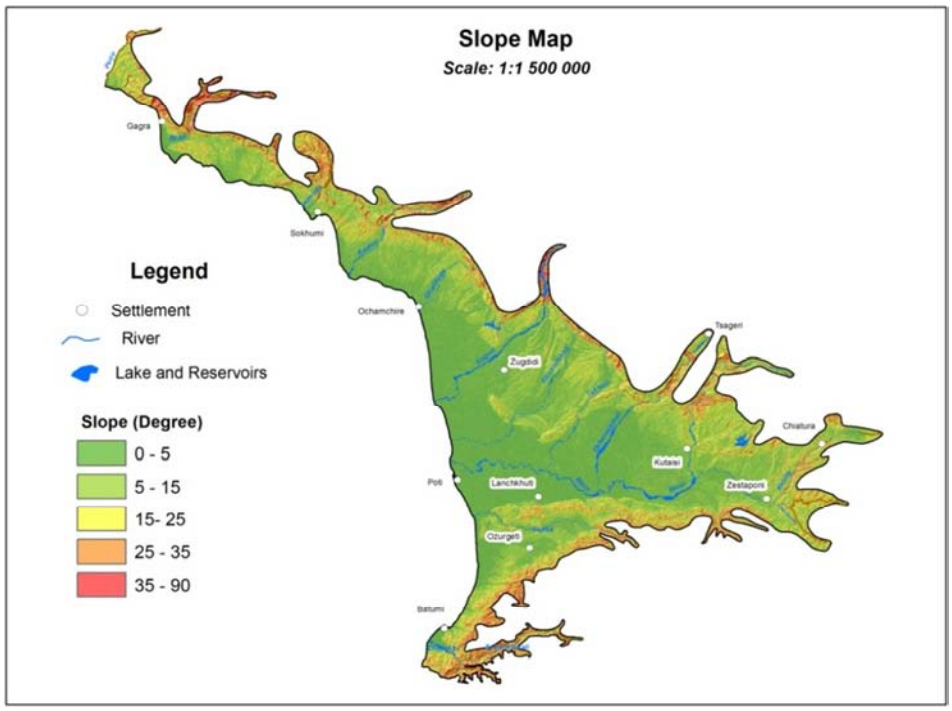

Figure 2. *Slope map.*

Table 1. *Different provisions of the hydrothermal coefficient (HTC) in the vegetation period of Feijoa.*

HTC	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	3.6	5.5
3.5	2.5	3.0	3.5	4.0	5.9

Western part of Georgia, namely Adjara is distinguished with the above-mentioned conditions, namely: excessive humidity, high temperature, sun radiation and high rates of luminescence duration, seasonal change of western and eastern winds, advection of cold air masses, which causes abrupt change of weather conditions, etc. [8; 14]. All that has a particular impact on growing and development of agriculture, productivity and geographic widespread and

distribution.

Notwithstanding the fact that Adjara is characterized with high overcast and excess of precipitations, sun luminescence here is higher and ranges between 1800-2300 hours, total radiation of sun per year amounts to 120/130 kkal/cm^2. Considering critical temperatures (figure 3), namely, according probability of these temperatures, a probability of damage of citrus plants was revealed in Adjara and we have received the following picture: in -4° temperature zone (Black Sea coast) damage of lemon is forecasted once in 4 years (25% probability), in - 6° zone orange Washington Neville may be damaged once in four years, and tangerine Unshiu is damaged quite rarely - once in 20 years (5% probability). As to feijoa, as compared to other subtropical cultures it is more frost resistance and is used to -12° [3], its 2-3 years old branches are used to 13—14°, and in conditions of -15-17° the surface of any soil is frozen, however during the next spring it gives sprouts and harvest in two years.

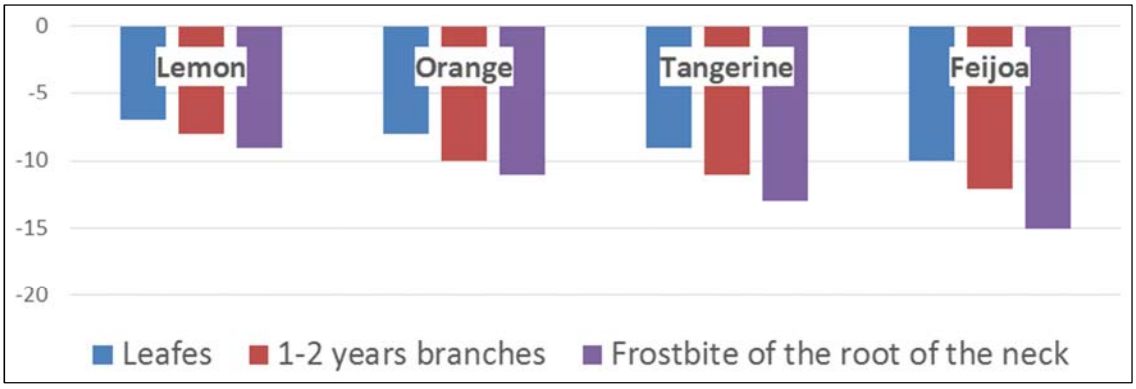

Figure 3. *Extreme temperatures causing damage of Citrus.*

One of factors of frost resistance is considered to be preparation of plant for winter, i.e. tempering, which can be successful when seasonal temperature is lowered gradually. Also, additional measures must be taken: selective, agro technical and ecological. In the present article, we will focus on the last two factors in relation to FEIJOA Sellowiana culture. We have studied some economic and biological peculiarities of some feijoa fruit [12; 16] afterwards the state Georgian agricultural products picking commission introduced it into citrus zone in Adjara-Guria and Samegrelo. Since detailed morphologic and biologic peculiarities of plants is a compulsory condition for revealing potential skills of adaptation in changed environmental conditions we carried out an experiment with the aim of revealing optimal terms of harvesting feijoa fruit [16]. Biological and physiological research was implemented during different stages of ripening on two forms (late and control form) of one of feijoa sort – superb (figure 4-5).

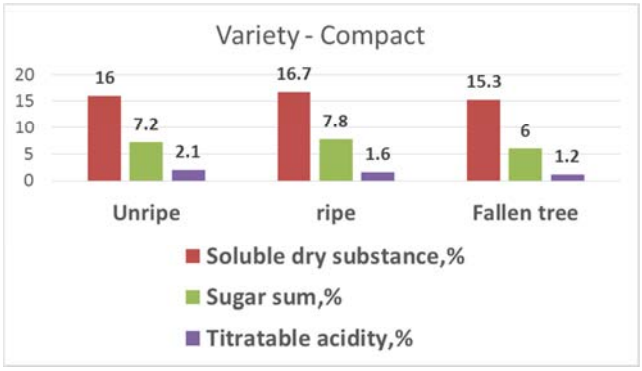

Figure 4. *Variety – Compact characteristics.*

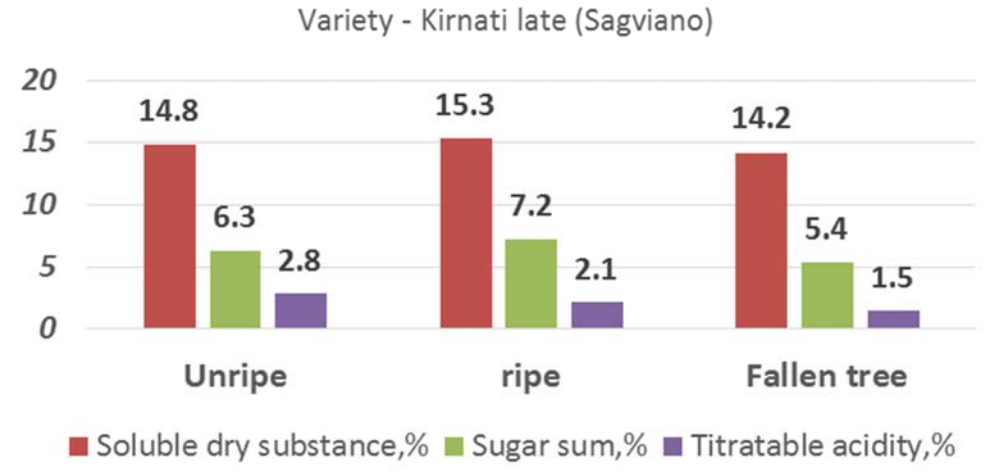

Figure 5. *Variety - Kirnati late (Sagviano).*

If we compare received results to ripening process of green fruit during the period of storage after harvest, we can conclude that ongoing biochemical processes are particularly identical: dissoluble dry substance and amount of sugar increases and titer acidity decreases (table 2).

Table 2. *Biochemical indices of variability of feijoa fruit during storage.*

#	Fruit physiological condition	Soluble dry substance, %	Sugar sum, %	Titratable acidity, %	Ascorbic acid, mg / 100 g
Variety - Compact					
1	Unripe	16.0	7.2	2.1	33.5
2	ripe	18.7	8.0	1.6	54.7
Variety - Kirnati late (Sagviano)					
3	Unripe	14.8	6.3	2.8	42.2
4	ripe	15.5	7.0	1.8	60.8

Thus, the process of ripening of feijoa fruit on the tree and during storage is identical, but it is important to harvest fruit during optimal phase, at the beginning of climacteric period in order to preserve useful features – taste and flavor; and prevent infectious and physiological diseases.

For studying quality features of fruit, sugar content was determined by Bertrand's method. Frost resistance of the plant was determined in laboratory of artificial climate by freezing of two-year old plants and cut branches, etc.

Natural (landscape), namely agriculture climate resources (duration of sun luminescence, sum of active temperatures, precipitations, humidity of soil and air, etc.) of the territory should be used for maximal profitability of agriculture, which may be effectively used in some regions for growth and development of agricultural crops and their rational disposition-distribution (zoning) (map 1). From this point of view, we [7; 14 have separated 7 agro climatic zones (table 3) in Western Georgia.

Table 3. *Agro climatic zones in Western Georgia.*

Zone	Altitude from sea level (m)	Actual temperature total (more than 10%)	Average of absolute and minimal temperature (°C)	Nonfreezing days
I	0-350	4000-4500	-3	280-310
II	351-560	3500-4000	-14-16	190-275
III	561-780	3000-3500	-18-8	186-267
IV	781-990	2500-3000	-12-22	175-216
V	991-1250	2000-2500	-14-23	140-205
VI	1251-1750	1500-2000	-15-28	120-180
VII	1751-2100	1000-1500	-19-29	100-150

As a result of implemented researches, on the basis of received database it was determined that most suitable physical and geographical (soil climatic) conditions for spreading of citrus plants in Western Georgia are revealed in 3 hypsometric agro climatic zones (I, II, III) and from regions - Adjara.

Optimal zone for growing of feijoa is mainly spread in Kolkheti lowland, hilly, shrubbery and Kolkhetian forest landscapes. Based on climatic and landscape peculiarities of the region under research, the zone, optimal for feijoa planting corresponds to Kolkhetian evergreen, undergrowth, humid landscapes, which are located in Northern and Northwestern plateaus. The zone, proper for planting is limited by oroclimatic barriers, meaning abrupt decrease of precipitations in Adjara on the plateau of Adjara-Imereti mountain ridge hollow and significant aridization of air, which makes climate unfavourable for feijoa planting [2; 17]. In the zone of Adjara plain restrictive factors for feijoa planting are considered to be soil and edaphic factors.

Here the soil is bogging and staining. Swamped ecosystems functionally play an important role in existence and maintenance of swamp ecosystem and their ecological cycle is connected to these systems, therefore their separation and replacement with any kind of plants would be an ecologic crime, we would receive serious reverse results, which would result in destruction of primary ecosystems, flora and fauna and afterwards cause threat of secondary bogging and saline, which we reckon inadmissible as other negative occurrences will have a negative impact on neighboring ecosystems and the society. In the zone of hilly, shrubbery landscapes, there is balanced co-existence of agricultural and small craft with local natural landscapes. The same may be said about lowland landscapes and the remaining territory of Adjara (which is not located in the zone of spreading of feijoa).

A particular part of territory in Adjara is not suitable for planting of feijoa. However, feijoa zone itself, occupying 30,5% of Adjara region is divided into single sub-zones, which is preconditioned by climatic, edaphic and relief factors, also by existing vegetation, representing areas covered by natural forest and its maintenance is important for the region.

Our research is of general recommendation character, as represented maps and materials may be used by private owners, locals etc., all who believe that this culture may be efficient if planted on their land and will be economically profitable and will take its place in local agriculture and have its particular sector in the field of fruit-growering.

Climatic and edaphic and landscape indicator for zoning of feijoa planting [13; 14] may be considered forests, spread in

the same landscape zone and same edaphic- hydrothermal conditions, required by feijoa plants. Under conditions of Kolkhetian landscapes floristic and ecologic indicator of feijoa plants and this ecosystem may be used in other regions, where feijoa is planted or there is a corresponding recommendation for its planting.

2. Methods of Research

Geographic and physical evaluation of any phenomenon and process is quite complicated task as it requires simultaneous consideration of multiply factors. Characteristics of the above factors are of different dimensions and quite big range. Based on the above it is advisable to use such multiply factor method [6; 11], which will give us an opportunity of handling of big amount of data with different range. Naturally, multiply factor approach is not limited by one particular method, as natural environment is a whole organism with correlation of composite components, events and processes. With the given approach, evaluation of main features of similar geographic objects was implemented by means of comparative analysis, which enabled classification (standardizing) of separate zones of the region and detection of experimental plots of land. By means of analytical method it became possible to evaluate and range climatic and geographic features, and by synthetical method – comparison of received results and elaboration of complex map (figure 1). By method of modeling be became able us to verify frost resistance of some sorts of feijoa (in conditions of gradual lowering of temperature in the laboratory of modeling of artificial climate). By means of computer software, we created GIS base and mapping of geography agro systems. Namely, for determination of the corresponding ecosystem in the zone of spreading feijoa plants we elaborated a map of large-scale ecosystems and GIS. We have determined ecosystem of the forest corresponding to feijoa zone, character of forest land and current condition of ecosystem and character of their indication [11; 14].

3. Main Results

As a result of experimental morphological researches and physical-geographical zoning it was received following results:

- Optimal natural conditions for spreading of feijoa culture plants have been chosen, evaluated and ranked by means of landscape-multiply factor method.
- We have implemented morphologic analysis of some morphometric features (biometric, beginning and end of first and second growth, beginning and end of blossoming, beginning and end of ripening of fruit and massive ripening, mechanical and biochemical content of fruit, evaluation by tasting, storage of fruit, frost resistance, etc.) of selective sorts of FEIJOA Sellowiana.
- Ranking of agricultural ecosystem of subtropical humid zone in Adjara region was implemented by means of multifactorial approach.
- For determination of corresponding ecosystems in the zone of spreading of feijoa plants we elaborated map of large-scale ecosystems and GIS system.
- On the basis of natural-geographic, mainly geomorphological factors and analysis of agro-climatic characters we have elaborated scientifically proven recommendations for zoning of agro-ecosystems, according to which it is quite possible that two already existing agro-climatic zones (30-200 m; 200-400m) are added by the third zone in the range of 400-700 m, which shall increase area of increasing of feijoa and most importantly this shall facilitate high-yield of this culture.

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