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Assessment and Mapping of Ecosystem Services of the Lagoon of Oualidia

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Abstract. Lagoon ecosystems bring a multitude of benefits to humanity. In addition to being a natural cultural heritage, they are sources of food, water and flood protection. However, human pressures threaten these benefits, called "ecosystem services".

To preserve them, policymakers need clear information on how biodiversity underpins these services, the demand for these services, the capacity of ecosystems to provide them, and the pressures that interfere that capacity.

In Morocco, the lagoon of Oualidia, located on the Atlantic coast, is characterized by an important faunistic and floristic richness. Recognized since 1956 as an important traditional center of shellfish culture in Morocco and more particularly of oyster farming, the lagoon of Oualidia undergoes the impact of five essential components: oyster farming, agriculture, fishing, salt marshes and the tourist activity.

In this work, we use the current techniques of GIS and ecosystem assessment and their services to evaluate ecosystem services provided by Oualidia lagoon, taking into account the importance of considering all the natural benefits offered by this lagoon. The result is budget maps derived from maps of demand and supply of ecosystem services.

Key words: Mapping, GIS, assessment, ecosystem services, offering, demand, budget, ecological integrity.

Introduction

Wetlands, which are complex, fragile and diverse, provide multiple services that contribute to the well-being of humanity and poverty reduction (MA, 2005, Maresca et al., 2011, Briner et al., 2013 ; IPBES, 2018). They have ecological, socio-cultural and economic values (de Groot et al., 2010, Schuyt and Brander 2004). Despite their importance, these services are now threatened by various pressures: overexploitation of fisheries resources, development of marine energy projects, climate change and ocean acidification, demographic and tourist pressure, increasing urbanization, change land occupation and various pollutions.

Morocco's coasts have many marine-influenced continental environments, particularly brackish environments that are of great ecological, scientific and socio-economic interest, including several lagoons (Bou Areg, Moulay Bousselham, Sidi Moussa, Oualidia, Khnifiss, etc.), several estuaries (Tahaddart, Loukkos, Oum Errabia, Bou Regreg, Sebou, Moulouya, etc.), salt marshes and two very large bays (Dakhla and Cintra). Currently 24 of these sites are listed as Wetlands of International Importance (https://www.ramsar.org/), with an area of 272,010 hectares.

The lagoon of Oualidia, object of our present study, is part of the complex Sidi Moussa-Oualidia which constitutes a site of Biological and Ecological interest. It presents a Coastal priority in the master plan of Protected Areas of Morocco. Since 2005, this complex has had international Ramsar status, which commits Morocco to take the necessary measures for its conservation, management and rational use.

The lagoon of Oualidia offers a set of eco-systemic services (ES) that constitute the source of income for the majority of the population of the municipality. These services are mainly fishing, agriculture, shell collection, aquaculture and tourism. These services are provided by the lagoon's biological diversity, its geographical location on the Atlantic coast, its morphology and landscape and its biophysical characteristics.

The Millennium Ecosystem Assessment (MEA) provides a conceptual framework for the ES that has been defined as the overall ecosystem benefits (Fisher et al., 2009); and they have been classified into four classes of services: Support Services, Regulatory Services, Supply Services and Cultural Services (Alfonsi, 2016).

- Support services: These are the services that create the basic conditions for the development of life on Earth (Soil formation, primary production, weather conditions, etc.). Their effects are indirect or appear in the long term.
- Supply or production services: These are the services corresponding to products, potentially marketable, obtained from ecosystems (agricultural products, fish products, drinking water, energies, biochemical and pharmaceutical products, etc.).
- Regulatory services: These are the services used to moderate or regulate natural phenomena (regulation of climate, erosion, parasites, etc.).
- Cultural Services: These are the non-material benefits that humanity can derive from ecosystems, through spiritual enrichment or the cognitive development of peoples (heritage, aesthetics, education, religion, etc.).

In this study, we propose the use of GIS and spatial tools to study the ecosystem services of the Oualidia lagoon and their contributions to the socio-economic prosperity of the local, regional and national population.

Materials and Methods

2.1. Study area

The lagoon of Oualidia, located on the Atlantic coast of Morocco, is 76 km south of El Jadida and 62 km north of Safi (Fig. 1). The coordinates of its main pass are: 32 ° 44'42 "North and 09 ° 02'50" W.

It runs parallel to the Atlantic coast by an NW / SE direction over an area of 3 km^2 with 7.5 km length and 0.4 km width. This lagoon represents one of the sites in Morocco where oyster farming has developed traditionally since the 1950s to supply the national oyster market and attracts many tourists.

From downstream to upstream, the lagoon of Oualidia is distinguished by different morphological units:

- The main lagoon pass, 150 m wide, and the secondary pass 50 m wide. These two passes allow the continuous communication of the lagoon with the Atlantic Ocean and its filling and emptying by the tidal flows;
- A cordon of consolidated dunes at an altitude of 10 m;
- An immense sand pit located downstream, submerged only in the open sea;
- Channels: a main channel 6.5 km long and 0.4 km wide in a depth of 5 m and secondary channels which formed with the main channel the 47% of the total area (3km^2) of the lagoon;
- A salt meadow 5.4 km long and 0.4 km wide;
- A muddy substrate upstream rich in halophilic plants;
- Isolated slikkes that constitute with the rest of the intertidal areas 53% of the total area of the lagoon;
- Salt marshes located at the upstream end and separated from the lagoon by a rudimentary artificial lock.

The lagoon supports several economic activities: oyster farming, watershed farming, livestock grazing in the lagoon at low tide, water sports and tourist activities (hotels and restaurants), and salt marshes.

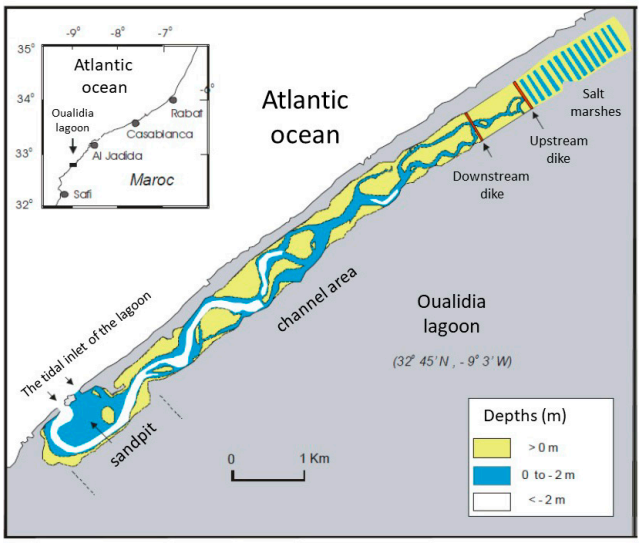

Fig.1. Geographic situation of Oualidia Lagoon

2.2. Methodological approach

The used methodological approach consists of three steps (Fig. 2):

1. the field survey;
2. the supervised classification of an Aerial photo of Oualidia lagoon;
3. The preparation of the ecosystem services matrix and maps.

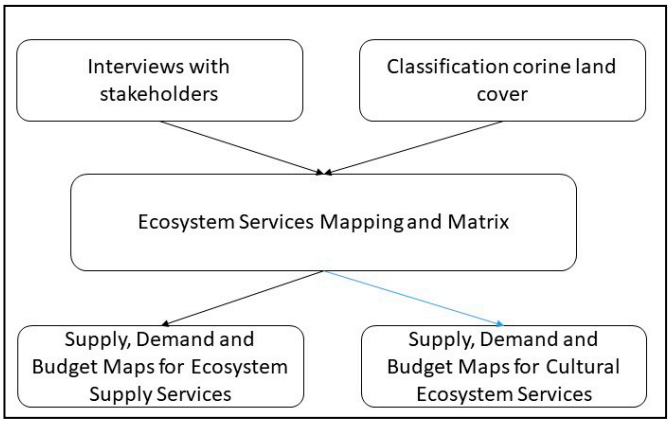

Fig2. Schema of the methodological approach

2.2.1. Field survey

The trip survey was conducted in the village of Oualidia during one week in February 2017. Interviews were done with different local stakeholders in the field of agriculture, fishery, aquaculture, tourist and shellfish collection.

2.2.2. Supervised classification

A supervised classification of the ortho-photo covering the study area was carried out based on the CORINE Land Cover reference.

The CORINE Land cover method, which is based on a standard classification hierarchical in three levels, comprises 44 classes divided into five major types of land use:

- Artificial territories;
- Agricultural territories;
- Forest and semi-natural environments;
- Wet area;
- Surface water.

In the current study, 23 LandUse /LandCover (LULC) classes have been generated.

For the validation of this classification, we calculated the KAPPA coefficient (COHEN, 1960; 1968) offered by the ERDAS IMAGINE 2014 software and the information collected in the field.

The KAPPA coefficient allows the estimation of inter-observer agreement for qualitative variables. When this coefficient tends to 1, it is an inter-observer agreement. On the other hand, when it tends to -1, it is an inter-observer disagreement.

The KAPPA index calculated here is equal to 0.79. This value tends to 1, which justifies a concordance between the classification carried out and the reality of the field.

2.3. Assessment approach

Based on the general assessment approach (Vihervaara et al., 2010; Nedkov and Burkhard, 2012; Burkhard et al., 2009; 2012), three matrices are proposed: supply matrix, demand matrix and budget matrix.

- **Supply Matrix**: It links seven ecological integrity indicators and eight ecosystem services to twenty-three classes of land cover. The selection of ecological indicators is based on Muller (2005), as these indicators represent the main components of ecosystem functionality. The scale of assessment of the capacities of the different classes of land cover to support ecological integrity or to provide specific services, are: 0 = no relevant capacity, 1 = low relevant capacity, 2 = relevant capacity, 3 = average capacity relevant, 4 = high relevant capacity, 5 = very high relevant capacity.
- **Demand Matrix**: This matrix is used to evaluate ecosystem service demands, using real data. The different LULC classes as well as the eight ecosystem services are indicated on the matrix.

  It should be noted that ecological integrity indicators are not included in this matrix because ecological integrity indicates ecosystem functions that do not directly promote human well-being.

  The values used indicate: 0 = no request; 1 = low relevant demand; 2 = relevant request; 3 = relevant average demand; 4 = high relevant demand; 5 = very high relevant demand.
- **Budget matrix**: this matrix corresponds to the budgets of the ecosystem services in the different classes of terrestrial coverage. Each field in the budget matrix has been calculated based on the corresponding field in the supply and demand matrix.

The scale varies from -5 where demand clearly exceeds supply, i.e. a strong under-supply to 5 where supply significantly exceeds demand, ie a strong over-supply. The value 0 corresponds to an offer = the demand, i.e. a neutral balance; Blank fields indicate that there is neither relevant capacity nor relevant demand for a particular ecosystem service.

3. Results

The map made by Corine Land Cover classification level 3, allowed to generate 23 classes of land cover/landuse (Fig.3). These classes were used to establish the matrix tables, themselves used to make spatially explicit maps of ecosystem services (supply, demand and budget) by assigning the scores quoted in the matrices to each polygon of the LULC map.

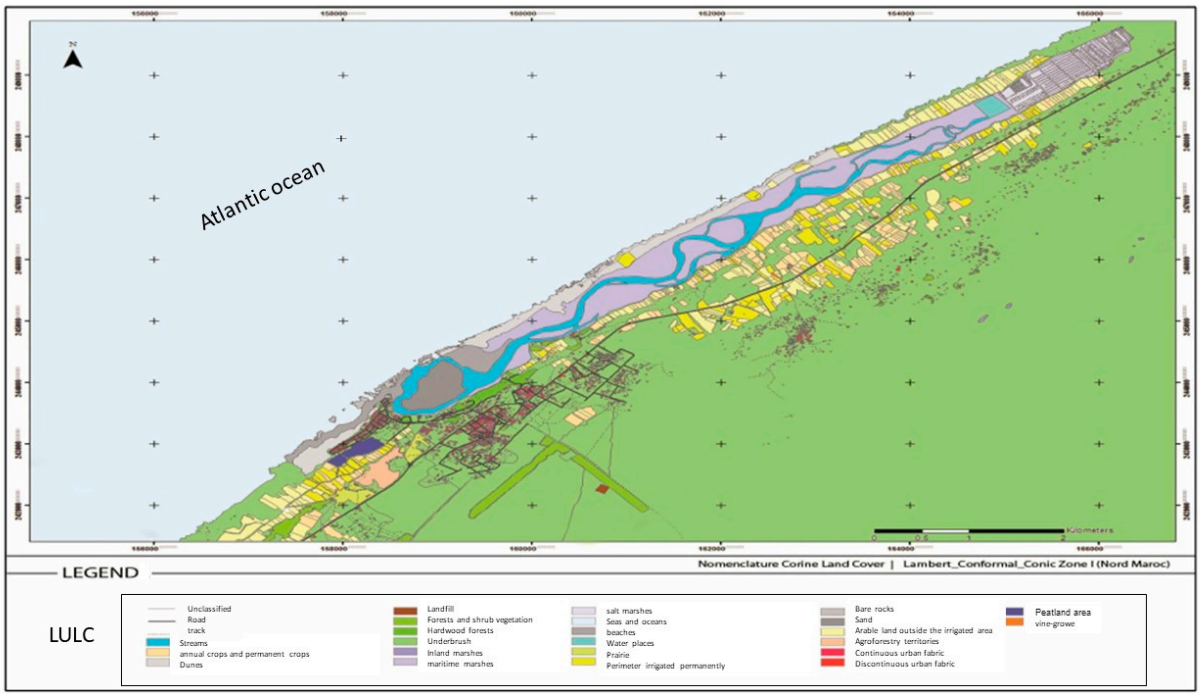

Fig.3. Classification of study areas

3.1. Assessment of ecosystem services offered by Oualidia lagoon

The supply matrix (Table 1) and map of ecosystem services offered by the Oualidia lagoon (Fig.4) show that the marine marsh, stream and the body of water are the land-use classes that offer most of the ecosystem services of supply to the population of the study area. These are services related to aquaculture, seashell collection and fishing activity. It should be noted that the income of the population of the city of Oualidia and the surrounding villages depends mainly on these sectors of activities which are practiced especially at the level of the wetland.

For the supply of cultural ecosystem services, classes representing the marine marsh, forests, moorlands and scrublands, beach, dunes and sand show the highest relevant capacity for both leisure and aesthetic values, as well as for the intrinsic values of biodiversity. In contrast, the inland marsh, continuous urban fabric and landfills do not represent any relevant capacity for cultural ecosystem services.

Table1. Assessment of ecosystem services offered by Oualidia lagoon

Type of cover LULC	Ecological Integrity							Ecosystem Supply Services							Cultural ecosystem services	
									Agriculture							
	Abiotic heterogeneity	Biodiversity	Biotic water flow	Metabolic efficiency	Exergy capture	Nutrient reduction	Storage capacity		Cultures	Livestock	Forage	Fishing	Seashell collection	Aquaculture	Leisure and aesthetic values	Intrinsic values of biodiversity
Continuous urban fabric	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
Discontinuous urban fabric	1	1	1	1	1	1	1		1	0	1	0	0	0	0	0
Road networks	2	2	0	0	0	0	0		0	0	0	0	0	0	0	0
Landfill	2	1	0	0	0	0	5		0	0	0	0	0	0	0	0
Arable land outside irrigated area	3	2	3	4	5	1	4		5	5	5	0	0	0	1	0
Perimeter irrigated permanently	3	2	5	2	5	1	3		5	5	2	0	0	0	1	0
vine-growe	3	2	3	1	3	0	2		4	0	0	0	0	0	5	0
Annual and permanent crops	2	2	3	2	4	2	3		5	5	5	0	0	0	1	0
Agriculture and natural vegetation	3	3	3	2	3	2	3		3	3	2	0	0	0	2	3
Agroforestry areas	4	4	4	3	4	4	4		3	3	2	0	0	0	3	0
Hardwood forests	3	4	5	4	5	5	5		0	0	1	0	0	0	5	5
Mixed forests	3	5	5	4	5	5	5		0	0	1	0	0	0	5	5
Natural Prairies	3	5	4	4	4	5	5		0	3	0	0	0	0	3	3
moorlands and scrublands	3	4	4	5	4	5	5		0	2	0	0	0	0	5	5
Beaches, dunes and sands	3	3	1	1	1	0	1		0	0	0	0	0	0	5	2
Bare rocks	3	3	0	0	0	0	0		0	0	0	0	0	0	4	0
Inland marshes	3	2	4	4	4	3	5		0	2	5	0	0	0	0	0
Peatlands	3	4	4	4	4	5	5		0	0	0	0	0	0	4	4
Salt marshes	2	3	4	3	3	3	5		0	2	0	0	0	0	3	0
Stream	4	4	0	3	3	3	1		0	0	0	3	3	0	5	5
body of water	4	4	0	4	4	3	4		0	0	0	3	3	0	5	4
Tidal marsh	4	4	0	5	5	3	4		0	0	0	4	4	5	5	4
Sea and ocean	2	2	0	3	3	4	1		0	0	1	5	5	5	4	2

Scale of capacity assessment

- 0 = No relevant capacity
- 1 = Low relevant capacity
- 2 = Relevant capacity
- 3 = Relevant average capacity
- 4 = High relevant capacity
- 5 = Very high relevant capacity

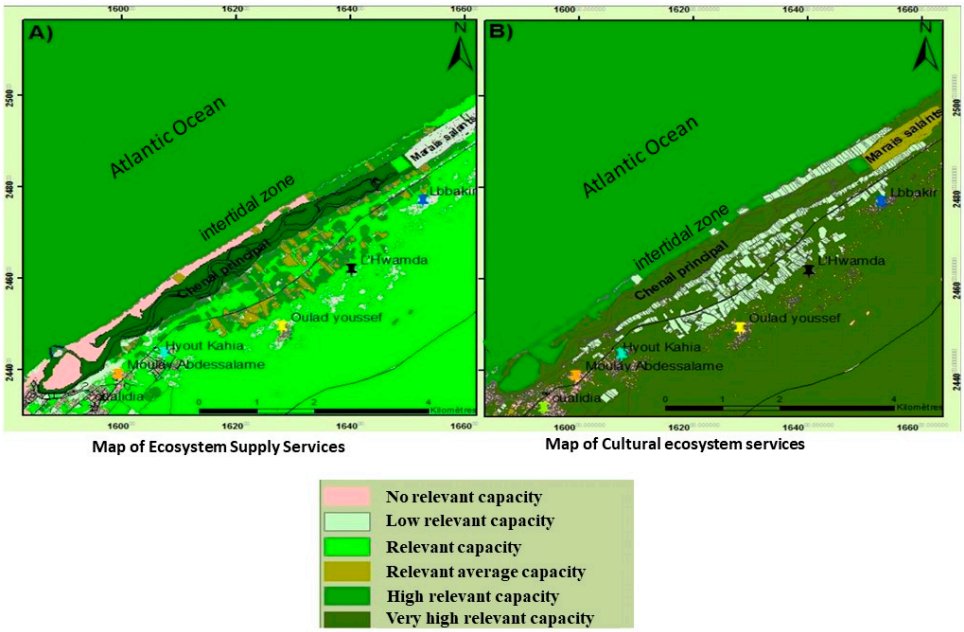

Fig.4. Maps of ecosystem services offered by Oulidia lagoon

3.2. Assessment of ecosystem services requested at Oualidia lagoon

According to Fisher et al. (2009), without human beneficiaries, ecosystem functions and processes are not services.

The maps in Figure 5 show that the highest cultural ecosystem services (right map) as well as supply (map left) are the human-dominated land use classes. Thus, the highest values are found in continuous urban tissue, discontinuous urban tissue, and road networks (Table 2).

Classes of natural land cover, such as irrigated arable land, permanently irrigated land, annual and permanent crops, agroforestry areas, Hardwood forests and mixed forests, etc. are characterized by a decrease in activities consuming ecosystem services and consequently, lower demand rates.

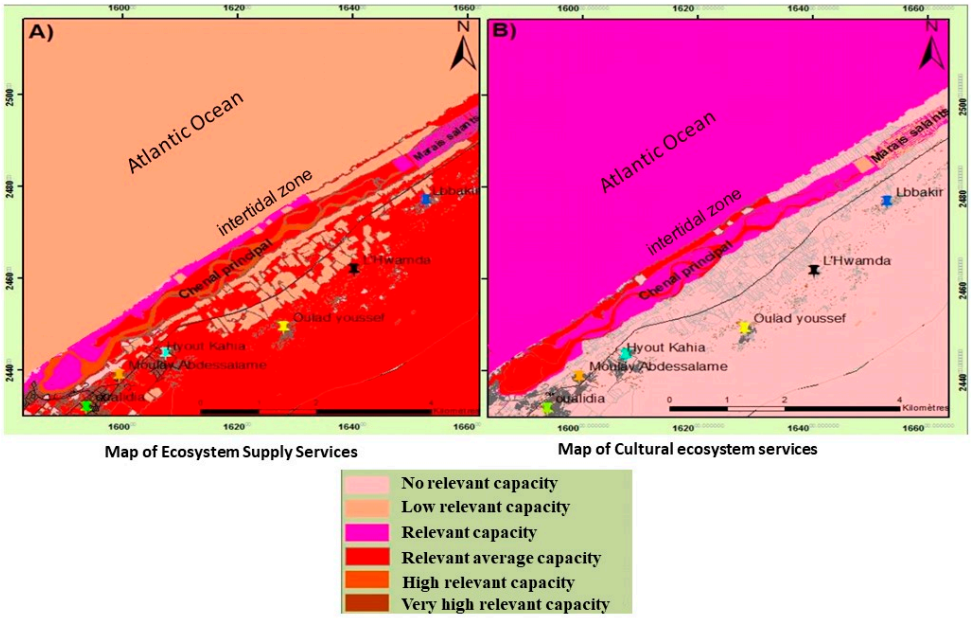

Fig.5. Maps of ecosystem services requested by Oulidia lagoon

Table 2. Assessment of ecosystem services requested at the Oualidia lagoon

Type of cover LULC	Ecosystem Supply Services	Agriculture						Cultural ecosystem services		
		Cultures	Livestock	Forage	Fishing	Seashell collection	Aquaculture		Leisure and aesthetic values	Intrinsic values of biodiversity
Continuous urban fabric		5	5	1	5	5	5		4	2
Discontinuous urban fabric		4	4	2	4	4	4		4	3
Road networks		0	0	0	0	0	0		2	0
Landfill		0	0	0	0	0	0		0	0
Arable land outside irrigated area		1	0	0	0	0	0		0	0
Perimeter irrigated permanently		1	0	0	0	0	0		0	0
vine-growe		1	0	0	0	0	0		0	0
Annual and permanent crops		1	0	0	0	0	0		0	0
Agriculture and natural vegetation		1	0	0	0	0	0		0	0
Agroforestry areas										
Hardwood forests		1	0	0	0	0	0		0	0
Mixed forests		0	0	0	0	0	0		0	0
Natural Prairies		0	0	0	0	0	0		0	0
moorlands and scrublands		0	0	0	0	0	0		0	0
Beaches, dunes and sands		0	0	0	0	0	0		0	0
Bare rocks		0	0	0	0	0	0		1	1
Inland marshes		0	0	0	0	0	0		0	0
Peatlands		0	0	0	0	0	0		0	0
Salt marshes		0	0	0	0	0	0		0	0
Stream		0	0	0	1	1	0		0	0
body of water		0	0	0	1	1	0		0	0
Tidal marsh		0	0	0	1	1	0		0	0
Sea and ocean		0	0	0	1	1	0		0	0

Scale of capacity assessment

- 0 = No relevant capacity
- 1 = Low relevant capacity
- 2 = Relevant capacity
- 3 = Relevant average capacity
- 4 = High relevant capacity
- 5 = Very high relevant capacity

3.3. Assessment of ecosystem services Budget of Oualidia Lagoon

Ecosystem services budget maps for the Oulidia lagoon have been calculated using maps of supply and demand for supply and cultural ecosystem services.

The scores obtained were grouped into classes ranging from -5 (demand exceeding supply) to 5 (supply exceeding demand) (Table 3).

The analysis of the budget maps in Figure 6 shows that the demand outpaces, significantly, supply in human-dominated land cover classes, particularly in continuous and discontinuous urban tissue, road networks and road networks. But, natural land cover classes, such as Agroforestry areas, mixed forest and moorlands and scrublands show scores approaching 5, which is explained by an offer of cultural ecosystem services exceeding demand. Similarly, the classes of Arable land outside irrigated area, Perimeter irrigated permanently, Annual and permanent crops, Tidal marsh and sea and ocean has high scores showing a supply that far exceeds the demand.

Table 3. Assessment of ecosystem services budgets at the Oualidia lagoon

Type of cover LULC	Ecosystem Supply Services	Agriculture						Cultural ecosystem services	
		Cultures	Livestock	Forage	Fishing	Seashell collection	Aquaculture	Leisure and aesthetic values	Intrinsic values of biodiversity
Continuous urban fabricc		-5	-5	-1	-5	-5	-5	-4	-2
Discontinuous urban fabric		-3	-4	-1	-4	-4	-4	-4	-3
Road networks								-2	
Landfill									
Arable land outside irrigated area		4	5	5				1	
Perimeter irrigated permanently		4	5	2				1	
vine-growe		3						5	
Annual and permanent crops		4	5	5				1	
Agriculture and natural vegetation		2	3	2				2	3
Agroforestry areas		2	3	2				3	
Hardwood forests				1				5	5
Mixed forests				1				5	5
Natural Prairies			3					3	3
moorlands and scrublands			2					5	5
Beaches, dunes and sands								4	1
Bare rocks								4	0
Inland marshes			2	5					
Peatlands								4	4
Salt marshes			2					3	0
Stream					2	2		5	5
body of water					2	2		5	4
Tidal marsh					3	3	5	5	4
Sea and ocean				1	4	4	5	4	2

Scale of capacity assessment

-5	Demand significantly exceeds supply
-4	
-3	
-2	
-1	
0	Neutral balance
1	Supply significantly exceeds demand
2	
3	
4	
5	

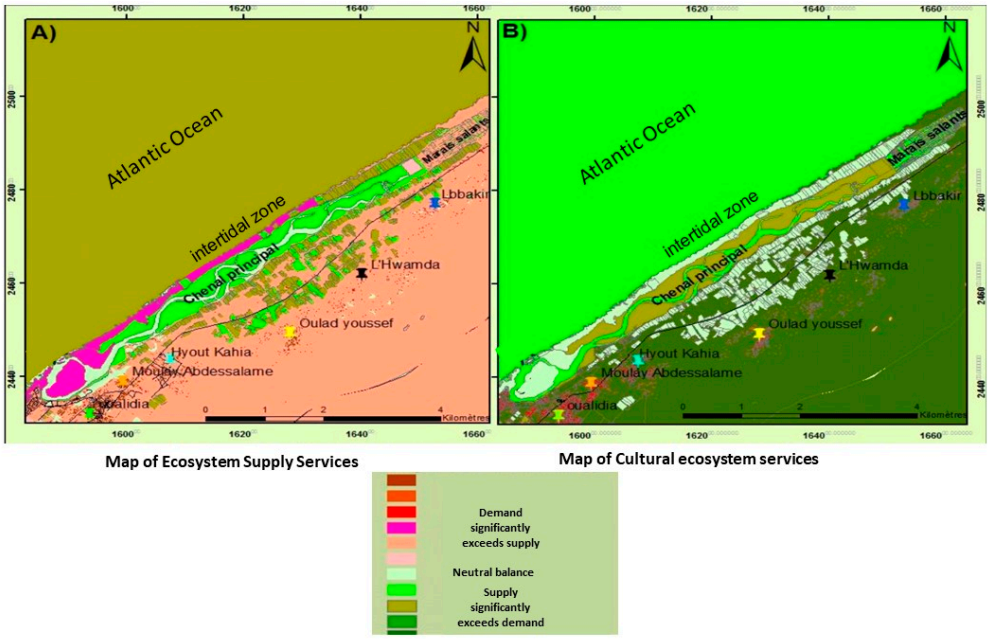

Fig.6. Maps of Ecosystem Services Budget of Oualidia Lagoon

Discussion and Conclusion

The well-being and growth of individuals, households, businesses and industries is virtually dependent on ecosystem services. Despite their importance, these services are now threatened by various pressures on marine and coastal ecosystems: overexploitation, climate change, demographic and tourist pressure, increasing urbanization, pollution, etc.

Recognizing that ecosystem services are fundamental to the survival of humankind and to its social and economic development, it is crucial to take them into account in planning and land management.

Among the richest ecosystems on the planet are wetlands, which provide multiple services that contribute to the well-being of humanity and the reduction of poverty.

The lagoon of Oualidia offers a set of eco-systemic services that constitute the source of income for the majority of the population of the municipality. They are mainly fishing, agriculture, shell collection, aquaculture and tourism. These services, provided by the lagoon's biological diversity and its geographical position on the Atlantic coast, give it the role of an attractor pole of ecological and recreational character. However, these potentialities remain limited to activities related to the beach such as: water sports, fishing and kayaking and create pressure on the underdeveloped road network.

This situation was demonstrated in this study through the assessment and mapping of ecosystem services. ES budget matrix shows positive scores for forest, river, sea, ocean, agriculture, fishing, aquaculture and negative scores for poorly developed infrastructure, such as roads and landfills.

The lagoon of Oualidia has ecosystem services whose supply exceeds the demand. The diversification of activities related to its natural landscapes and the development of infrastructure is an asset for the development of this municipality and its region.

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Index of Economic Development of Russian Regions

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Abstract. There is a large number of methodologies for assessing the state of the economy of countries and regions. Along with the estimation of economic growth, there are attempts to objectively assess the economic development of territories. Such techniques exist in our country, but its usage is mainly limited to certain regions. The article presents the continuation of research on the methodology developed by the authors for an integrated assessment of economic development and its individual components at the level of the regions of the Russian Federation with the help of the Economic Development Index (IED). This index takes into account the experience of similar techniques, but at the same time aims to minimize the number of indicators used in order to focus on the most important of them and to facilitate the interpretation of results. Calculation of the index based on selected numerical indicators which we believe are simple, and at the same time completely reflect qualitative changes in economy, development of resource potential of the region, level of personal consumption for the population, level of production of goods and services: gross regional product (GRP), value of fixed assets, foreign direct investment (FDI) and investments in fixed assets. All indicators referred to the average population. The methodology uses only indicators of official statistics, which helps to avoid distortion of subjective assessments. These results can be used to monitor changes in the level of economic development and to solve the system regional problems.

Keywords. economic index, economic development, GRP, regions of Russia, investments.

1 Introduction

Until recently, the approach to development as the achievement of economic goals was predominant. In economic theories, people were understood only as a means of production [1]. It was believed that the correlation between the well-being of the population and macroeconomic indicators is very high. Therefore, the gross domestic product per capita was one of the most important indicators for assessing the dynamics of the well-being of the population [2]. But the approach to measuring the economy is changing at the present stage of the development of science and the emphasis of research is shifting from the indicators of economic growth to the search for indicators that reflect qualitative changes. But the approach to measuring the economy is changing at the present stage of the development of science and the focus of research is shifting from the indicators of economic growth to indicators that reflect qualitative changes in the economy.

The difference between the development of the economy and its growth J. Schumpeter in his book The Theory of Economic Development explained: "Put in a row as many mail coaches as you wish, - you will not get a railroad." According to J. Schumpeter, economic growth is a quantitative change, i.e. increase production and consumption of the same goods and services over time. Economic development - positive qualitative changes in production, in products, in services, in management, in the economy as a whole, i.e. innovation [3]. Growth is purely quantitative, and development involves qualitative changes. Especially important is the assessment of economic development within the framework of the concept of sustainable development. The concept imposes certain restrictions on economic growth, primarily because of the destructive effects on the environment of uncontrolled exploitation of natural resources, both mineral and ecological. Within the concept of sustainable development, new approaches to evaluation arise. Although

GDP remains one of the most important indicators for assessing the state of the economy, today it is not enough.

2 Materials and methods

The article presents the continuation of the research on the method of integrated assessment of economic development and its separate components at the level of the regions of the Russian Federation with the help of the Economic Development Index (IED) [4] at the level of the regions of the Russian Federation. The calculation of the economic development index is based on three important indicators of economic development: regional product, the value of fixed assets and investments. Let's consider in detail the choice of indicators.

As a key indicator for measuring economic success, the volume of material and non-material goods produced in the framework of economic activity in monetary terms-gross value added, gross domestic product, gross national product and gross regional product are usually taken. The intensity of production of goods, the number of people who consume services and goods (per capita) or their production (per employed person) gives a qualitative picture of the effectiveness of using the resource potential of the territory and also serves as an indicator of the level of material well-being [5]. For the index of economic development, the gross regional product (GRP) per capita is used as the key indicator characterizing the development of the economy. This is a very inert, slowly changing indicator that takes into account the successes, failures and features of economic development over a long period of time, and the prospects for the development of the economy (cases of significant reduction in per capita output from high levels in modern history are rare) [6].

No less important indicator of national wealth and production potential (as a material basis for the successful development of the region's economy) is the value of fixed assets. First of all, fixed assets should be considered as a resource. V.T. Zhukov and I.M. Maergoiz noted that they both measured the economic power, and the base of the current reproduction process, and economic activity in the territory [7]. Fixed assets - produced assets that are to be used repeatedly or permanently for a long period (but not less than a year), for the production of goods, provision of market and non-market services [8]. In the process of operation, all elements of fixed assets wear out and lose some of their original value. Therefore, when estimating the residual value of fixed assets for the index of economic development, it is necessary to take into account depreciation using the wear coefficient. This characteristic of the state of fixed assets is rather arbitrary since the physical deterioration of objects occurs unevenly in time. However, in the period between general inventories of fixed assets, it is almost impossible to more accurately assess the level of depreciation.

Finally, perhaps the most important indicator characterizing the opportunities for qualitative changes in the economy is investments. Investments can act as one of the main factors of a positive change in the country's economy. At the same time, the individual characteristics of each of the economic entities within its territory are preserved. This can be achieved by investing specifically in those areas of the region's economy, where the greatest potential is identified. The importance of investing is confirmed by the fact that investments are concentrated in large megacities with well-developed infrastructure and in resource-rich regions, thereby improving the socio-economic situation in them [9]. In addition, investment is important in the functioning of the economy, since it represents a process of redistribution of funds from entities that own them to those in need [10]. To account for investments in the index of economic development, foreign direct investment and investment in fixed assets are used.

Investments in fixed assets directly affect the commissioning of production facilities, the growth and renewal of fixed assets and the pace of economic development. And foreign direct investment serves as an additional source of money for expansion and renewal of fixed capital, implementation of investment programs and projects that provide recovery and revival of the economy, the creation of new jobs, and saturation of the domestic market with competitive services and goods. The inflow of foreign direct investment (FDI) into the economy of any country depends on its economic condition and forecasts of the stability of its economy in the Medium term. Since they are mainly directed to the development of production, then the return from them is expected not earlier than in a few years, and for some projects, it can reach 5-8 years, especially for socially significant projects (for example, the construction of processing plants). In addition, investors are sensitive to changes in the economy and are eager to withdraw their

investments on time in the event of unfavourable conditions. Therefore, FDI is also an excellent indicator of the sustainability of economic development.

So, the Economic Development Index (IED) integrates the objective quantitative indicators of qualitative changes in the economy: gross regional product (GRP), fixed assets cost adjusted for the depreciation rate, foreign direct investment and fixed investment. The indicator of FDI was translated into rubles at the rate of the World Bank [11] and combined with the indicator of investments in fixed capital is combined into a single indicator - investments. All indicators are attributed to the average annual population. It was calculated based on the evaluation algorithm (Tikunov 1997). It includes the normalization of the system of indicators by the formula:

$$\hat{x}_{ij} = \frac{|x_{ij} - {}^{0}x_j|}{|{}_{max/min}x_j - {}^{0}x_j|}, i = 1,2,3,\dots,n; j = 1,2,3,\dots,m$$

Where ${}^{0}x$ are the worst theoretically possible values; in this study, zero values for all three indicators (the worst values for each indicator can be also used); ${}_{max/min}x$ are the most different from the ${}^{0}x$ values; n is the number of territorial units (150); m is the number of indicators used for calculations (3). All initial indicators were given equal weights. The purpose of this normalization is to translate the indicator into a deviation from the specified best or worst value.

Summation and averaging are often used for aggregating the indices. However, by averaging a few initial indicators, all information was reduced to the mean level. This approach is unreliable for evaluation. That is why when developing the methodology, the authors used a method based on calculating the Euclidean distances to the worst unit (d). It allows emphasizing the effect of individual coordinates with anomalous indicators since they are squared.

For convenience of further analysis, the obtained values were additionally normalized by the following formula:

$$\hat{d}_i = \frac{d_i - min\, d}{max\, d - min\, d}, \quad i = 1,\ 2, 3, \dots, n.$$

The value of $\hat{d}_i$ varies from zero to one, where zero represents the worst comprehensive evaluation and one is the best.

3 Results and discussion

Based on the values obtained and the separation of homogeneous steps, a map was constructed (Fig. 1). The values for the 10 leading and worst regions are presented in Table 1. Using the RGB colour triangle technique, the shares of the components of the economic development index were visualized (Fig. 2).

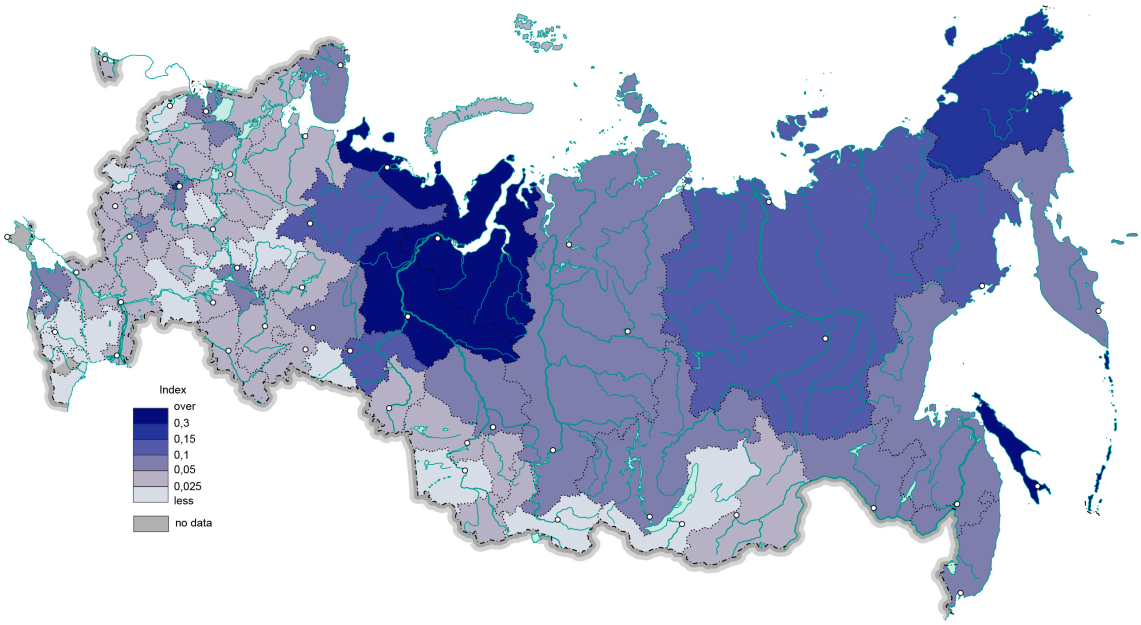

Fig. 1. Economic Development Index 2014

Table 1. IED values for 10 leading and worst regions

№	Region	Index	№	Region	Index
1	Nenets Autonomous District	0,990	73	Chuvash Republic	0,018
2	Yamalo-Nenets Autonomous District	0,758	74	Kirov region	0,017
3	Sakhalin Oblast	0,365	75	Altai region	0,016
4	Khanty-Mansiysky Autonomous District	0,300	76	Ivanovo region	0,013
5	Chukotsky Autonomous District	0,188	77	Republic of North Ossetia-Alania	0,013

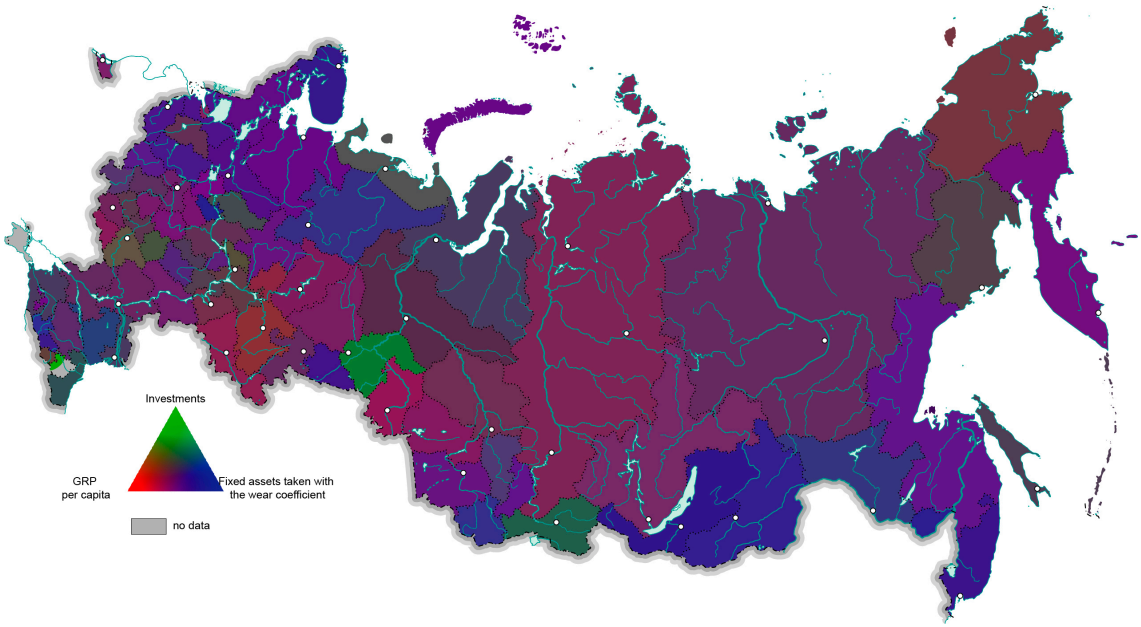

Fig. 2. The ratio of components of the index of economic development.

The calculated IED indicators, on the whole, correspond to the notions of differences in the level of economic development of Russian regions. The Russian Federation is characterized by a huge gap in economic development between the donor regions and the rest. This gap is particularly striking in the stepless scale map (Figure 3).

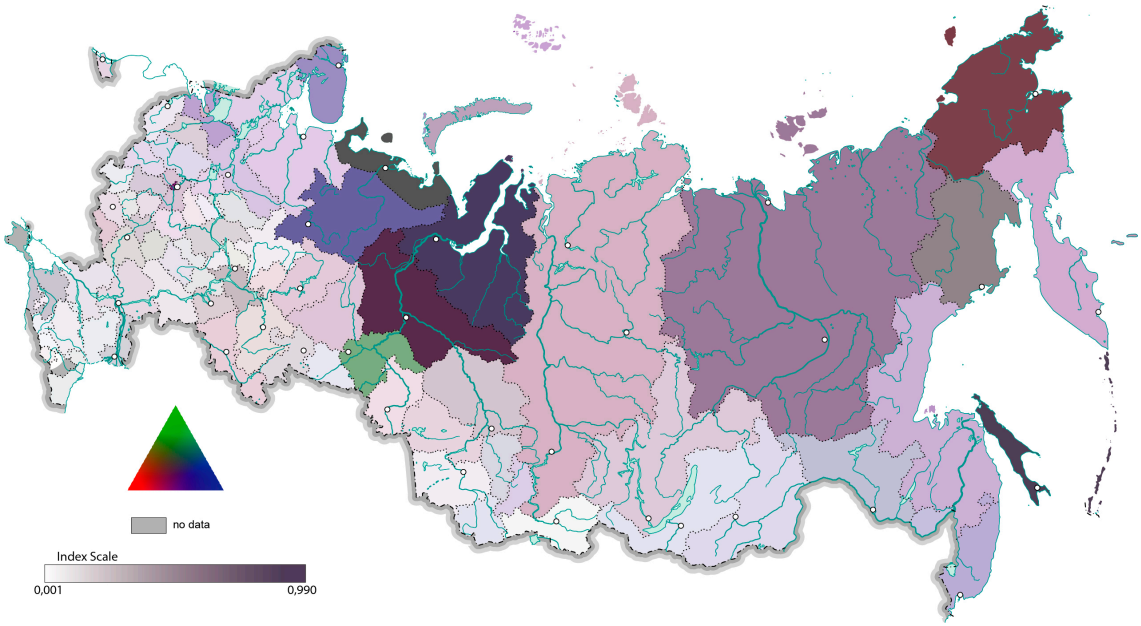

Fig. 3. Map of the ratio of components and changes in the index of economic development.

Regional differences were further aggravated by the crisis of the Russian economy. In 2014 the recession of foreign investments began, which can be called an indicator of the crisis. Investors began to withdraw more of their funds than to invest. This is clearly seen on the RGB map (Fig. 2), where blue (value of fixed assets) and red (GRP) predominate, with rare exceptions. This is in view of the fact that the indicator of investment includes not only FDI but also investments in fixed assets. Of those districts, whose foreign direct investment balance remained positive, it is possible to single out Moscow, the Tyumen region, and Sakhalin. There, the balance exceeded 3 billion dollars, and the withdrawal of funds, on the contrary, was reduced. The greatest outflow of investments in St. Petersburg, the Krasnoyarsk Territory and the Sverdlovsk region.

The first place in the IED rating is taken by the Nenets Autonomous District. This sparsely populatedregion is characterized by a huge GRP per capita (4,252,407.8 rubles, which is comparable to Norway or Qatar), the highest investment attractiveness. The economy of the region is of a mono-profile nature, and the increase in gross regional product almost completely provides oil production. It is followed by very similar in its hydrocarbon-oriented economy Yamal-Nenets Autonomous District, the Sakhalin Region, and the Khanty-Mansi Autonomous Area.

The main competitive advantage of these regions is the considerable reserves of hydrocarbon raw materials. The abundance of resources acts as a catalyst and accelerator of the growth rate of the annual volume of incoming foreign direct investment and the growth of GRP in these regions. The Chukotka Autonomous District lags behind the Khanty-Mansiysk, which is due to its mining orientation (extraction of gold, silver, tin, tungsten, mercury, coal and brown coal). Possessing a powerful resource potential, all these subjects of the federation have an undeniable advantage in the level of economic development. But their focus on oil and gas extraction determines the strong dependence of economic well-being on the conjuncture and the level of demand in the foreign market.

Moscow is below the sparsely populated and raw regions in the IED rating. It accounts for 21% of the total GRP of Russia, more than 19% of the value of fixed assets and more than 13% of all investments. Moscow is not only the core of the largest agglomeration of the country but also the capital of Russia, so its development is influenced by two factors: agglomeration and institutional, t .e. the capital status [13]. The agglomeration effect allows achieving the best economic results due to the territorial concentration of production, labour resources, reduces the costs of business and consumers.

Capital status, in turn, brings institutional advantages for development, providing a high concentration of headquarters of the largest companies, human resources and finance. The totality of these factors leads to such high indicators. In addition, much of the income is generated not in the capital itself, but in the regions in which they are actually located. In Moscow, head offices of virtually all major Russian industrial holdings are concentrated, as well as representative offices of transnational companies. High positions testify to stable fundamental prerequisites for socio-economic development.

As for the regions with the worst economic development, the absolute outsider of the rating for all used indicators was the Republic of Ingushetia. The contribution of the economy of Ingushetia to the all-Russian one is the lowest, only 0.09% of the total gross regional product (GRP) of Russia. The per capita GRP of Ingushetia is the lowest in the country after the Chechen Republic - 113 791,2 rub. per capita. The most significant source of budget revenues in the region is subsidies. At the end of 2014, taxes in the republic amounted to only 10% of all regional budget revenues. Moreover, in Ingushetia, the index of investment per capita is low (34,175.4 rubles). According to the rating agency Expert, the investment rating of the region is 3D (low potential - extreme risk) [14].

4 The conclusion

The creation of an integral index of economic development for the regions is dictated by the need to identify key indicators for their practical use from a large number of indicators. The proposed methodology shows its validity and can be used to assess and rank Russian regions according to the level of economic development. The index of economic development allows, based on official statistics, to make an analysis of economic development and comparison of subjects of the Russian Federation. Minimization of the number of indicators used for convenience and ease of application of the methodology was considered as one of the main conditions. Using the methodology allowed to classify regions by integral parameters. As a result, an analysis of the economic development of the regions of the Russian Federation for 2014 was made. Leaders of economic development and problem regions are revealed. Specific indicators that have a decisive importance in the formation of a low rating of these regions are identified.

The values of the economic development index and its dynamics can be used to assess the effectiveness of economic policy and the management of the region.

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Detailed Mapping of Land Use – Land Cover Using an Object-Oriented Classification Method on High Resolution Satellite Data: A Case Study in the Usumacinta Watershed, Mexico

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Abstract Land use is the interaction between humans and the biophysical environment with cumulative impacts on the structure, function, and dynamics of ecosystems at the local, regional, and global levels of ecological organization. Human activities that produce changes in land cover, such as agriculture, is a major cause of the ecological footprint. Land-use and land-cover changes have great effects for the environmental and socio-economic sustainability of communities that inhabit the territory. In the southeast of Mexico, the Tabasco and Chiapas states shares, one the most important hydrologic system of Mexico, the Usumacinta watershed. Historically, this watershed is continually affected by hydro meteorological phenomena, which result in landslides in the highland and floods in the lowland, which affect year after year, human settlements, productive activities and natural resources. This vulnerability condition increases in the face of global warming and to the extent that human intervention through the expansion of agriculture, which involves slash and burn, deforestation, drying of wetlands, leads to the loss and deterioration of Ecosystems, modifying the hydrological dynamics of the watershed.

The National Institute of statistic and Geography provides spatial information about land cover and use, at the national level, scale of 1:250,000. This information is not suitable for local planning purposes; this is particularly evident in the highlands, where the farming systems are set up in small plots (between one and five hectares), and therefore, by the scale limitations of the products used (LANDSAT images, 30 meters of spatial resolution), the mapping of land use and land cover on that small plots, it is no possible. In the cartography products of Landsat images, the agriculture on small plots are not mapped as a separate units, and it is mainly associated with grassland and secondary vegetation, and in a lesser proportion with primary vegetation.

The recent availability of high-resolution satellite remote-sensing images coupling with advances digital image processing techniques offers an improved opportunity to map a more detailed scale the land use and land cover, which will be an important tool to monitor the environment at local scales. In these sense it is the objective of this study, to carry out a detailed mapping of land use-land cover at the Usumacinta watershed, using an object based classification of very resolution satellite images.

To mapping agriculture areas an Object-oriented Classification Method in combination with a knowledge-based image classification, on High Resolution Spot images (spatial resolution 1.5 meters) was used. The procedure to images classification includes the following steps: Image segmentation, variables calculation, model classification design, model classification implementation, classes merge and vectorization. The results of this procedure is a classified image in vector format. Then a field work was carried out to check the land use land cover, using GPS to locate points, which allow to adjust the polygons of land use – land cover classes through of digital interpretation. Finally a cartographic generalization was carried out, considering 5000 m2 (0.5 ha) as the minimum decision area (land mapping unit) in the final cartography product.

Some of the results obtained include: a) detailed mapping of agricultural areas represented in the existing cartography as secondary vegetation for the most part and to a lesser extent as primary vegetation, b) pasture areas are discriminated against agricultural areas, c) Concern to the secondary vegetation it was possible to separate the arboreal, shrub and herbaceous vegetation.

In addition, as a result of the procedure implementation, a particular spatial patterns of land use/land cover were found. Concern to cartographic units a proposal is presented to introduce new cartographic units such as association (where two or more types of use are predominant) and consociation (where a single type of use dominates). This cartographic approach allows to make a final cartographic output more practical and more stable in the time, particularly useful in hillside areas where migratory agricultural activities are very common and cultural, leaving the land to rest for periods that can range from 6 months to 5 years.

Some applications of the final results are: a) they permit a more precise estimations on change area (loss or gain in the areal extent of specific land use land cover). This provides an indication of whether target land uses are increasing or decreasing in area over time; b) a more precise estimation of natural vegetation which lead to more precise environmental statistics, such deforestation; c) the results can be used as an indicative to implement restoration measures on natural vegetation; d) It can be an input to calculate a more precise estimations of agriculture statistic's, and finally the results can provide information about the ecological footprint of the study area. All of this aspects can guide the design and implementation of public policies about land use.

Keywords: Agriculture, land use land cover mapping, cartographic units.

1 Introduction

Land use system is the interface between society and the biophysical environment; it is concern how humans use ecosystems services provide by natural resources. Human activities that produce changes in land use - Land cover, such as agriculture, is a major cause of the ecological footprint (Etter and McAlpine, 2008). Land-use and land-cover changes have great effects for the environmental and socio-economic sustainability of rural communities (Yuan, 2008). It is also considered a central part of the functioning of the Earth system as well as reflecting human interactions with the environment at scales from local to global (Aspinall, 2008).

Land use–related research, notably for agriculture and forestry, has a long history of direct and strong application to land management. A capacity for detecting and reporting land use change is critical to evaluating and monitoring trends in natural resource conditions and the effectiveness of public investment in natural resource management. The information needs for such a synthesis are diverse; remote sensing has an important contribution to making and documenting the actual change in land use/land cover in regional and global scales (Olokeoguna, Iyiolab, and Iyiolac, 2014) and in the last decades because of availability of high-resolution satellite, at local scales. Understanding the dynamics of agricultural change (or agricultural trajectories) is an important dimension of sustainability and a necessary first step to evaluating land-management strategies in relation to local livelihoods (Dougill et al. 2001, Raquez and Lambin 2006, Fischer et al. 2008, after Paule et al., 2011).

A capacity for detecting and reporting land use change is critical to evaluating and monitoring trends in natural resource conditions and the effectiveness of public investment in their management. Land cover change occurs at different spatial scales, range from local to global geographical scales; moreover, there appears to be a gap in the available information for local decision-making process and rational planning.

In Mexico, despite ongoing mapping land use - land cover efforts; there remains a need for development of basic datasets providing quantitative and spatial land use/land cover information, mainly a detailed scale. Rates of forest loss are accelerating due to extensive grassing, subsistence agriculture and shifting cultivation. The National Institute of Statistic and Geography provides spatial information about land cover and land use, at the national level, scale of 1:250,000. This information is not suitable for local planning purposes; this is particularly evident in the highlands, where the farming systems are set up in small plots (between one and five hectares); therefore, by the scale limitations of the products used (LANDSAT images, 30 meters of spatial resolution), the mapping of land use and land cover on that small plots, it is no thinkable. In the cartography products of Landsat images, the agriculture on small plots are not mapped as a separate units, and it is mainly associated with grassland and secondary vegetation, and in a lesser proportion with primary vegetation.

The recent availability of high-resolution satellite remote-sensing images coupling with advances digital image processing techniques offers an improved opportunity to map in a more detailed scale the land use and land cover, which will be an important tool to monitor the environment at local scales. In these sense it is the objective of this study, conduct a detailed mapping of land use-land cover at the Usumacinta watershed, using high-resolution satellite images.

2. The object-oriented classification method

With the emergence of high resolution satellite images (e.g. SPOT 6-7, 1.5 meter of spatial resolution), the Earth's surface is captured in ever increasing fine detail. The metric characteristics of this satellite data are acceptable for large scale land use mapping (Xiaoxia, Jixian and Zhengjuna, 2004). High resolution remote sensing images provide more convenient and more detailed data for civil use such as land use, urban planning and environmental monitoring (Luo, Ming, Shen, Wang and Sheng, 2007). In the real-world entities (object, parcels) are associated with different classes dependent upon the resolution; they can be recognized with the best efficiency and effectiveness when the characteristics of the object are concentrated and outlined at a relevant resolution scale (Krawitz 1974, Chen and Zhao 1989, after Blumberg and Zhu, 2007).

The traditional method to classify satellite data (supervised and unsupervised classification) are based on the grey value of pixel itself, that is to say, only the spectral information is used for classification. The result will be unacceptable when classifying the VHR image data (Xiaoxia, Zhang Jixiana Liu Zhengjuna, 2004). To overcome this so-called H-resolution problem, some pixel-based methods have already been implemented (Yu et al., 2006), but the traditional per-pixel image classifiers based on a statistic relationship can no longer meet the challenges in classifying very high resolution satellite imagery (Toll, 1984; Xia, 1996, after Guo, Kelly, Gong and Liu, 2007). To solve this problem an object-oriented classification method is suggested. Object-based classification may be a good alternative to the traditional pixel based methods, to overcome the H-resolution problem and salt-and-pepper effect, it is useful to analyze groups of contiguous pixels as objects instead of using the conventional pixel-based classification unit (Yu et al, 2006).

In Object-oriented image classification, objects, parcels, and fields all refer to ground features, such as pastures, urban residential, forests, agricultural fields, rivers, lakes, roads; they all have a homogeneous composition and a set of identifiable characteristics. This objects do not refer to individual entities; instead, they are defined as contiguous regions of pixels that have a more uniform radiometric property among them than those across other regions (Gao, 2009). Object-oriented image classifiers operate on objects or group of pixels instead of individual pixels. It uses the 'image object' or 'local pixel group' as a basis; thus, the image object can take the spatial context of the pixel population into account (Blumberg and Zhu, 2007)

Instead of relying exclusively on pixel spectral information, object-oriented image classification allows inclusion of additional information such as shape, texture, size, and context derived from the relationship between adjacent pixels, as well as ancillary information (e.g., DEM data) from other object layers in the classification; thus, the image object can take the spatial context of the pixel population into account (Blumberg and Zhu, 2007, Gao, 2009).

In general, the object-oriented classification process can be divided into the two main workflow steps: multiresolution segmentation and fuzzy classification of the resulting image objects. Segmentation means the groups of neighboring pixels into regions or segments based on the similar criteria such as scale, color and form (Xiaoxia, Jixiana and Zhengjuna, 2004). Multiresolution segmentation, the first and important procedure in the eCognition software, allows the largely knowledge-free extraction of homogeneous image objects in any chosen resolution, especially taking into consideration local contrasts.

According to Gorte (1998 after Blaschke, 2000) from most studies following a segmentation approach it is argued that image segmentation is intuitively appealing; human vision generally tends to divide images into homogeneous areas first, and characterizes those areas more carefully later. Following this hypothesis, it can be argued that by successfully dividing an image into meaningful objects of the land surface, more intuitive features will result (Blaschke, 2000).

The most image classification methods have one limitation in common: they rely solely on the evidences derived from the image itself. No external knowledge is involved in the decision making. Although context is partially considered in object-oriented image classification, this evidence is not explicitly spelled out for all land covers to be mapped. The solution to overcome the above limitation lies in the incorporation of external knowledge into the classification process, namely as intelligent image analysis (Gao, 2009). The external knowledge may be derived from the image itself independently of image classification or from other data sources (digital elevation model, land use map).

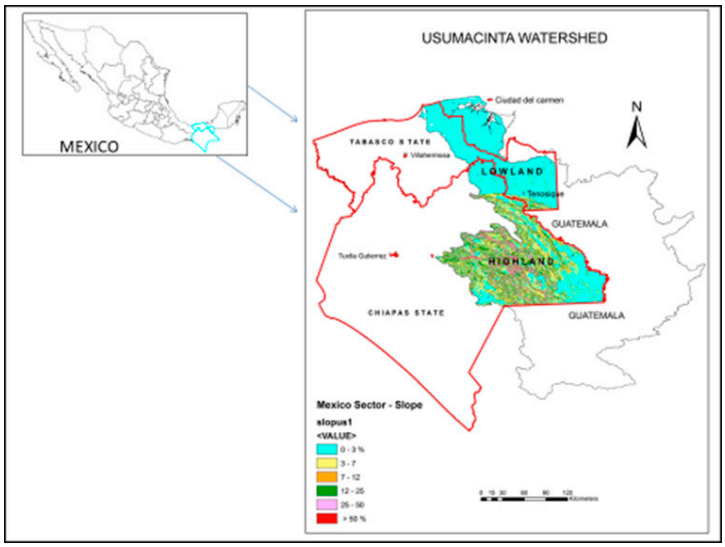
3. Method

3.1 The study area

The Usumacinta watershed, an important trans-boundary basin, encompasses 77.265 km2, from which the 43.6% is located in Mexico, 56.3% in Guatemala and 0.04% in Belize **(Fig. 1).** In Mexico is one of the most important watersheds and includes 5 municipalities of Tabasco State, 15 of Chiapas, and one of Campeche. The area has an average annual precipitation ranging from 1200 to 4000 mm; supports a population of about 1.000.000 inhabitants distributed in 5000 localities. The area includes 12 natural protected areas (8.500 km2).

In the Usumacinta watershed in Mexico the native vegetation is grouped into three main ecosystems, namely: hydric vegetation (mangroves, "popal" and "tular"), coniferous and oaks forest (includes the mountain Mesophyll Forest) and the Tropical forest Evergreen (Rzedowsky J. 1998, modification of CONABIO, 2008). The impact of human activities, mainly those related to agriculture and livestock, which in some areas date from the time of the colony has affected in a moderate to severe such ecosystems.

The watershed is constituted by two well defined sectors: Low land (low Usumacinta) and highland (Lacantun-Chijoy); in the low land the livestock is the principal activity (65%) and the crops 35%. The highland area the land cover consist of coniferous and oaks forest, mountain Mesophyll Forest and the Tropical Evergreen forest, on different stages of degradation. The land use consists of extensive livestock and annual (maize and beans) and perennial crops (coffee, oil palm). Shifting cultivation[1] which consists of various slash-and-burn methods, is one of the most widespread farming systems. It is stablished in small plots (< 5 hectares) in areas of moderate to steep land, it is dedicated to self-sufficiency with weak technology and little capital.



3.2 Methodology

The data used in this study include high-resolution and multi-spectral images (30 SPOT images of spatial resolution 1.5 meters) and as auxiliary information a digital elevation model (spatial resolution 15 meters) and Land use map (INEGI, 2016). Sentinel images (10 meters spatial resolution) was used to update land use land cover.

An object based classification method in combination with a knowledge-based image classification was used; the general procedure implemented with the software ECognition, V-8.7.2 is illustrated in figure 2.

[1] Shifting cultivation is usually defined as an agricultural system in which temporary clearings are planted for a few years with annual or short-term perennial crops, and then allowed to remain fallow for a period longer than they were cropped (Christanty, 1986). It is called by different names in different parts of the world; termed as Ladcmg in Indonesia, Caingin in Philippines, Milpa in Central America and Mexico, Ray in Vietnam, Conuco in Venezuela, Roca in Brazil, Masole in the Congo and Central Africa (Paule et al.,2011)

For each one objects resulted from the segmentation process the following variables was calculated: the mean, brightness, standard deviation and max difference for each one of the four bands. Beside the following spatial characteristics was calculated: area, lengh/amplitude, x distance to scene left border and y distance to scene right border. With these variables a decision classification model was design, considering beside auxiliary information of digital elevation model and land use map. Several champagne of field work was realized to collect information about land use land cover for checking the results of classification; based on this information an editing process by image interpretation was done to improve the classifications results. Because in the vectorization process the minimum mapping unit area considered was 0.1 hectare, finally a generalization, having account 0.5 hectares as minimum mapping unit area was done. A final process that must be done is assembling of the 30 classified images to obtain the land use and land cover map for the study area.

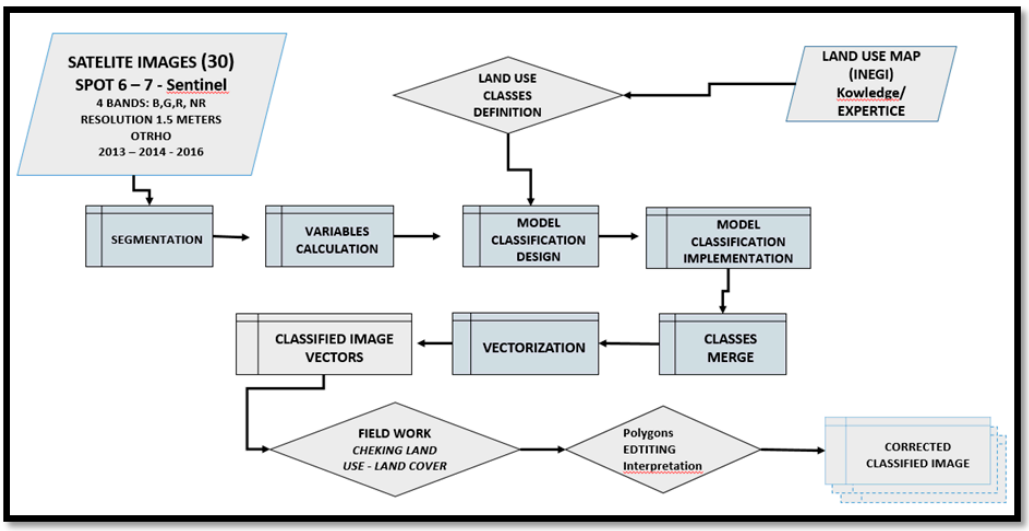


Figure 2. General procedure for image classificaction

4. Results and Discussion

The results presented here are an advance of the implementation of the methodology for the detailed cartography of land use and land cover described above. By using high resolution images it was possible discriminate and mapping agricultural and grassland areas, which in the existing cartography were represented as shrub vegetation, in most cases, and to a lesser proportion by primary vegetation. This is illustrated in figure 3 and 4, where one window of the results of object based classification (*figure 3*) is compared against the existing land use map (*figure 4*). In this last image the light green color represent shrub vegetation, which correspond in the in the classified image to a mosaic of grassland, crops and shrub vegetation.

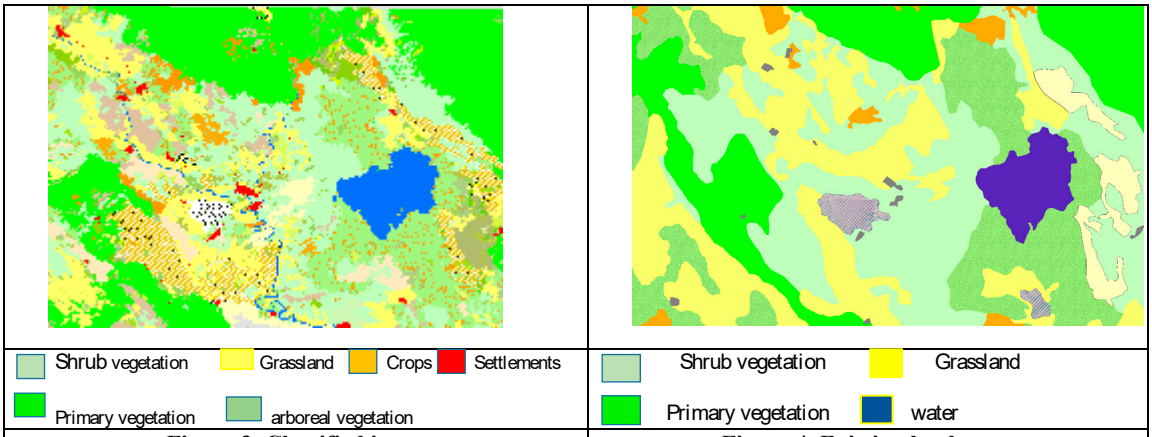


Figure 3. Classified image | **Figure 4. Existing land use map**

In the same way the grassland in the existing land use map equally correspond with a mosaic of grassland, agricultural areas and secondary vegetation. It means that in the existing land use map the crops are not mapped, on the contrary in the classified image areas of pasture are discriminated against agricultural.

Another important result was the detailed delimitation of human settlements, as is illustrated in figures 5 y 6 that correspond to classified image and existing land use map respectively. In the existing land use map (figure 6) only one settlement (grey color) is mapped against several settlements (pink color) as show in figure 5. Spite of that the radiometric information of settlement was very complex, it delineation was possible by a combination of radiometric and spatial patters, which were identified by expert knowledge. By incorporate this knowledge into classifiers improve classification accuracies (Guo, Kelly, Gong and Liu 2007).

Besides, in the classified image (figure 5) the detailed mapping can be observed as a complex mosaic that include grassland, crops, secondary and primary vegetation, which is represented in the existing land use map as unique class (agriculture, orange color). Finally, when the secondary vegetation was mapped, it was possible to separate the arboreal, shrub and herbaceous vegetation.

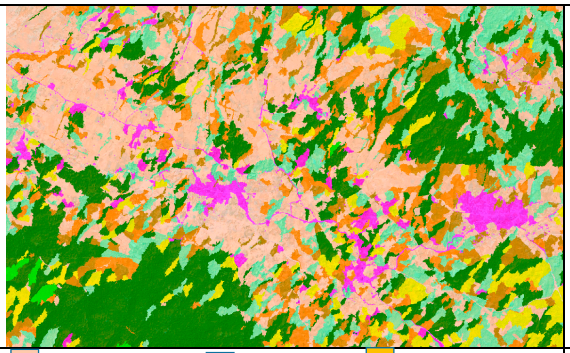


Figure 5. Classified image

Figure 6. Existing land use map

In the traditional image classification results the model of the terrain does not match with the representation of geographical objects, such as parcels and waterbodies (Fisher 1997, Stein et al. 1999). In the image object-oriented classification techniques, thanks to segmentation process that generate objects instead of pixels, this difficulty is obviated, and so , the output maps do not need to be extensively edited before they can be stored into GIS databases.

As additional improve in the final cartography can be say that one of the most regular noise that results in the classification process is the named “salt and pepper” effect, it mean the presence of several pixels caused by the lack of the spatial relationship between pixels; by segmentation, one image can be virtually reorganized by image objects, rather than pixels, within a specific resolution scale, in which certain image objects will get the best recognition (Blumberg and Zhu, 2007) therefore the mentioned noise do not appear.

The spatial expression of the shifting cultivation system is a specific spatial patterns that consist of a mosaic in constant movement, which makes that land use cartography time out quickly, therefore the authors propose use cartographic units such as *association*, where two or more types of use predominate (ex: pasture/crops, crops/pasture, perennial crops/annual crops) and *consociation*, where a single type of land use exist. This cartographic approach allows to have a final cartographic output more practical and more stable in the time.

5. Conclusions

In advance, some conclusions that can be draw from this study are:

- The use of high resolution of images to mapping land use allows to identify and discriminate more precisely the types of land cover and land use; it also allows calculate a more precise estimations on area change (loss or gain in the areal extent for different types of land use). This provides an indication of whether target land uses are increasing or decreasing in area over time. It also permit a more precise estimation of natural vegetation which lead to more precise environmental statistics.

- The results can be used as an indicative to implement restoration measures on natural vegetation and as an input to calculate a more precise estimations of agriculture statistic's, and finally the results can provide information about the ecological footprint of the study area. All of this aspects can guide the design and implementation of public policies about land use.

- The very detail provided by high resolution images and the use of advanced image analysis and processing techniques allow the association of different types of land use due to the same spatial complexity in which they are distributed (different mosaics of land use and land cover), as well as permit a major differentiation of different land use and land cover.

- Object-oriented approaches classification provides an important tool for mapping detailed land uses and land cover.

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Cartography and Geoinformation in Georgia: Past, Present and Future

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Abstract. Cartography is 3 areas (aspects) in Georgia: 1) Cartography as academic science; 2) Production and system of technological means; 3) Cartography as a disciplinary subject. The development of cartography as a science in Georgia consists of several stadiums: a) cartography in the 18th century. This stadium is connected to the name of *Vakhushti Batonishvili.* The first Georgian maps were created during this period. Vakhushti Batonishvili was composed: First atlas in 1735; The Second Atlas in 1745 and the Third Atlas in 1752, b) Cartography in the XIX century. This stadium is connected to the large-scale topographycal cartography of the Southern Frontier Zones of Georgia's coastline. In this period the so-called maps that cover most of the entire territory of Georgian. c) Cartography in the XX century. At this stadium of development the original concepts was created by cartography – the doctrine of the subject, the method and the language. The theory of cartography or metacartography was created, where semiotic aspects of map language were considered first time. Creation of these concepts is related to the name of *Alexander Aslanikashvili*. Important achievements in Georgia during this period are marked in Atlas Cartography, Georgian's Complex Atlas and several thematic Atlas were published. In the 20th century, cartography was successfully implemented by geoinformation systems. Many cartographic-geoinformation products were created. This novelty is releted to *Nikoloz Beruchashvili* in Georgia. Cartography is presented in the field of production as a field of production. Successfully is a cartographic factory, which is produced and typographically printed in various types of cartographic editions. Cartography is represented in military affairs. The Ministry of Defense of Georgia is the topography and cartography center. There are bachelor, master and doctoral programs with the use of cartography-geoinformatics. The cartography, together with topography, is also included in the professional education program in colleges. Graduates of these institutions successfully work in both state and private structures.

Keywords: Metacartography, Geoinformatics, Topography

1 Introduction

This writing presents the retrospective analysis of the development of cartography in Georgia since the XVIII century. Georgia is the cradle of the theory of cartography and, accordingly, the concept of metacartography, which in a novel way comprehended the main issues of cartography: subject, method and language. After the formation of the theoretical foundations of cartography, the process of research in this area received a new boost. The scientific school of cartographers in Georgia was founded under the leadership of Professor Alexander Aslanikashvili, and its traditions continue at the present.

The cartography in Georgia is represented by three directions: 1) Academic science; 2) Production and system of technological means; 3) Educational discipline in the education system.

2 Research

2.1. Cartography as academic science. The Cartography as a branch of science, in Georgia was born in the 18th century. In this period, its development is associated with the name of the outstanding Georgian geographer, cartographer and historian Vakhushti Batonishvili (Bagrationi). He has made three atlases, which drawing up is dated, respectively 1735, 1745 and 1752. This atlas was published in 1998 in connection with the 300th anniversary of Vakhushti Bagrationi [7]. These cartographic works, with their scientific standards, met all the requirements of European cartography. The Tbilisi Geography research institute was named in honor Vakhushi Batonishvili. Cartography as a science originates at the Tbilisi State University and at the above mentioned Institute of Geography. In the form of academic department and specialization at the university, and in the form of division at the institute.

The significant role in shaping the development of Georgian scientific cartography, was played by *Sergi Tskhakaya*. Under his leadership, topographic works were carried out: in Poland, in Manchuria, in the Caucasus, on the border of Turkey and Persia. He returned to Georgia in 1917, and since this time was managing all the topographic works carried out on the territory of Georgia.

It can be noted the activities of Professor *Andria Benashvili* in the development of Georgian cartography, topography and geodesy. He is one of the founders of the Tbilisi University and Polytechnic Institute. In 1918, he founded the chair of astronomy-geodesy and the cabinet of geodesy in the Tbilisi University. By this he laid the foundation for the study of topography and cartography. He also created the first manual on topography in Georgian. In 1924 in the Geographic Society of Georgia was opened a cartography office, which was made into the Institute of Cartography in 1928. Academician *Alexander Javakhishvili* became the director of this institute. Here also worked Sergi Tskhakaya. The first fundamental product of this institute is the 12-sheet geographical map of Georgia on a scale 1 : 200 000. The Geographic Research Institute was founded in 1933. He took upon himself the functions of the Institute of Cartography. The cartography department was the leading one of the three departments of this institute.

In 1936, the Department of Topography and Cartography was created at the Tbilisi State University. Educational materials on topography, cartography and geodesy were compiled and printed in Georgian.

The turning point (the moment) in the formation of cartography is the 70s of the XX century, which is associated with the name of the world famous theoretician - cartographer, A. Aslanikashvili. He presented the epistemological essence of cartography as a system in a new way. He processed a large triad of cartography: object, method and language, and laid the foundation for the general theory of cartography [1; 2; 3; 4].

This period in the development of the theory of cartography is known by the violent development of the cartographic concepts (Table 1**)**. Of these concepts, the leading role was assumed by the concept of A. Aslanikashvili, that he called "Metacartography" [4]. The appearance of this concept represents a kind of advance of the "performing-technical background" of cartography. The author of the concept of A. Aslanikashvili, with the term "Metacartography", identified the general theory of cartography (metatheory), which in his opinion should unite all parts (branches) of cartography into a single logical-methodological system and define his place, for this science, in the general epistemological system of sciences.

Table 1. Cartographic concepts

№	Name of concept	formation period	school of sciences (country)	Author (and)	Area recognition
1	Cartography	40s of XX	Russian (USSR)	Liodt, Salishchev	USSR
2	Metacartography	70s of XX	Georgian (Georgia)	Aslanikashvili	USSR France
3	Graph-communicative	60-70s of XX	Vienna (Austria)	Arnberger Krechmer	USSR Austria Germany
4	Cartology	60-70s of XX	Polish (Poland)	Rataysky	Poland Czechoslovakia Eastern Europe
5	Cartonomy	80s of XX	Russian (USSR)	Lyuty	USSR Eastern Europe
6	Cartosemiotic	90s of XX	Georgian (Georgia); German (Germany); Canadian (Canada)	Kekelia, Volodchenko, Schlichtmann	Georgia Eastern Europe
7	Geoiconic	90s of XX	Russian (Russia)	Berlyant	USSR Eastern Europe
8	Geoinformational mapping	90s of XX	Worldwide	–	Global

Meta-cartography is the first concept that considers cartography in the rank of natural science, which defines its basic notions (map, mapping, etc.). The foundation of this concept is a newly meaningful and defined:

1. The object of cognition of cartography - an objectively existing order of lending of objects and phenomena of nature and society (a specific space), and its change in time. Cartography reveals and "by cartographic methods transfers the structures and regularities of complex spatial systems of those objects and phenomena that are in spatial relations with each other and explains these spatial-timed mutual relations;

2. The method of cognition - the modeling of a specific space of natural phenomena and society, which implies in itself specific cartographic forms of logical methods of cognition-comparison, analysis, synthesis, abstraction, generalization and modeling;

3. Objective language of science (cartography) - the language of the map, which realizes the materialization of these logical methods of the thinking, into the cartographic forms, that participates in the modeling process;

4. Connections with dialectical materialism and with the theory of knowledge (with the help of the category of space-time), as well as links with special sciences (with the help of language and method).

The above-mentioned basic concepts and definitions create the concept of meta-cartography as the original system. The accumulated knowledge in cartography as in the system is fixed by the object language (map language) of cartography as a science in the very same maps (since a particular space can't be adequately displayed by other languages). Based on this the goal of cognitive functioning of cartography is the creation of new and new thematic maps.

In the concept of metacartography, the language of the map is defined as a specific sign system, a means of displaying new knowledge on the map, the basic form to transfer cartographic information. The language of the map contains in itself a full continuum of semiotic relations - the syntactic aspect, the sigmatic aspect, the semantic aspect and the pragmatic aspect. Logical and historical existence of a map language is defined with relative correspondence in this language, between the means of mapping of space, with the mapped space using this language.

According to the concept of metacartography, the map is the result of the cognitive mapping of a concrete space of objects of reality. It is the subjective image of the objective world, "the linguistic expression of reality" [4]. The creation of a map is an "act of penetration and objectification". A map is a specific form of transmission of relative truth, and not a conditional image. It displayed the space of objects, by the certain degree of adequacy. Two aspects of reality - space and content (the spatial and meaningful certainty of objects of reality) are displayed on the map, in dialectical unity. The information for which the map language and cartographic science exists is displayed on the map by the "Spatial behavior of signs"

Among the terms of modeling, a map is defined as a sign space-shaped model that functions both on the empirical (in the descriptive and measuring plane) and logical (with scientific interpretation) steps. The property - to transfer new knowledge (before creating yet unknown map) - the main property of the map, as a model, of the cognitive point of view. In this case, there is an objective unity, but in no case is the identification of the object of mapping and the subject of cartographic modeling implied. The subject of mapping is not the subject only for cartographic research. The subject of cartographic modeling is the specific space of the object of mapping. Based on this map is the material expression of the connections of cartography with other sciences [12; 13; 14].

The existing scientific and technical literature on cartography contains knowledge only about the method i.e. that is created and materialized already created maps. In the metacartography concept, the cartographic method and the cartographic method of scientific investigation are considered separately. The following subjects have been studied: the subject of cognition of cartography, the cartographic method of investigation, as a system of cartographic forms and the meta-language of cartography, or the language of the map. On the next stage, a whole informational arsenal of cartography was studied - the map theory (map study) and the doctrine of methods, technical methods of operation, that at this stage of the conception are represented in three interrelated parts: mathematical cartography (the theory of mapping of spatial frames of reference), Theory of the using, drawing up and editing maps (the theory of remaking of imaged objects of mapping). On the third level, are displayed relations of cartography with other sciences in two directions - geographic cartography and astronomical cartography (which for their part are divided into parts).

The research of the unity of geography and cartography is given considerable attention in the concept of meta-cartography. The logical form of the historical unity of these two sciences, the geographic role of cartography, is based on the thesis of identifying the subjects of the study of these two sciences - the spatial interrelationships of reality in the planetary space-time reference system. Each science that implements a similar connection with cartography forms a new geoscientized science that for its part fully owns new epistemological features from maternal science. Cartography by A. Aslanykashvili is not a private geographic science (as many scientists claim today), but it penetrates into all geographic sciences and in parallel is the logical and methodological basis of the systemic unity of these sciences [5].

The concept of metacartography had a great influence on the development of the theory of cartography. We can say that the ideas presented in this concept are fundamentally based in cartography. The object of cognition of cartography - "concrete space" was conducted in a deductive way, which spreads its features on any aggregate, in any frame of reference. A spatial reference system (coordinate grid) is a necessary element of the structure of a particular space. From there, a direct ontologization of the spatial model takes place. Each map displays a specific space, only because in it, the lending of the things and objects is displayed using a coordinate system. In fact, the search for a general geographic theme (subject of research) begins and ends with an analysis of the language of the map. It is not the topic of the map (it can be any) that comes out beyond the brackets, not the specific side of the objective reality (its search occurs in this process), not the map (it is the image with sign language), but namely the language of the map, as the key, with which we open each natural or socio-economic phenomenon. In this context, the design of a particular space (in a given coordinate system) is just a typical model of real-space mapping (a grammatical construction) that indicates the way the real world is displayed by means of the map language (map-text). This conclusion proves that the nonexistence of the "object-essential" limitation of cartography on the sphere of cognition [4; 14].

For explanation of the above, you can see a hypothetical example - an analogue, which, as the subject of analysis, examines the texts of a unified language. Suppose there is such a science as linguography (similar to cartography), the object language of which is a natural spoken language. Such in cartography is the language of the map, and the knowledge that it achieves about the real world is fixed in the texts of this language (as it happens on maps, in cartography). For linguography, we will ask the question - what does she perceive? And try to distinguish this pre-knowledge. This should be done in the way, as it was done by A. Aslanikashvili, with the help of a clearly realized scheme. To do this, we need to identify what is dis-

played in all the texts of a single language (past, present, future), i.e. "general theme" (as an analogy to "general cartographic ones", as it is in A. Aslanikashvili). For simplification, it is not worthwhile to pay attention to the moments of the evolution of the language.

Finding the "general text theme" turned out to be not so difficult. It is enough to indicate in general terms how the modeling of the external world takes place and the person's vision (researcher) perceives it in the structure of the language - with morphological, syntactic and pragmatic categories. For example, the noun, is always identified with the objective side of objective reality.

Thus, from the "concrete space", as from the object of cognition of cartography, there is a direct path towards the study of the language of the map, according to which A. Aslanikashvili went in his conception. The language of the map in "metacartography" is considered as the "object language of cartography" and artificially creation as one of the phenomena of the existence of cartography as a science. In the first stage this consists in allocating the language of the map as a communicative function of this science, which is a new study in theory cartography.

The concept of "meta-cartography describes such key issues of cartographic science as: The subject of cognition of science and the disclosure of the understanding of "concrete space " in interconnection with time; The internal structure of science; The epistemological essence and functions of the cartographic method of scientific research; The theory of cartographic generalization; The question of scale in cartography; The Semiotic aspects of the map language; The logical scheme of interconnection cartography with other sciences. As can be seen from the listed issues and problems in the concept of "metacartography", all questions of cartography as a logical-methodological system were fundamentally investigated. All these issues are theoretically justified in this conception, and this is the advantage of this concept in comparison with other concepts.

2.2. Cartography - production and system of technological means. In this direction, cartography, in Georgia, has been developing since the XIX century. In this period, several small cartographic companies worked in Tbilisi, which mainly dealt with the issue of large-scale military maps. In the 50s years of the XIX century, the Cartographic Factory N8 was built in Tbilisi, which is still functioning [11]. The national Atlases of Georgia were published here in 1964 and 2012 [6; 17]. There also are printed both educational, and research maps and other cartographic works. Since 80s of the XIX century, geoinformation systems (GIS) with appropriate software have been introduced in Georgia. The author of this innovation in cartography was *Nikolai Beruchashvili* [14]. The first expert geoinformation system in the Caucasus was created under his guidance (on the example of the district of Oni).

Since 1982, N. Beruchashvili headed the Department of Cartography-Geodesy and Geoinformatics of the Tbilisi State University. So he adequately continued the work of his great teacher A. Aslanikashvili. At this department, N. Beruchashvili founded a synthetic direction of cartography - landscape mapping. Almost all regional landscape researches, conducted under his leadership, were finished by drawing up large-scale landscape maps. N. Beruchashvili is the author of the landscape map of the Caucasus (1979) and the landscape-ethological map of the World (1991). He developed an electronic version of the landscape map of Georgia at a scale of 1 : 500 000. He is also the founder of the new direction at the department - dynamic cartography. The second major direction, in which N. Beruchashvili made a great contribution is geoinformatics and computer modeling. In 1995 he published his monograph "The Caucasus: Landscapes, Models, Experiments", in which all the theoretical positions and practical results of scientific research are concentrated and summarized. Under his authorship in 1993 was come out an educational book "Personal computers in geography" [8; 18]. In the field of geoinformation mapping N. Beruchashvili compiled geoinformation atlases for two regions of Georgia: Adzharia and Racha-Lechkhumi-Lower Svaneti. His publication with color computer illustrations was edited in France. These studies gave him the opportunity to conduct a number of scientific experiments: on a local, regional and global scale. In co-authorship with Russian, Armenian, Azerbaijani and French geographers, N. Beruchashvili created a unique cartographic work - the Caucasian geopolitical atlas. This cartographic work was published in 1996 in Paris in French, and in 2011 in Tbilisi in Georgian [9]. The geopolitical atlas of the Caucasus consists of five parts, in which the general geographic features, population and ethnic composition of the Caucasus are discussed.

The problem of modeling the seasonal dynamics of landscapes of the Earth has a special place in the scientific work of N. Beruchashvili. These works were accompanied by field expeditionary research, conducted in various mountain regions of our planet.

N. Beruchashvili is the author of the so-called cartographic film during the demonstration of the daily dynamics of the landscapes of Georgia, which has been introduced into dynamic mapping since 1985. The first experiments in this direction under his leadership were held at the Tbilisi State University.

In the educational process of the Department of Cartography-Geodesy and Geoinformatics, N. Beruchashvili introduced the educational disciplines of the geoinformation cycle, both in the bachelor's and in the magistracy. He investigated the matters of time scale of the cartographic form of space-time synthesis in his works. He is the founder of video computer cartography at the Tbilisi state University. Beruchashvili significantly advanced the new concept - geoinformation mapping in his works. On the basis of the Department of Cartography-Geodesy and Geoinformatics within a framework of an interuniversity agreement with the Sorbonne University, under the personal guidance of N. Beruchashvili was created a program of Georgian-French magistrature in the specialty "The dynamics of the environment." The rector of the Sorbonne University, prof. Robert Pete was invited in the Tbilisi State University on his initiative, in autumn 2005.

Table 2. Implemented profile projects

№	project name	Period acting	Region of research	Organization (donor)
1	Compiling GIS for an environmental assessment of a gypsum deposit	1993	District of Ambrolaury	Ministry of the Environment
2	Complex geoinformation atlas	1996	Autonomous Republic of Adjara	Government of Adjara Autonomous Republic
3	Geopolitecan geoinformation atlas	1996	Caucasus	Soros Foundation
4	Complex geoinformation atlas	1997	Racha-Lechkhumi and the Lower Svaneti	Soros Foundation
5	Mapping the landscape-ecological framework for the purpose of forest zoning	2000	district of Oni	World bank
6	Mapping the landscape-ecological framework for the purpose of forest zoning	2001	district of Ambrolauri	World bank
7	Mapping the landscape-ecological framework for the purpose of forest zoning	2003	district of Borjomi	World bank
8	Mapping the landscape-ecological framework for the purpose of forest zoning	2004	district of Tsagery district of Lentehki	World bank
9	Mapping the landscape-ecological framework for the purpose of forest zoning	2005	district of Mestia	World bank
10	Mapping the landscape-ecological framework for the purpose of forest zoning	2006-2007	Region of Imeretia, Region of Guria, Region of Mengrelia	World bank
11	National Atlas	2006-2009	Georgia	World bank
12	Update geinformatsion atlas	2007	Autonomous Republic of Adjara	World bank
13	Geoinformation mapping of degraded lands (by the example of Tusheti)	2013-2014	Tusheti	GEF
14	Geoinformation atlas	2018	district of Bolnisi	Municipality of Bolnisi

Annually at the department of cartography-geodesy and geoinformatics perform magistraters' graduation works on a special subject, that was developed by N. Beruchashvili.

In order to implement the forest management profile projects since 2000 in Department of Cartography-Geodesy and Geoinformatics have been began works. Under the guidance of N. Beruchashvili, a methodology was developed for compiling maps of the landscape-ecological framework for different regions of Georgia (Table 2).

Cartography is also represented in government departments. The topographic section operates in the Ministry of Defense, which includes a cartographic-geoinformation center. The service of cadastral providing enters in structure of Ministry of Justice. The service of Cartography and geodesy functions in this latter one department. The cartographic and geo-information works are also carried out in the mayor's offices of the major cities of Georgia.

The cartographic, geodetic and geoinformation works are also carried out by private firms in Georgia. Among these firms can be noted: Geographic, Geoland, Senson, Geoanalitic, Meridian, Scafis, etc.

2.3. Cartography in the educational system. Cartography is also presented in the education system. The educational program of school geography is saturated with matters of cartography, and on the other hand cartography supplies school geography by his products: maps, atlases, globes and other cartographic works. The matters of cartography are studied on three levels in the education system:

1. Secondary school;
2. Colleges;
3. Higher educational institutions.

Cartography is an educational discipline in colleges and in higher education institutions. As well, other subjects of the cartographic cycle (cartography, mathematical cartography, cartometry, thematic cartography, satellites cartography, space cartography, remote sensing) are studied at universities. The teaching materials and monographs are published on cartography and geoinformatics (Table 3) [10, 15, 16].

Table 3. Editions (literature) on cartography and geoinformatics

№	Name	Author (and)	Textbook, monograph, atlas	publication year	language
1	Topography	A.Benashvili	Manual	1933	Georgian
2	Geodesy manual	S. Tskhakaia	Manual	1951	Georgian
3	Geomorphological block diagrams	A.Aslanikashvili	Manual	1955	Georgian
4	Cartography	S. Tskhakaia	Manual	1962	Georgian
5	Atlas of the Georgian SSR	editorial board	Atlas	1964	Georgian, Russian
6	Geodesy	G. Khundzhua	Manual	1965	Georgian
7	Photogrammetry	R. Chekurishvili	Manual	1965	Georgian
8	Stereophotogrammetry	R. Chekurishvili	Manual	1967	Georgian
9	Cartography questions of general theory	A.Aslanikashvili	Manual	1968	Georgian
10	Metacareography main problems	A.Aslanikashvili	Manual	1974	Russian
11	Fundamentals of Cartography	A.Samadbegov	Manual	1977	Georgian
12	Decoding aerial photographs	R. Chekurishvili	Manual	1977	Georgian
13	Cartometry	D. Kekelia	Manual	1985	Georgian
14	Four dimensions of the landscape	N. Beruchashvili	Manual	1986	Georgian

15	The ethology of the landscape and the mapping of environmental conditions	N. Beruchashvili	Manual	1989	Russian
16	Resorts and resort resources of the Georgian SSR	editorial board	Atlas	1989	Russian
17	Cartographic heritage of Vakhushti Bagrationi	I. Matureli	Manual	1990	Georgian
18	Geophysics of the landscape	N. Beruchashvili	Manual	1990	Russian
19	Landscape science	N. Beruchashvili, N. Elizbarashvili	Manual	1992	Georgian
20	Landscape Practice at the Hospital of Martqopi	N. Beruchashvili, D. Nikolaishvili	Manual	1993	Georgian
21	Personal Computers in Geography	N. Beruchashvili	Manual	1993	Russian
22	Caucasus: landscapes, experiments, models	N. Beruchashvili	Manual	1995	Russian
23	Cartesomyotics: matters of theory of Cartographic signs	D. Kekelia	Manual	1998	Georgian
24	Geoinformation and expert systems	D. Nikolaishvili	Manual	2004	Georgian
25	map study (part 1)	T. Gordeziani	Manual	2004	Georgian
26	map study (part 2)	T. Gordeziani	Manual	2004	Georgian
27	Social and economic cartography	G. Liparteliani, G. Liparteliani	Manual	2004	Georgian
28	Fundamentals of Mathematical Mapping	D. Kekelia	Manual	2004	Georgian
29	spatial-timed analysis of landscapes of Georgia	D. Nikolaishvili	Manual	2009	Georgian
30	Geopolitical Atlas of the Caucasus	editorial board	Atlas	2011	Georgian
31	Climate and agroclimatic atlas of Georgia	editorial board	Atlas	2011	Georgian
32	National Atlas of Georgia	editorial board	Atlas	2012	Georgian
33	Methods of geographical research	D. Nikolaishvili	Manual	2012	Georgian
34	Cartographic concepts (theoretical analysis)	T. Gordeziani	Manual	2012	Georgian
35	Topography with the basics of geodesy	R. Tolordava	Manual	2013	Georgian
36	Theoretical bases of landscape cartography	T. Gordeziani	Manual	2014	Georgian
37	Fundamentals of Geographic Information Systems	Z. Laoshvili	Manual,	2018	Georgian

5 doctoral students have got their Phd for last 10 years period in cartography and geoinformatics. 8 doctoral students are studying at present, at the Tbilisi State University in the field of cartography and geoinformatics. The main directions in which the doctoral students and young scientists work are: Thematic Cartography, Historical cartography, Military cartography, Landscape cartography, Topographical cartography.

International relationships in cartography, geodesy and geoinformatics is managed by non-governmental organizations: Geographical Society of Georgia, Georgian Cartographic Association, Geodetic Society of Georgia. 12 international and 15 local scientific conferences were held for last 30 year period in Georgia in Cartography and Geoinformatics. The scientists of the cartography of Georgia accepted and take part in the work of a number of International Forums.

Conclusion

Cartography is a penetrating science for those sciences that are engaged in the study of their research subjects on a particular territory. A synthetic part of cartography - geographical cartography, is not an integral part of geography as a system, it acts as the logical and methodological basis of geographic science. Cartography in Georgia mainly develops in three directions: 1) Cartography as an academic science; 2) cartography as a production and system of technological means; 3) cartography as a teaching discipline in the educational system. The scientific basis of the Georgian cartography was laid by Vakhushti Bagrationi in the 18th century. He created the first atlases in the Georgian language, which still have not lost their scientific importance and value. The top of scientific cartography on a global scale are the scientific works of the famous Georgian scientist A. Aslikanishvili, who created the original concept of metacartography.

Professor N. Beruchashvili laid a great contribution in the development and implementation of geoinformation systems in Georgia. He created several geoinformation atlases for regions of Georgia and the Caucasus. He is the founder of geoinformatics as an educational subject in higher educational institutions of Georgia.

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The Complex Geoinformation Atlas of Kutaisi

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Abstract. The main focus of the scientific work is establishment of complex geoinformation cartographic methods of cities. The idea of creation of the complex geoinformation atlas of Kutaisi has arisen on Department of a cartography-geodesy and geoinformation science of the Tbilisi state university some years ago. For creation of a breadboard model of the atlas the softwares: Mapinfo Professional, ArcGIS, Adobe Illustrator was used. The atlas consists of five basic parts: 1. Geopolitical location and boundaries, 2. Natural conditions, 3. History and Archaeology, 4. Public Events, 5. Large-scale plan of City. The scale of maps included in it varies from 1 : 500 000 to 1 : 10 000. As bases topographical maps of different scales were used. On these maps were created vectorised maps. The contents and conventional sings of a map were developed. The last were divided into two parts: the basic (general for all maps) and thematic (for everyone separately) conventional sings. Works for improvement of substantial aspects of the atlas which mean updating the out-of-date information now are performed. The final result will be the methodology developed by the complex geo-informative cartography of cities, Kutaisi and its surrounding geoinformation system and complex atlas.

Keywords. Geoinformation Complex Atlas, Geoinformation System, Thematic Map.

1 Introduction

Creating fundamental atlases is the greatest achievement of universal science. They reflect all the fields of science on earth (and possibly even in cosmos) about ongoing events. Any kind of atlases have some important functions:

- To save accumulated information with which atlas should be used for practical purposes;
- Scientific, research and informational purposes, which's goal is to acquire new knowledge.

Considering these functions it is clear that the atlases give us opportunity of scientific generalization and drawing the conclusions and as well the possibility of independent analysis of an actual material. For this purposes atlases are the most informative, visible, concrete, comfortable to use and different from any other source. Therefore, atlases are irreplaceable for human society and their further development is an irreversible process.

Based on the history of atlas creation it is noteworthy that creating atlases of individual cities started relatively late. This process counts for several decades and duration is much far behind from the historical period of atlas creation. It is widely known that at every stage of community development were followed by the growth of cities and an important part of the Earth's population brought up in it. As a result of this process, in the modern world, most of the population is already concentrated in urban settlements. Modern city is a very difficult system which consists of many qualitatively different subsystems. Therefore, the problem of management of this very difficult system had come on the agenda. The problem could not be solved without analyzing the problem and analyzing the obtained knowledge. In this case, once again appeared the unique feature of cartography as science and as enterprise field. Cartography can interconnect many different elements of nature and society and finally form it as a united knowledge. Exactly this feature of cartography conditioned creating atlases generally and then, creating specifically cities atlases. This has contributed to the development and implementation of modern technologies. It should be noted that without using modern technologies it would be impossible to satisfy society's increased requirement.

In favor of cartography it should be said that nowadays there are lots of geographical atlases, which are different from each other with purpose, content, spatial volume and the size of format. This is caused because cartography deeply touches in different sciences research fields and with cartography it's possible to reflect any event with its spatial and time peculiarities which is characterized by the community and nature.

2 Research

The idea of creation of the Complex Geoinformation Atlas of Kutaisi has arisen on Department of a cartography-geodesy and geoinformatic science of the Tbilisi state university some years ago. About the same period began to create this satin, which has changed over time and evolved as both - content and technologically.

This is the first attempt of processing necessary methods scientifically Georgian cartographic science. It should be noted that for now, from Georgian cities there are different kinds of atlases only about Tbilisi, but none of them is complex atlas. Also, there was not processed creation of complex geoinformation atlas of the city, till today. In the process of working on the work we had to process complex geoinformation cartography methodic of the city and then, based on it, we had to gather existing information and analized it. Kutaisi is first city in Georgia which's complexive atlas was made by geoinformation cartography method (digital form), what more increases it's scientific value. Process of creating complex geoinformation atlas of Kutaisi consists of four stages:

- Discuss and analyze theoretical basics of complex cartography;
- Discuss and analyze methodological basics of complex cartography;
- Processing of researchable territory's complex geoinformation cartography atlas creation;
- Analysis of the results obtained from complex geoinformation cartography.

Below is a brief review of each stage:

1. Theoretical basics of complex cartography involves geographical atlases and main principles of their classification, role of spatiality volume and scales, thematic diversity, purpose and use, overview and analysis of different geographical atlases. Within the framework of this phase was reviewed and analyzed dozens of complex and thematic atlases. As a result, we got great knowledge about atlases.

2. Methodological basics of complex cartography is very abundant and important in it’s contents. It includes the following issues: atlases design, themes and destination determination, scoping of maps, cartographic projections of the selection, copyright, editorial, field and desk work, the creation of the potter and conditional indications system. In the same chapter we should consider using different forms of research methodology in the process of complex cartography of cities. This is cartographic generalization, cartographic forms of generalization, comparison, analysis, synthesis and modeling.

3. The third chapter involves the method of creating complex geoinformation atlas in the study area, which combines the following issues:

a) Methodological issues and internal structure of the complex geoinformation atlas of Kutaisi;

b) Complex characterization of the study area, which will be carried out in the following sequence: general information, natural conditions, history and archeology, public events;

c) Process of creating complex geoinformation atlas of Kutaisi includes all levels of mapping:
- Creation of mathematical basis;
- Identification of cartographic projections, scales and formats;

d) Creation of conditional indication system;
- Creation of general basis;
- Field decryption of the survey area;
- Creation of database;
- Drawing thematic maps;
- Preparation and publication of atlas.

For creation of a breadboard model of the atlas the softwares: Mapinfo Professional, ArcGIS, Adobe Illustrator was used.

The atlas consists of five basic parts:

- Geopolitical location and boundaries;
- Natural conditions;
- History and Archaeology;
- Public Events;
- Large-scale plan of City.

The scale of maps included in it varies from 1 : 500 000 on 1 : 10 000. They are based on various scales topographical maps. From this were created digital maps. The contents and conventional sings of a map were developed. The last were divided into two parts: the basic (general for all maps) and thematic (for everyone separately) conventional sings. Works for improvement of substantial aspects of the atlas which mean updating the out-of-date information now are performed. The final result will be the methodology developed by the complex geoinformation cartography of cities, Kutaisi and its surrounding geoinformation system and complex atlas. The complete Atlas comprises up to 50 maps that are of different content, scale and territorial integrity (Figures: 1, 2, 3, 4, 5, and 6).

4. The forth chapter will be devoted entirely to the analysis of the results obtained, which includes the following: Atlas map analysis according to the main indicators of classification, analysis of the geoinformation system and it's interrelation of maps, geoinformation system and complex atlases.

Our goal is not only to create complex geoinfomation atlas of Kutaisi but also in general development of complex geoinformation cartography methods of cities. It will be used as one of the manuals for scientists and researchers who work on this direction. Research methods which are processed in work, are basics of theoretical cartography and are part of practical and logical work.

Work has theoretical meaning for for different kinds of scientists, and as well for any person who is interested in Kutaisi. You can get important theoretical knowledge as about research territory and also generally about in the direction of scientific research of cartography and geography. Till today, no work has been published and scientifically worked out such a large volume of systematized information about Kutaisi.

Practical meaning of work is derived from its wide value, which is generally characterized by complex atlases and geoinformation systems. It can be used for cognition, for learning purpose, for better study of city infrastructure and for managing. For urban planning and for planning and organizing the work process, for social sphere monitoring, for tourism purposes and etc. Except this, on basics of our complex geoinformation atlas, it is possible to create different kinds of content operative maps and change them as needed. This method is widely used in modern, civilized world and is extremely important.

Atlas of Kutaisi should contain as many, as precise and as complete information as possible. After a certain period outdated information must be renewed. It will be easier with atlas digital form. It will be quick and easy to introduce new information than atlas created by traditional method.

Conclusion

In conclusion, we can say that develop of city's complex geoinformation cartography is irreversible process and has direct connection with modern technologies and development of modern technologies. The reason for this is that it is necessary to create a complex geoinformation atlas of any city. This promotes cartography's development as a science in this direction and the management of the city as a very difficult public system. It follows that soon a modern, civilized city without its own complex geoinformation atlas will be unimaginable.

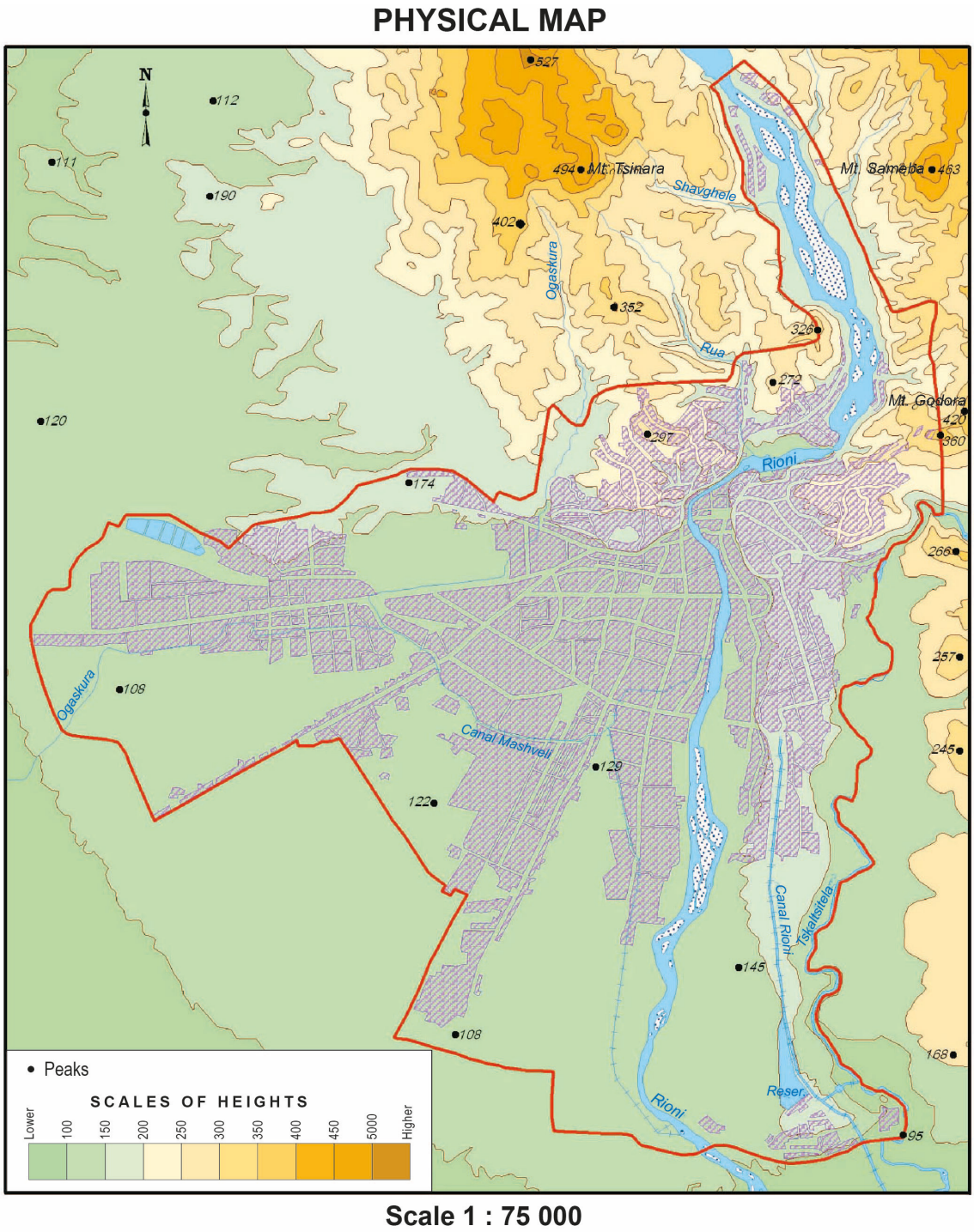

Fig. 1. Physical Map.

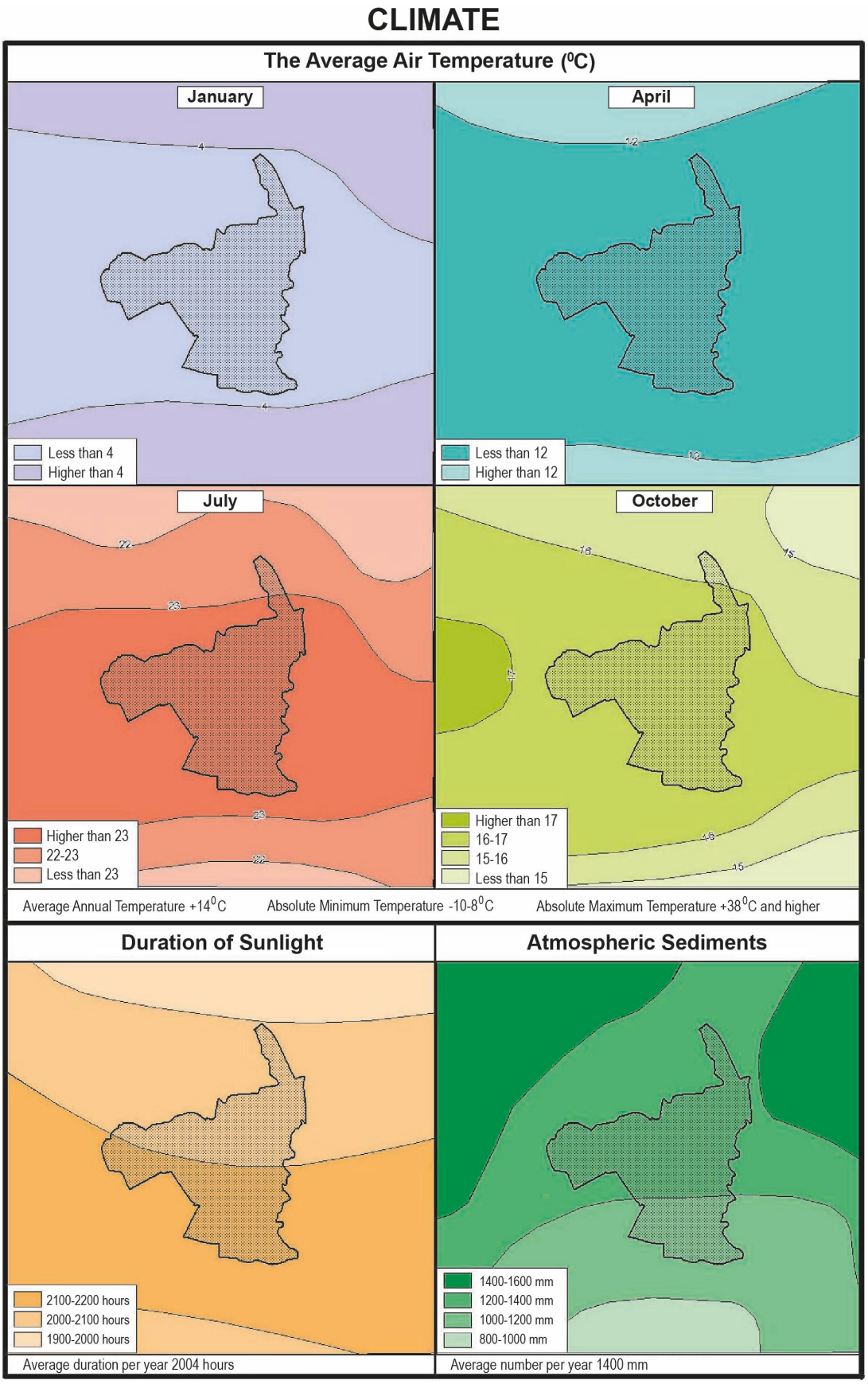

Fig. 2. Climate.

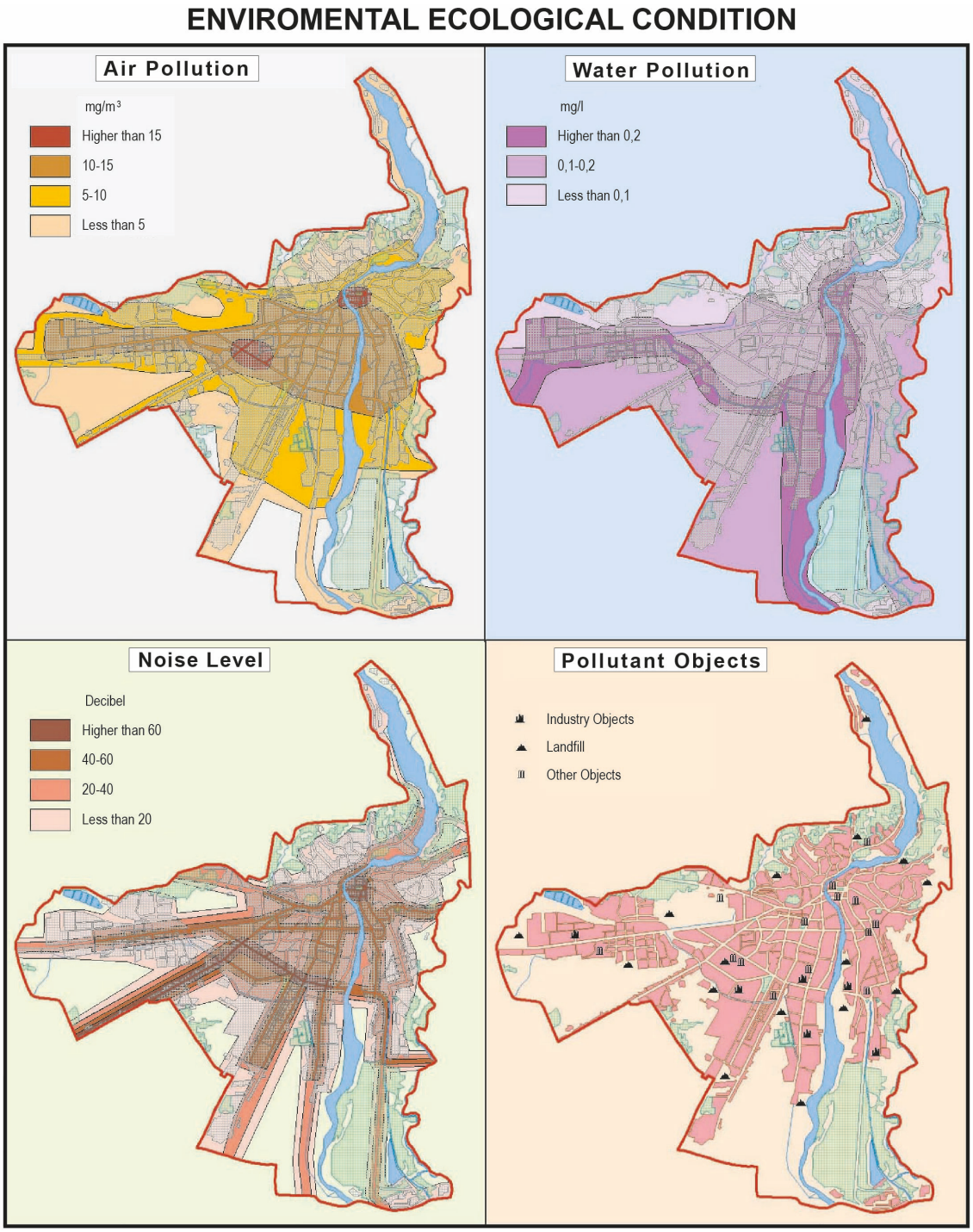

Fig. 3. Enviromental Ecological Condition.

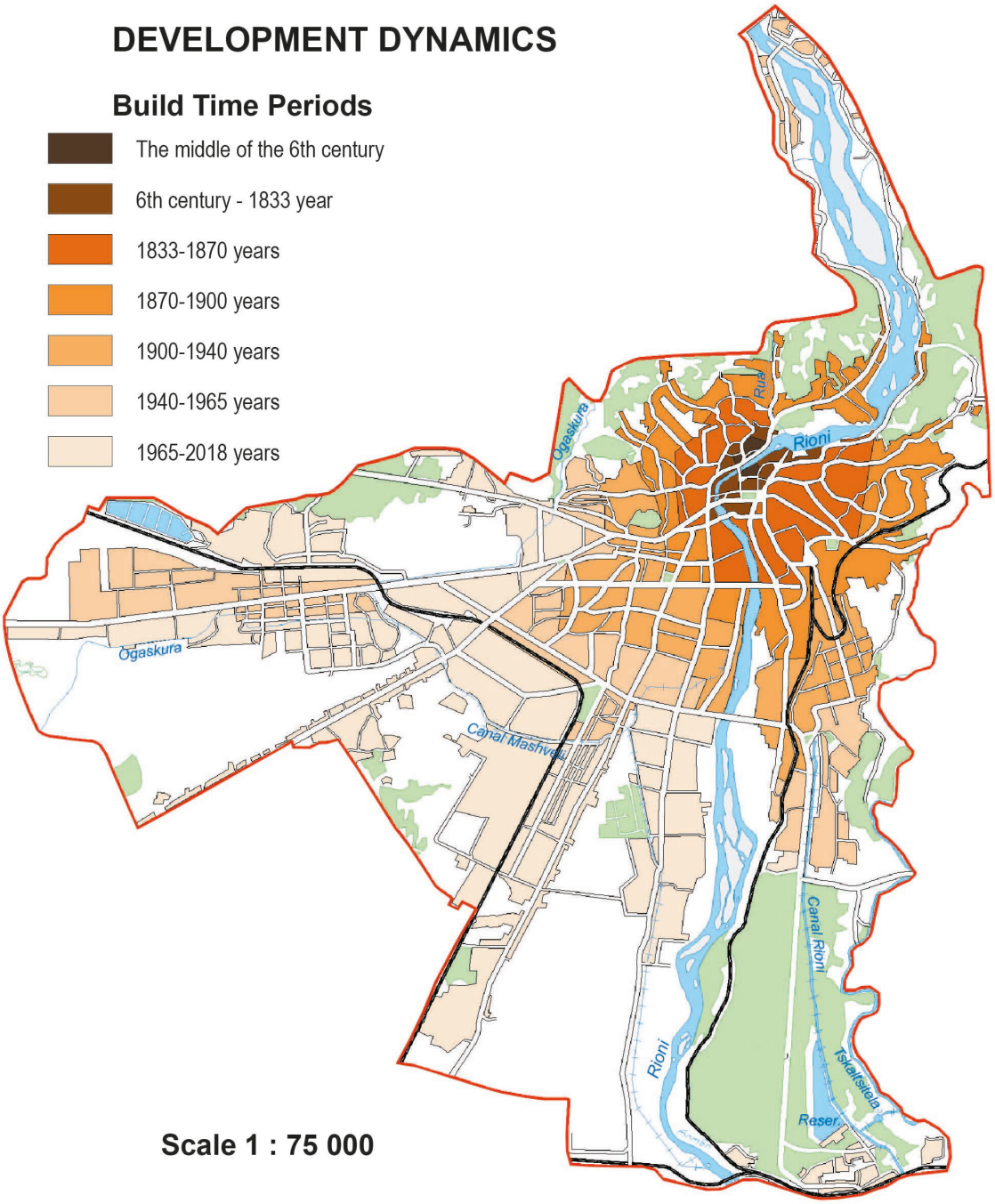

Fig. 4. Development Dynamics.

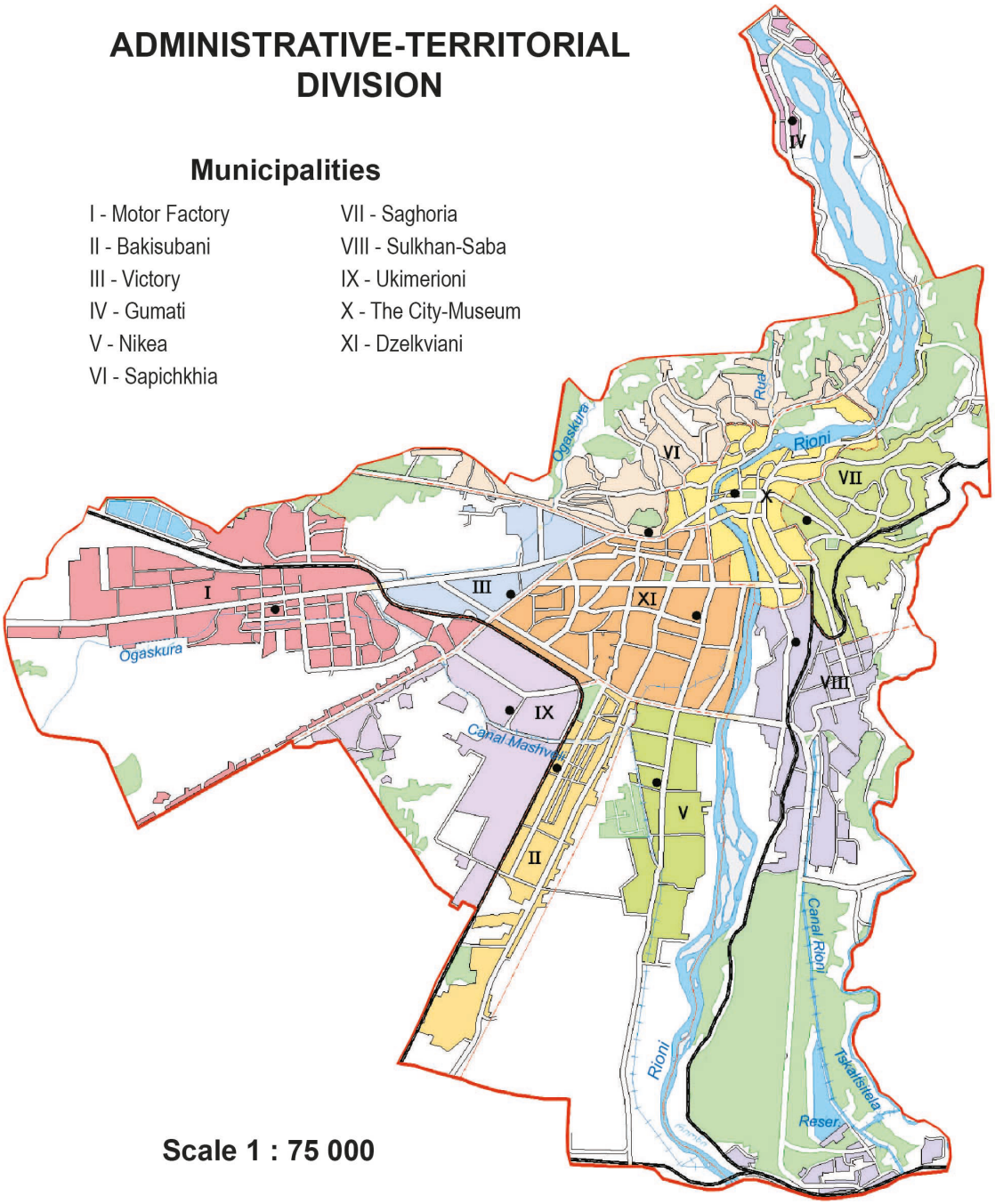

Fig. 5. Administrative-Territorial Division.

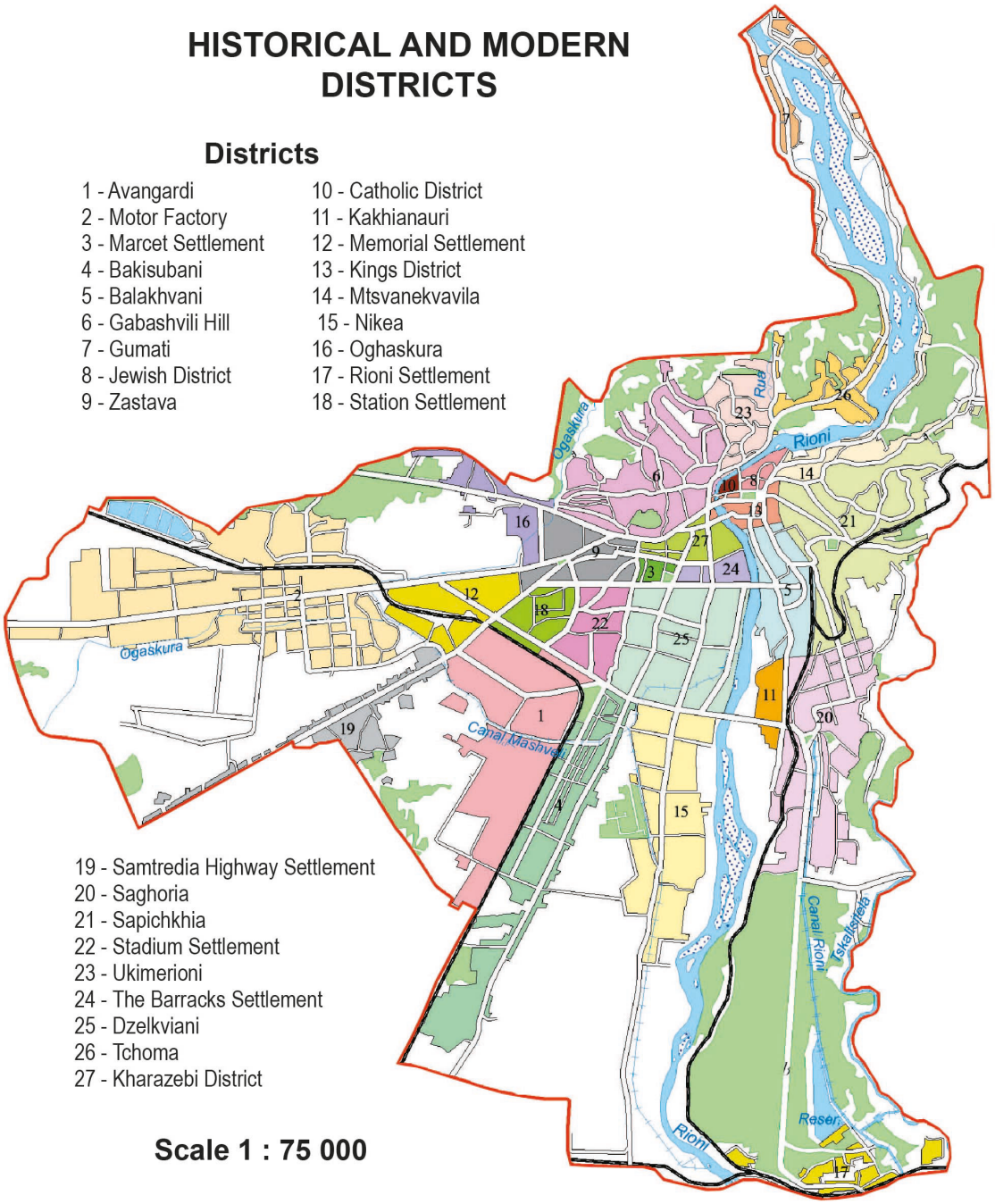

Fig. 6. Historical and Modern Districts.

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GIS in Tbilisi Water Supply Network

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Abstract. Nowadays, Popularity of GIS is increasing worldwide. A good example of it is the corporate GIS implemented by GWP - Georgian Water and Power in 2013 in Tbilisi Water Supply System. It was based on digital data of water supply and wastewater network and intellectual resource of geographical students of Tbilisi State University. Based **on** a well-established and scientifically-grounded concept, works were gradually implemented by GIS unit with GIS server.

The system significantly improved quality of water supply service. GIS system is linked to the company's billing data, dispatch, emergency service, project works and accounting. Integration has been successful; It Improved planning of the new networks. GIS became an important part of GWP's corporate information systems. Currently, Microsoft Dynamics AX (Axapta) is integrating with GIS system that will further improve the company's spatial data management process.

Keywords. Geographic Information System, Corporate Information Systems, Water Supply Network, GeoDataBase.

GIS in Tbilisi Water Supply Network

In informational century role of Geographic information system (GIS) in business management is increasing tremendously. Many company management systems are completely transferred to GIS. Information systems are the basis of any corporate geo-information system. They are mainly used for coordinated work of programs. These programs provide company employees with the information needed for the decision-making process and automation of a number of procedures.

Traditionally, corporate information systems **(IS)** were built to support specific business functions, and had thus to be developed in complete alignment with the organisation's functional breakdown. This has resulted in a wide range of systems being deployed within a single organisation, each relying on different technologies, serving a specific purpose within a specific functional area (e.g. logistics, human resources, customer relationship management, supply chain management etc) and not necessarily − communicating with neighboring applications. Early systems were often difficult to customize and/or extend, and it was practically impossible to replace or evolve parts of them. Their platform-and technology-dependency resulted in committing organisations to long term technology decisions. In cases where information exchange among systems was needed, tight coupling had to be pursued. Developing interfaces between such systems was often associated with significant technical challenges [01].

In terms of software technologies, **GIS** is not just one and several software complexes. It consists of a variety of elements that are related to each other. The general structure of GIS can be visualized as a schema [02] (Fig. 1).

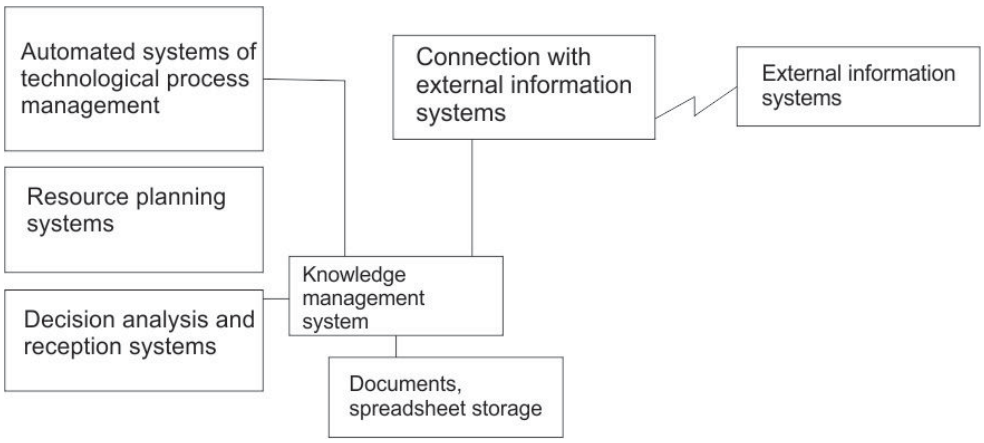


Fig. 1. Structural model of information systems

Not long ago, the organization's information provision was not conceivable for accounting information systems. Improving the company's economic development and business scale, the evolution of information technology, the introduction of WEB-technologies, the desire to automate the procedures sooner or later will necessarily lead to the implementation and development of corporate information systems (GIS) [02].

In recent years, discussions about **GIS** development are mainly about practical use of it, where spatial data analysis technologies - **GIS** is taking huge place.

In Georgia, **GIS** is more than three decades old. Recently, there is an active introduction and rapid development of corporate geo-informational systems. Water supply and sewerage systems are good example of it.

Georgian Water & Power (GWP) serves the capital of Georgia - Tbilisi and its nearby cities (Rustavi, Mtskheta, Tskneti). It is a very difficult, routine technical-intellectual work to supply water to the population. Most of them are related to spatial information processing and analysis. The GWP has inherited old system of water supply and wastewater, which causes frequent accidents. Because of the fact providing water supply to population is often interuppted and precious water resources are spent on the waste. In order to improve the situation, the company is gradually renovating old cast iron and steel pipes with polyethylene material, and implementing new technologies.

Development of the company was followed by the introduction of the geo-information system in the GWP. Also, some circumstances have also contributed to acceleration of implementing GIS. Water Supply Co-operation is a complex system of many structural units related to each other, and effective work of system is essentially determined by implementing and using information technologies. Among them **GIS** is very important. In case of GWP, several large structural units can be singled out: Administration, Water Supply system, User (customers) and Partners. They perform various works within a single business process, including complex vertical and horizontal connections, and most of them are spatial.

Years ago, GWP's activity significantly was delayed by the lack of spatial / cartographic information on the water supply and sewerage system network. The company had an incomplete compilation of old paper plans (1: 2000, 1: 5000 scale), an incomplete network in AutoCAD, and only mains-water pipelines implemented in GIS-format. Most of the information was stored in the memory of several older employees. Consequently, any form of decision making and realization was based on these data and was often performed obediently. The result was not always good. In addition, the procedures were very timely and losing effect. Obviously, all of these have been negatively impacted on the quality of working process. There were frequent and different kinds of conflicts.

In 2012, GWP decided to integrate spatial data into its **GIS** format. For this purpose, 8 staff have been prepared, who have studied ArcGIS software package. Zurab Laoshvili, an expert in Geo-Information Systems Development Foundation (GIS) in Georgia, led the study course. The process of teaching has

shown the need to introduce corporate GIS. On the grounds of surface analysis of the existing situation, the proposal was prepared in the fund, which was approved by the management of the company and ordered the introduction of **GIS** technologies.

First of all, a conceptual scheme was developed to implement and develop a corporate **GIS** (the study of expert data, technical and software design, spatial data organizing, organizing GIS server, creating consumer programe support, preparation of personnel and job creation, etc.). According to the preliminary plan schedule, the works were implemented step by step.

At the initial stage, spatial data and information technologies in the company were studied; On the grounds of analyzing spatial tasks faced by the company, the specific tasks of implementation of corporate GIS was planned.

GWP's information systems were studied:

- An informative model that represents a combination of the **GIS** functionality rules and algorithms. It includes all kinds of documents, guidelines and data (including spatial) structure.
- Rules of development and change of information model.
- Softwares that were used at **GIS** for the moment.
- Technical base (computers, peripheral devices, network, compliancy systems, databases, etc.).

The hierarchical model of GWP information system was determined (Table 1).

Table 1. Hierarchical Model of Information System

Application applied in a specific field
System services: Internet, E_mail, database management system, team work tools
Network operating systems
Transportation system Local and global network
Computers Personal, Work Station, Server, Meinfreim, Cluster

The diagram below, presents the general architecture of the planned geographic information system (GIS) and its components.

The elements of the diagram are grouped in four thematic layers: data, software, users and other information systems linked to the centralized **GIS** (Fig. 2).

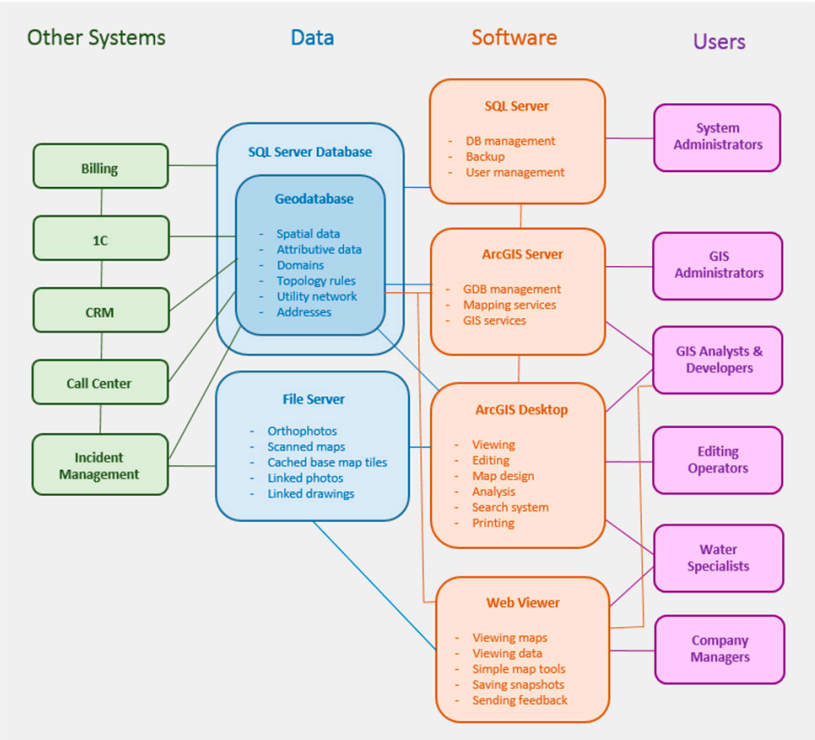


Fig. 2. System architecture

Together with company employees, the original architecture, structure and design of geometric bases was developed (Table 2).

Table 2. A fragment of the pipe attribute table.

W_PIPE			
Geometry Type	**Line**		
Name	**Type**	**Size**	**Description**
Id_Pipe	Long Int	-	Pipe identifier. OBJECTID in geodatabase.
Cod_City (**)	Short Int	-	City code. City Postal Code.
City	Text	20	City
Depth_Ini	Double	-	Initial depth, m
Depth_Fin	Double	-	Final depth, m
Land_Level_Ini	Double	-	Land level in the beginning. Complete with manhole cover level or connection element level if that is outside of manhole (meters above sea level)
Land_Level_Fin	Double	-	Land level at the end. Complete with manhole cover level or connection element level if that is outside of manhole (meters above sea level)
Diameter	Double	-	Diameter, mm
Slope	Double	-	Slope
Length	Double	-	Length, m

W_PIPE			
Material (*)	Text	2	Pipe material (iron, cast-iron, concrete, fiber cement, PVC, ceramics)
Network_Cat (*)	Text	2	Network category (main, primary, secondary, tertiary)
Inst_Date	Date	-	Element installation date
Canc_Year	Date	-	Element cancellation year
Need_Replace (*)	Text	2	Needs replacement (Yes, No, Acceptable)
Need_Repair (*)	Text	2	Needs repair (Yes, No, Acceptable)
User	Text	25	User who last edited the element
Last_Edit	Date	-	Date of last edition
Incidence	Text	255	Incident description
Remarks	Text	255	Remarks
Surveyor_Code	Text	8	Element surveyor code
Elem_Ini	Text	10	Initial element of the pipe. Code from surveyor
Elem_Fin	Text	10	Final element of the pipe. Code from surveyor

Significant task was to create jobs. It should not have been done at the expense of company employees. The GIS service was created, which was staffed by the Department of Geography at the Faculty of Exact and Natural Sciences of Tbilisi State University on the basis of bachelor's degree. They were studying different levels of **GIS** in the university and at the same time, these technologies were further enhanced in "GIS Group". The connection to the Higher Educational Institutions was a prerequisite consideration of the concept of corporate GIS.

The corporation has turned its activities almost entirely into data spatial analysis systems. The structure of geographic databases has been developed on the basis of company units and departments (dispatch, emergency, projecting, billing, etc.) and the implementation of the existing spatial information has begun. In parallel mode, high-level Topo-geodesic devices were used to identify, edit, and replace the data. The technical information on water supply and water supply facilities was entered into ISO standards data form fill up in field conditions (Fig. 3).

ავარია Wreck					(წყალმომარაგება) (Water Supply)	
ჯგუფი / Surveyor team						
მონაცემთა შეგროვების თარიღი / Date of data collection						
CRM კოდი /CRM code						
დაზიანების ტიპი / Type of the damage						
ზედაპირის საფარი / Type of surface(*)	ასფალტი Asphalt	გრუნტი Gravel	ქვაფენილი carriage-way			
	მიწა soil	ბეტონი concrete	უცნობია unknown			
გრუნტის ტიპი / Type of graound(*)		მიწა soil	მიწანარევი ღორღი shingle with soil	თიხანარევი მიწა soil with clay		
		ღორღი shingle	კლდე rock	უცნობია unknown		
გამორთვის დონე / Turn off level(*)		კარგი good	საშუალო middle	ცუდი bad	უცნობია unknown	
სხვა კომუნ. არსებ. / other comunication(*)			კი yes	არა no	უცნობია unknown	
კომუნიკაციის ტიპი / Type of comunication(*)	წყალანირება	ელექ. კაბელი elec. cabel	ბუნე. აირის მილი Gas pipe	ინტერ. კაბელი inter. Cabel		
	საჰაერო მილი air pipe	გათბ. მილი hea. pipe	ტელეფ. კაბელი telep. Cabel	საწიაღვრე storm water	უცნობია unknown	
კომუნიკაციის მანძილი დაზიანებიდან Distance from comunication to wreck						
ქსელის კატეგორია Network category(*)	მაგისტრალური main	გამანაწილებელი Distributional	წყალდენი	განშტოება branch off	უცნობია unknown	

Fig. 3. A fragment of field-filled shape field (on the example of accidents).

Field data processing and reflecting it in geographic databases were carried out together with the water specialists of different districts of Tbilisi. Improvement of the formal basis was carried out in parallel regime. The GWP's address base, which is conceptually well-processed and created on the basis of **GIS** requirements, can now be considered as the best.

Significant step was to launch the **GIS server** and implement the **GIS network**. These works were implemented by "Idea Design Group". The pilot project took place:

- Integrating information systems with **GIS server**.
- Developing analytical functionality.
- Building a search engine (search the required objects with attributes).
- Creating a Web **GIS** application.

Monitoring and dispatching of accidents, projecting new networks, hydraulic calculations, billing, management and accounting activities are managed by **GIS** systems, which greatly improved corporate solutions, network management, communication with customers and general water supplyment.

For example we will bring the wreck management system. As a result of diagnostic identification of the accident, the location of the wreck will be instantly reflected on a digital map, which results in all the objects that are not supplied with water (Fig 4, 5, 6). Given the spatial-time and logistical information (the location of the accident, the length of the damaged section, the emergency group location, the distance to the warehouse, etc.) is included in the calculation of the accident. Processed information on water termination and restoration is going on as a sms notification to the customer. The information about the customer is kept in the adress database.

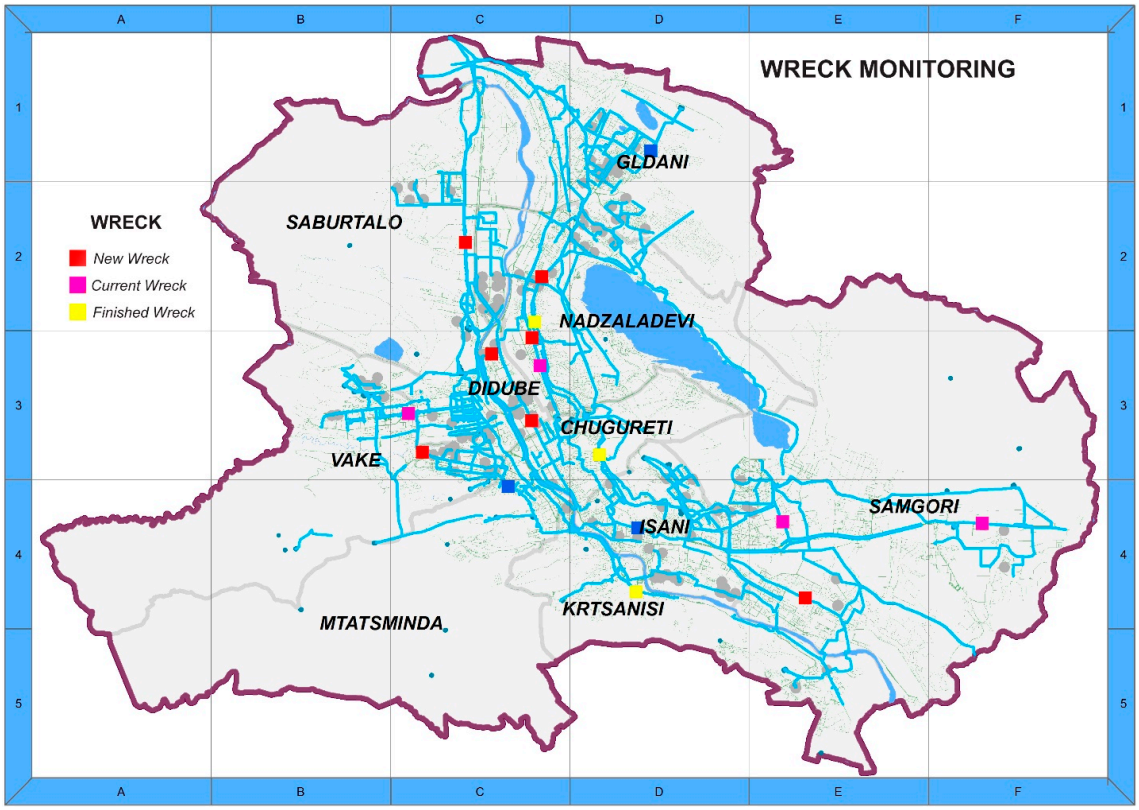
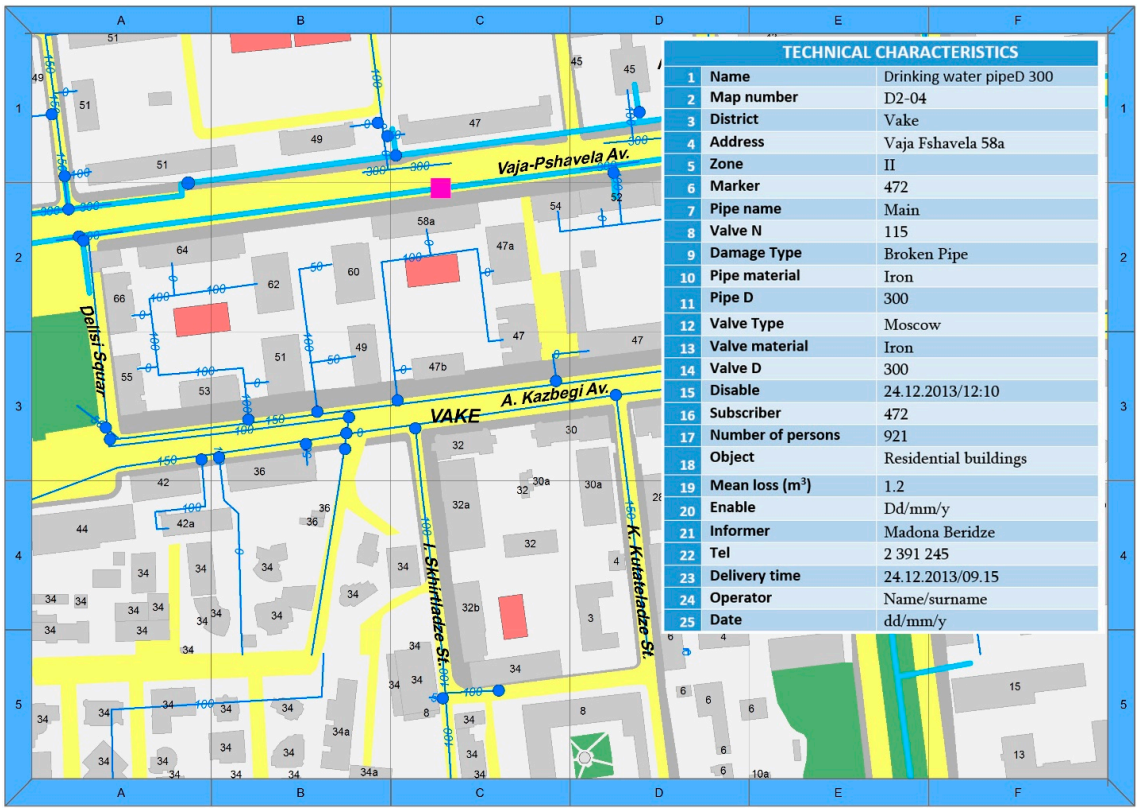


Fig 4. Monitoring of new, current and completed wreck



TECHNICAL CHARACTERISTICS		
1	Name	Drinking water pipeD 300
2	Map number	D2-04
3	District	Vake
4	Address	Vaja Fshavela 58a
5	Zone	II
6	Marker	472
7	Pipe name	Main
8	Valve N	115
9	Damage Type	Broken Pipe
10	Pipe material	Iron
11	Pipe D	300
12	Valve Type	Moscow
13	Valve material	Iron
14	Valve D	300
15	Disable	24.12.2013/12:10
16	Subscriber	472
17	Number of persons	921
18	Object	Residential buildings
19	Mean loss (m^3)	1.2
20	Enable	Dd/mm/y
21	Informer	Madona Beridze
22	Tel	2 391 245
23	Delivery time	24.12.2013/09.15
24	Operator	Name/surname
25	Date	dd/mm/y

Fig. 5. Location and technical specifications of specific wreck

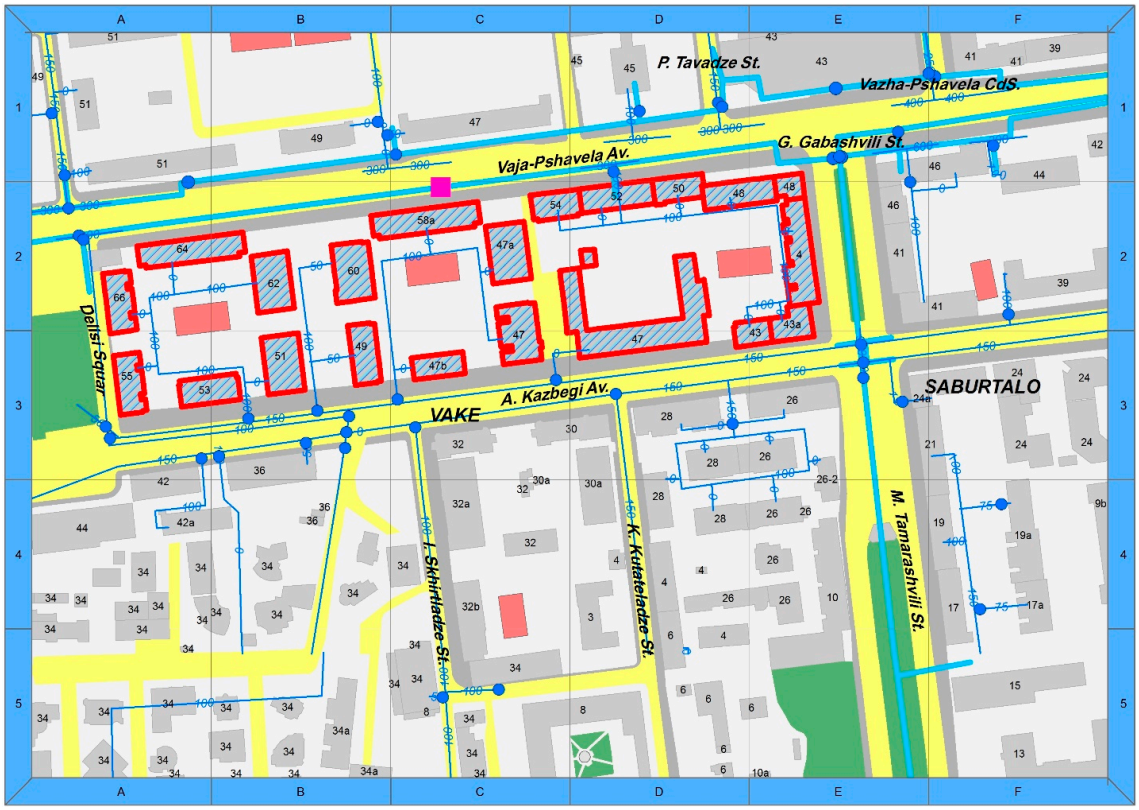


Fig. 6. Buildings, which are not supplied with water as a result of a particular accident

"Georgian Water and Powers" management is carried out according to international standards - ISO 9001. Implementation of its requirements (from 2026) The Company is obliged to be focused on improving the service constantly, increasing production, technical and technological operations, and employee's motivated actions. **GIS** has a special role in ensuring high quality works.

Maintaining Quality Management Certificate is based on continuous monitoring of the company's activities. In this direction "Georgian Water and Powers" continues implementation of planned projects and rehabilitation works to achieve the ultimate goal - uninterrupted and high quality water supply for Tbilisi population and uninterrupted operation of sewerage systems.

GIS has an important place in the rehabilitation of water supply and water supply network. The financial and spatial-time planning and monitoring of these works is carried out by Geographic Information System.

Since 2016 Microsoft has introduced the **Microsoft Dynamics AX (Axapta)** program. This is a multifunction automated system for large and small businesses. He introduced the company *"Proxima Solutions"*. Currently the axapta integration with **GIS** is in process.

Consequently, the GWP gradually implemented a well-defined conceptual scheme for the corporate **GIS**, which has significantly improved the company's activities. The **GIS** system has gradually become an important and evolving part of GIS.

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Planning-Mapping the Khertvisi Historical-Cultural Landscapes

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Abstract. The Khertvisi historical-ethnographical cultural landscape is located at the Southern Georgia, to the vill. Khertvisi of Aspindza Municipality, the confluence of the rivers Mtkvari and Paravani. This cultural landscape includes the historical monument, the most beautiful Khertvisi castle, numerous natural and cultural elements of historical heritage located at the territory adjacent to the castle. These are: ruined village, artificial terraces, ruined mill, mineral spring, water supply system and other infrastructure. By this water supply system, the gardens of fruit trees planted out at the artificial terraces were irrigated in the historical past. The castle and population of the adjacent villages were supplied with the fruits and vegetables planted here. The cultural landscape is semi-ruined but represents one united aesthetically pleasant gorgeous historical-ethnographical complex.

The neglected cultural landscape might be restored, maintaining the initial image and functional purpose, houses might be repaired in the retro style as hotels and the cultural landscape might be developed as the remarkable tourist-recreational complex.

The article refers to the issues of planning, mapping and future development of the Khertvisi historical-ethnographical cultural landscape. Study of the cultural landscape is the urgent issue from two main points of view: 1) Historical retrospective mapping and 2) application of the gained results in the territorial planning as the model of effective management of traditional natural management.

The study has been laid upon various literal and cartographic sources – as historical as up-to-date. During the field researches of 2014-2016, Khertvisi castle, the adjacent ruined villages' traces and other infrastructure have been examined, planned and mapped. According to the preliminary drafted questionnaire, the local population have been interviewed. The exact localization, type, the specific agricultural purpose, metric indices and the current state have been established.

The studies have revealed that Khertvisi areas are characterized by the abrupt and average inclination slopes, rocks where it has been very difficult to process the agricultural land, so it has been terraced. The part of terraces is destroyed today, and where they are maintained - they are not used as arable land. These locations are usually applied as hay-meadow. In the nearest past, these cultivable lands where processed ploughed, cultivated by population.

The terraces in Samtskhe-Javakheti are mainly of two types: walled (built by stone rows) and without walls. The last one is applied on the more inclined slopes and the width of its platform is wide, mainly it is applied for one-year cultures. In the Khertvisi areas, due to the large inclination of the slope, the walled terraces are built. They had been applied for multi-year plants. The fruit trees, especially vine, have been widely spread in old times.

The Khertvisi terraces, covered appr. 3km alongside to the riv. Paravani are presented at both sides of the river, at the slopes of the south, north and south-eastern exposition. It has been established that at the right embankment of the riv. Paravani, the part of terraces are almost preserved. The terraces located at the left embankment of the riv. Paravani are almost ruined.

In the riv. Paravani gorge, we have conducted the following topo-geodesic works:

1. Planning the terraces located at the left embankment of the gorge in 1:5,000 scale and determination of localization of the former ruined houses (ruins of the dwelling and auxiliary buildings) using GPS. For this purpose, to the opposite direction from the fence of the fortress of Khertvisi, tachometric walking has been held and from its standing points, the terraces, pathways, irrigating channel and ruins of the

buildings have been planned. The length of the main road constituted approximately 2,650 meter. The fall of the irrigating channel (from the source to the territory adjacent to the fortress) constitutes -17.27 m. (i=0.0065 m).

Our observations and the analyze of the situation existed on the site allows to suppose that in the case of cleaning the road, even the traffic of modern transport may be possible there and restoration of the channel is not a large difficulty. In parallel to the planning the terraces, the local geographical and other interested objects (stone works, passes on the channel etc) coordination, photographing and visual examination (establishing the measures, description).

2. Via GPS, the ruins of the existed buildings and other objects are coordinated. Their total number is several hundreds.

To revitalize the areas economically and industrially, the whole complex (castle, terraces, ruined village, ruined mill, bath-house, mineral springs, water supply system) should be given the correct functional purpose –of the historical-geographical tourist recreational complex in order to promote the social-economic progress of Samtskhe-Javakheti after the correct planning and proper management.

Keywords. Cultural Landscape, Planning, Tourist Recreational Complex

Introduction

In recent times it became obvious the significant growth in tourism flow in Georgia. Growing tourism flow and changing the ethnic composition of the population lead not only to changing the ethno-cultural environment and behavioral stereotypes. Also, in certain conditions it is the factor of the development of the tourism infrastructure of Georgia and its regions and their arrangement in compliance with the new requirements. The development of tourism infrastructure in Georgia and its regions will be based on the analysis of the processes and deep knowledge of the issue concerned.

Setting the issue

It is now clear that governing bodies in Georgia do not have a high attraction landscapes' planning for new territorial planning of tourism infrastructure, there is lack of scientifically-grounded data of the mapping system, geoinformatic instruments.

Therefore, in recent years, Georgia is paying great attention to landscape ecological mapping system [04], tourist-recreational [03], of natural [01] and historical monuments [02], [05]. Historical retrospective mapping system of tourist interesting objects and use of the results in territorial planning is very important for development of the modern level of tourism infrastructure.

The South Georgia as a distinctive touristic-recreational region, is one of the most important regions of Georgia. The Government of Georgia already undertakes significant work in improving tourism infrastructure. This is confirmed by the Rabati Fortress in Akhaltsikhe region. Rabati Fortress and its surroundings as a historic-ethnographic cultural landscape, on the basis of planning, mapping system and landscape-ecological territorial planning was restored and arranged according to modern requirements. He is now the most beautiful tourist-recreational complex and represents the source of unforgettable impressions for tourists. It should be noted that after the restoration of Rabati Fortress, the tourist flow in this region has significantly increased.

There is no doubt that the Khertvisi historic-ethnographic cultural landscape, after the restoration at the level of modern demand, along with the rocky excavated city Vardzia and other important tourist-recreational objects of the region will play an important role in the growth of tourism.

The article refers to the issues of planning, mapping and future development of the Khertvisi historical-ethnographical cultural landscape. Study of the cultural landscape is the urgent issue from two main points of view: 1) Historical retrospective mapping and 2) application of the gained results in the territorial planning as the model of effective management of traditional natural management.

The Khertvisi historical-ethnographical cultural landscape is located at the Southern Georgia, to the vill. Khertvisi of Aspindza Municipality, the confluence of the rivers Mtkvari and Paravani. This cultural landscape includes the historical monument, the most beautiful Khertvisi castle, numerous natural and cultural elements of historical heritage located at the territory adjacent to the castle. These are: ruined village, artificial terraces, ruined mill, mineral spring, water supply system and other infrastructure. By

this water supply system, the gardens of fruit trees planted out at the artificial terraces were irrigated in the historical past. The castle and population of the adjacent villages were supplied with the fruits and vegetables planted here. The cultural landscape is semi-ruined but represents one united aesthetically pleasant gorgeous historical-ethnographical complex.

The neglected cultural landscape might be restored, maintaining the initial image and functional purpose, houses might be repaired in the retro style as hotels and the cultural landscape might be developed as the remarkable tourist-recreational complex.

Materials and research methods

The study has been laid upon various literal and cartographic sources – as historical as up-to-date. During the field researches of 2014-2016, Khertvisi castle, the adjacent ruined villages' traces and other infrastructure have been examined, planned and mapped. According to the preliminary drafted questionnaire, the local population have been interviewed. The exact localization, type, the specific agricultural purpose, metric indices and the current state have been established.

Research results and their examination

The studies have revealed that Khertvisi areas are characterized by the abrupt and average inclination slopes, rocks where it has been very difficult to process the agricultural land, so it has been terraced. The part of terraces is destroyed today, and where they are maintained - they are not used as arable land. These locations are usually applied as hay-meadow. In the nearest past, these cultivable lands where processed ploughed, cultivated by population.

The terraces in Samtskhe-Javakheti are mainly of two types: walled (built by stone rows) and without walls. The last one is applied on the more inclined slopes and the width of its platform is wide, mainly it is applied for one-year cultures. In the Khertvisi areas, due to the large inclination of the slope, the walled terraces are built. They had been applied for multi-year plants. The fruit trees, especially vine, have been widely spread in old times.

The Khertvisi terraces, covered appr. 3km alongside to the riv. Paravani are presented at both sides of the river, at the slopes of the south, north and south-eastern exposition. It has been established that at the right embankment of the riv. Paravani, the part of terraces are almost preserved. The terraces located at the left embankment of the riv. Paravani are almost ruined (Fig.1).

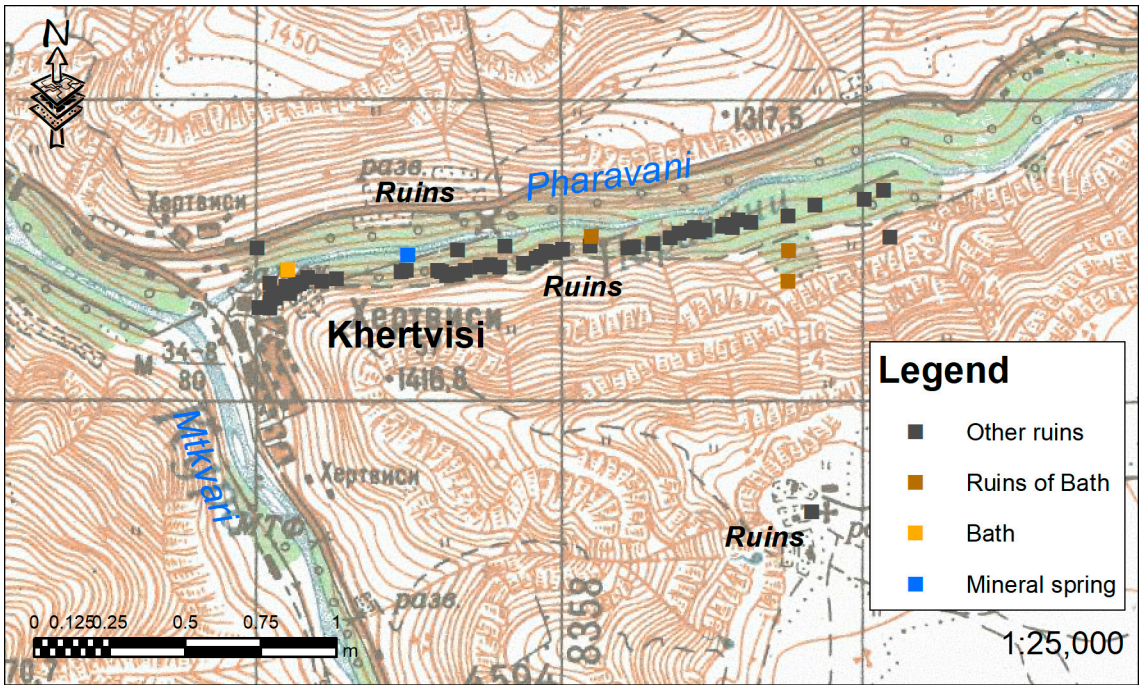

Fig. 1. Historical-cultural landscapes of Khertvisi

The irrigation channel for terraces has been wired from the river Paravani. It is still functioning and comes to Khertvisi fortress. The irrigation channel creates a dividing axis between the settlement and the agricultural area of terraces.

Terraces are located down to this channel. They are represented by different types of platforms according to the inclination of relief. The number of platforms is often up to ten, rarely more than ten. The platforms of the terraces are built of the stone fences – Darijis, the height of which is two meters above. Between the platforms there are rock stairs everywhere-a staircase is created. Staircase platforms are easily connected with each other.

Residential buildings are mostly located above the channel, although some buildings are located near the Khertvisi fortress, down to the channel. Houses are often placed on the opening of the channel. There are small stone bridges on the channel, which could be probably used for moving from the road to the channel and enter the house. In some places the stone stairs are arranged to enter the building of the house due to the height of the house. Residential buildings had one, two or three compartments, with fireplace elements, hobs, narrow windows. They resemble dugout houses. Several houses sometimes create one quarter and are fenced with stone-fence.

There was a mill with several compartments at the stream from the river Paravani. The ruining of the building and mill stone are still in place. In 1952, a small hydroelectric power plant was built on the right embankment of the river Parvani near the mill, which is still functioning.

Near Khertvisi fortress, on the right embankment of the river Paravani there is a twin-dome building, which was once a bath house. Today it is left without any function.

There are a lot of cultural ruins on the whole territory of the irrigation channel, stone extractors, Satsnakhelis and so on. They probably belonged to the house owners.

Below to terraces, on the left embankment of the river Paravani there is a mineral spring. Its debate is small but has a great demand. Every day you will meet with people from Aspindza, Akhalkalaki, Akhaltsikhe, sometimes from Batumi, who take mineral water with a large reservoirs.

Earlier, an youth camp was arranged in Khertvisi fortress. Today this area is destroyed. However, the castle does not have a bad appearance.

In the riv. Paravani gorge, we have conducted the following topo-geodesic works:

1. Planning the terraces located at the left embankment of the gorge in 1:5,000 scale and determination of localization of the former ruined houses (ruins of the dwelling and auxiliary buildings) using GPS. For this purpose, to the opposite direction from the fence of the fortress of Khertvisi, tachometric walking has been held and from its standing points, the terraces, pathways, irrigating channel and ruins of the buildings have been planned. The length of the main road constituted approximately 2,650 meter. The fall of the irrigating channel (from the source to the territory adjacent to the fortress) constitutes -17.27 m. (i=0.0065 m).

Our observations and the analyze of the situation existed on the site allows to suppose that in the case of cleaning the road, even the traffic of modern transport may be possible there and restoration of the channel is not a large difficulty. In parallel to the planning the terraces, the local geographical and other interested objects (stone works, passes on the channel etc) coordination, photographing and visual examination (establishing the measures, description).

2. Via GPS, the ruins of the existed buildings and other objects are coordinated (Table 1.). Their total number is several hundreds.

Table 1. Geographical coordinates, absolute height and number of the objects located nearby the Khertvisi Fortress

N	Name of objects Geographical coordinates	Name of objects Geographical coordinates		Absolute Height H	Points
		f	λ		
1	Ruins (yard and house ruin)	41°28′779	043°17′252	1163	1
2	„ - -“	41°28′788	043°17′247	1160	1
3	„ - -“	41°28′805	043°17′238	1148	1
4	„ - -“	41°28′800	043°17′277	1157	1
5	„ - -“	41°28′800	043°17′283	1160	1
6	„ - -“	41°28′800	043°17′292	1160	1
7	„ - -“	41°28′802	043°17′300	1162	1
8	„ - -“	41°28′805	043°17′308	1161	1
9	„ - -“	41°28′808	043°17′315	1160	1
10	„ - -“	41°28′816	043°17′328	1158	1
11	Ruins (the right side of the filed road)	41°28′787	043°17′286	1170	5
12	Ruins (the left side of the filed road)	41°28′810	043°17′362	1171	3
13	Ruins (the left side of the filed road)	41°28′815	043°17′397	1172	7
14	Ruins (the right side of the filed road)	41°28′830	043°17′549	1176	3
15	Ruins (the left side of the filed road)	41°28′832	043°17′561	1181	2
16	Ruins (the right side of the filed road)	41°28′834	043°17′636	1175	2
17	Ruins (the left side of the filed road)	41°28′832	043°17′646	1172	4
18	Ruins	41°28′825	043°17′658	1173	1
19	„ - -“	41°28′829	043°17′683	1178	1
20	Stone (processed)	41°28′828	043°17′677	1168	1
21	Ruins	41°28′835	043°17′701	1171	1
22	„ - -“	41°28′841	043°17′737	1174	1
23	„ - -“	41°28′846	043°17′760	1172	1
24	„ - -“	41°28′842	043°17′784	1174	1
25	Ruins (the right side of the filed road)	41°28′879	043°17′794	1177	2
26	„ - - “ (the left side of the filed road)	41°28′849	043°17′840	1179	3
27	Ruins Q	41°28′859	043°17′870		1
28	Ruins (special)	41°28′863	043°17′880	1164	
29	„ - -“	41°28′872	043°17′892	1178	1
30	„ - -“	41°28′870	043°17′913	1179	1
31	Ruins (the right side of the filed road)	41°28′876	043°17′931	1173	5
32	„ - -“	41°28′882	043°17′997	1175	3
33	Ruins	41°28′880	043°18′087	1180	1
34	„ - -“	41°28′883	043°18′100	1180	
35	Ruins (the right side of the filed road)	41°28′889	043°18′146	1173	4
36	„ - -“ (the left side of the filed road)	41°28′900	043°18′186	1175	
37	Ruins Q	41°28′908	043°18′207	1178	1
38	Ruins (the right side of the filed road)	41°28′914	043°18′236	1178	9
39	„ - -“ (the left side of the filed road)	41°28′911	043°18′255	1180	4
38	Yard (like the cult ceremonial)	41°28′919	043°18′244	1175	
39	Ruins (the right side of the filed road)	41°28′915	043°18′268	1177	5
40	„ - -“(the left side of the filed road)	41°28′926	043°18′320	1182	2
41	Ruins Q	41°28′923	043°18′311	1185	1
42	„ - -“	41°28′921	043°18′333	1179	2
43	Ruins (the right side of the filed road)	41°28′935	043°18′347	1179	4

44	„ - -“ (the left side of the filed road)	41°28′930	043°18′378	1180	15
45	Ruins (the right side of the filed road)	41°28′943	043°18′465	1181	2
46	„ - -“ (the left side of the filed road)	41°28′963	043°18′528	1176	3
47	Ruins	41°28′975	043°18′645	1182	1
48	„ - -“	41°28′992	043°18′690	1184	1
49	„ - -“	41°28′909	043°18′708	1186	1
50	Pool ruins	41°28′881	043°18′468	1228	1
51	„ - -“	41°28′826	043°18′468	1216	1
52	„ - -“	41°28′9	043°18′00		
53	Mineral source	41°28′860	043°17′824	1145	1
54	Bath	41°28′830	043°17′824	1145	1
55	„ - -“	41°28′141	043°17′130		1
56	The former mill	41°28′871	043°17′683	1138	1
57	Khertvisi Fortress Fence	41°28′867	043°17′207		
58	The entrance in yard of Khertvisi fortress	41°28′771	043°17′240		
59	Fence	41°28′760	043°17′239		
60	„ - -“	41°28′551	043°17′312		
61	Construction	41°28′777	043°17′240		
62	Tower	41°28′784	043°17′852		
63	„ - -“	41°28′761	043°17′213		
64	Construction	41°28′760	043°18′642		
65	The ruins of the church and old cemetery	41°28′416	043°18′535	1637,0	

Outcomes

To revitalize the areas economically and industrially, the whole complex (castle, terraces, ruined village, ruined mill, bath-house, mineral springs, water supply system) should be given the correct functional purpose –of the historical-geographical tourist recreational complex in order to promote the social-economic progress of Samtskhe-Javakheti after the correct planning and proper management.

- In the case of acquiring the tourist-recreational function by the castle, its infrastructure must be arranged to maintain historic authenticity and arrange a visitor's residence (the army standing there had a residential place there!). Then the price of the object will increase much more.
- In the event of restoration of the village ruins, if several buildings will acquire the function of the museum and the rest turn into the residence of the visitors, the tourist-recreational importance of this place will be further increased.
- If the number of houses of the village ruins and the fortress is taken into consideration. Their number is more than one hundred. This object will be able to host several hundred visitors simultaneously.
- The object of interest for visitors is a mineral spring. Maybe its geological study can make it possible to increase the flow of water. But for the visitors it will be quite enough for this debate.
- The product grown on the terraces is not only the object of the visitor's consumption but also the possibility of participation in the process of making and looking through (picking up, making Bakmas, etc.).
- Visitors' interest will be increased by the fact that they will live in Khertvisi but they will have opportunity to visit other historical and cultural objects of the region (Vardzia, Vani boilers, Zarzma, Kumurdo etc.)
- The service of such a large facility will require a large number of personnel who will be employed by different jobs. This will help to employment of local people and create new jobs

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Estimated Mapping of Wine Growing and Winemaking in Georgia (on the example of the region of Kakheti)

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Abstract. An important outcome of the work is the assessment map of vineyards spread in Kakheti region. This cartographic work is a graphic type map, based on the administrative net, municipal level. On the map, auto-column pedagogic chart is attached to the municipal centre denomination point, with the average positive temperatures of the vegetation period (March-October) on the one hand and on the other, with positive absolute temperatures. Also, the potential benefit of the area for viticulture is based on the color of the background on the map depicts the viticulture assessment in the area of the particular municipality to determine the areas of prospective distribution of vine culture. This part of the map is reflected in a 3-step scale.

Spatial analysis of the Viticulture Zone assessment map of the Kakheti region gave us the possibility to classify the region's territories according to the viticulture development representation: 1) Gurjaani, Telavi and Kvareli municipalities 3rd. Factors: dominated by oriental and southeastern exposures; Brown type soils; Annual precipitation 800-1000 mm; Absolute negative temperatures 7^0-9^0; Absolute positive temperatures 17^0-19^0. 2) Akhmeta, Sighnaghi, Sagarejo and Lagodekhi municipalities - 2 ball. Factors: dominated by South-Western and Western exposures; Alluvial acid types; Annual precipitation of 600-800 mm; Absolute negative temperatures 6^0-7^0; Absolute positive temperatures 16^0-17^0. 3) Dedoplistskaro municipality - 1 ball. Factors: dominated by north-western and northern exposures; Breeze with hardwood type soils; Annual rainfall of 400-600 mm; Absolute negative temperatures 4^0-6^0; Absolute positive temperatures 15^0-16^0.

The resulting assessment of viticulture and winemaking assessment cartography in the study area - synthetic map and the appropriate geoinformation (GIS) system makes it possible to monitor cartridge content, and open, renewable system.

Keywords. Estimated mapping Growing Winemaking

1. Introduction

Georgia has been the country of vines and wine since ancient times, and historically wine-growing and wine-making has perfomed the function of one if the leading branches of economy.

The diverse and rich information about growing vines and producing wine in Georgia can be found in historical and modem scientific literature as well.

Iv. Javakhishvili reviewed 413 vine species from the ancient period in his work:
Economic History of Georgia [1]

Nowadays there are more than 420 species in Georgia or 2.5% of the whole world assortment, from which 27 are for wine, 14 – for table, 41 standard species. According to the ecological and economic conditions Georgia is divided into 10 main regions from the view point of specialization and concentration of vine growing, of which Kakheti, Kartli, Imereti, Racha and Lechkhumi are the most important regions (see map 1). All regions are both producers and users of grapes and wine.

2. Research

The climate of Kakheti is favorable to develop industrial species of vine of high quality. They are: Rkatsiteli, Saperavi, Mtsvane, Kaberne, Khikhvi. Kakheti gives more than half of branded wines of the republic. In Kakheti, 54% of vineyards of the country are placed and 65-68% of total in Georgia are produced. In Kakheti Alaznis Valley is situated 250-300 meters above sea level and Telavi 800 meters above it. Within these heights vine grows everywhere and gives abundant crop, but typical Kakhetian wines are made from the vines situated on the slopes, the height of which are between 400-450m and 700m. The climate of Kakheti is the best for developing high-quality industrial vines:

Rkatsiteli, Saperavi, Laberne, Khikfavi. Influence of the environmental conditions are so great, that it often annuls features of the species. For example, the Georgian Sort of vine Saperavi gives quite different wines in Kakheti, Armenia, Crimea. Productivity of vines as well as of any other plants is determined by internal (biological) and external (ecological) factors. On the base of chemical and organoleptical data high high producing culture of vine-growing and wine making has been formed in Kakheti for ages. Demand for the Kakhetian wines increased for relief conditions in Kakheti. More than the half of its territory is placed on the agricultural territory (600.6 hectares).

In her Kakheti, from the micro zones of vine-growing, north – east and south-west sides of the Gombori mountain range, neighboring territories of the Alazani field, south-west and southeast slopes of the Kakhetian Caucasus, the left bank of Alazani (the river) (Teliani, Tsinandali, Ikalto, Mukuzani, the towns of Akhmeta, Gurjaani, Kvareli) are not able. In outside Kakheti vineyards are mainly spread on the southern slopes of the Gombori range and in some places they are laid out at the height of 1000 meters. The town of Sagarejo is distinguished by vineyards), Kakhuri Mtsvane, Saperavi, Khikvi and others too.

In 1999, in Kakheti, 110 000 tons of grapes were produced which gave 50% of the harvest received in Georgia.

In 2000-2003 there were produced 206 tons: in 2000 – 105 tons, in 2001-75 tons, in 2003 – 6 tons.

Tab. 1. Wine-making in Georgia 2010

Region	Number of the enterprises	Produces (dekaliter)	Turnover (thousand Laris)	Number of the employed
Georgia	112	161086.5	164366.0	3411
The city of Tbilisi	23	49536.5	49224.2	812
Ajara	1			47
The region of Racha, Lechkhumi and Kvemo Svaneti	3			90
Rh region of Samegrelo-Zemo Svaneti	1			283
The region of Imereti	10	222.2	355.5	83
The region of Kakheti	44	699997.5	71747.3	1587
The region of Mtskheta and Mtianeti	6	1436.1	2400.7	83
The region of Kvemo Kartli	2			45
The region of Shida Kartli	22	20729.5	20860.7	411

On the territory of Kakheti the plain forests landscapes are spread. The landscapes of the Iverian plain fields create favorable conditions for developing vine – growing. The main trait of the landscapes of the Kakhetian flelds is low lands and mildly humid subtropical climate. In some years dry period creates profitable conditions, for developing vine-growing. The plain of Alazani compared with the other landscapes of the plain of Eastern Georgian is characterized by the mildest and wettest climate.

There are the following natural territorial complexes in the landscapes of the Kakhetian plain forests:

1. Groves with surplus humid regime, bast (raffia) forests with well-developed grass covering in the powerful alluvial soils. 2. Relatively high terraces are represented with mildly humid oak forests in skeletal and alluvial soils of little thickness. In the landscapes of the Kakhetian plain vineyards lie the large area (Rkatsiteli, Saperavi, Kaberne Savinion, Kakhuri Mtsvane, Khikhvi).

The landscapes of the Iverian plain fields are widely spread in Shida Kartli and Gare Kakheti. The landscapes of the Iverian fields occupy rather wide hypsomhypsometricale within 200-1000 meters above sea level. Variety of relief shapes are represented here:

Low lands, hills, foothills. The climate is transitional from mildly warm to subtropical. According to humidity the landscapes of the Iverian fields belong to mildly dry climate that creates favorable conditions for vine growing and developing.

The landscapes of the semi-desert of Eldari′s plain (dry subtropical) are formed in conditions of dry subtropical climate, which cause forming of plants of semi-desert and desert soils. The climate of the Eldari′s landscape is dry (arid) subtropical with unfavorable conditions for vines.

In Georgia, in Kartli, high culture of vine growing and wine making has been developed too. The climate of Shida Kartli is semi mild or semi dry with hot summer and rather mild winter. We can belong it to the northern variety of the climate of the climate of the Mediterranean Sea climate, the landscapes of which are similar to the lowland landscapes of the northern Italy, privately of Lombardia lying at the bottom of the Alps (T.Davitaia) [2].

Vines dominate in the cultural landscapes here. The geographical environment and natural conditions of Shida Kartli are distinguished for their diversity that makes certain influence on the development of the spheres of agriculture. Kvemo Kartli is specialized in producing ordinary table wines. The main sorts planted here are: Rkatsiteli, Tavkveri, Tavrizi, Saperavi, Chinuri and Aligote. Vine growing of Shida Kartli is specialized in producing wine materials of champagne and sparkling wine of high quality: Chinuri, Goruli, Mtsvane, Rkatsiteli, Aligote, Pinoebi, Shavkapito, Saperavi too.

There are 12-13% of the general area of vineyards of Georgia here.

Imereti represents the region giving various production. High-quality table wines, champagne materials, branded ports, sparkling wines, cognac materials and others are made here. The main species of vine are: Tsitska, Tsolikauri, Dzelshavi, Aligote, Otskhaburi, Saperavi, Krakhuna and the others. In Imereti vineyards occupy 18% of the general area of the vineyards of Georgia and according to this index this zone is on the second place after Kakheti.

Vine is a traditional culture in Racha and Kechkhumi too. The following sorts are mainly spread here: Alexsandrouli, Ojaleshi, Tsolikauri, Tsulikidzistetra. In Racha and Lechkhumi high-quality branded semi sweet dry and naturally sweet table wines are produced.

Only 2-3% of the vineyards of the republic are represented here.

Abkhazia, Samegrelo, Guria and Ajara are distinguished by large areas and quality of the production from the rest of the regions. In some microzones of these zones vine growing has an industrial importance and Ojaleshi, Chkhaveri and other rather high-quality wines are received. All these zones are users of grapes and wine.

In Georgia vines grow well up to 1200m above sea level.

Academician T.Davitaia notes that in wine the sort of the vine and the place from which it is received are reflected like in the mirror [2]. In low lands vines grow well and give heavy harvest, but as it is confirmed by research many times and practice as well, harvest is of lower quality than on the slopes. It is known that vine-growing of the countries of the world is mainly placed within the zones of subtropical and mild climates, where sun the rays are bent aside from right angle less than in the northern areas. For this reason quantity of light and warmth are comparatively more here. That′s why exposition and micro relief conditions connected to it have great importance together with general macro relief conditions (mountain,

plain). The vineyards giving wines of high quality are mainly placed on the slopes all over the world. For this reason vine is often called slope culture.

In regard to the exposition, the power of the root system of the vines changes. In the soil spread on the slopes of northern exposition, as in more humid one, the roots of the vines are in less depth than slopes of southern exposition in comparatively dry soil. World practice of vine growing shows that the same species of vine set on slopes and low lands give wine of different quantity and quality. Herewith, as we have mentioned above we more often receive heavy harvest but of low quality. Vines are often damaged by frost, wreckers and diseases, which are caused by micro and phito climate conditions.

Complicated adaptation of anthropogenic factor. From the so – called cosmic factors [3] (radiation, temperature of air, wind, external phenomena of weather: frost, hail, etc). According to T.Davitaia the leading climate factors of the direction of vine growing and wine making must be thought to be:a) annual rainfall which creates certain regime of soil humidity, amount of temperatures above 10^0C, average temperature of the warmest month. According to this index 5 agro climate zones and ten agricultural areas are separated, each of them is different by specificity of agro climate typical features and correspondingly, peculiarity of growing agricultures are different.

In Georgia culture of vine is spread in rather hypsometrical range, beginning from the sea-level and ending in 1200 (1340)m. According to the landscapes analysis of spreading vines is based on different literary [4] (Ramishvili, Tabidze, 1960, Georgian Geography 2003) and cartographic sources, privately on the map of Georgian vine growing and on the map of the Georgian Landscapes [5]. The types of the vertical structure of the national territorial complexes are reflected on the latter. It shows the quality of anthropogenic transformation of the territory. From 71 species of landscapes, different species of vines are met only in some of them, which is 13 almost 2/3 of the Georgian landscapes. These landscapes are united in 2 classes, 7 types and 13 subtypes. Within low lands we can meet 20 species of landscapes and within highlands – 21. In low lands we can meet vines in almost all landscapes except hydromorphical and arid-denudative. As to mountain landscapes, we can meet vines in the whole height spectrum, from lower mountains and including the lower zone of the landscapes of average mountain forest. In Ajara they are met in the height range where we can generally meet in Georgia and it occupies 14 sorts of landscapes. Kartli is different from this point too, where vines are spread in 13 sorts of landscapes. The least height diapason of spreading vines is characteristic for Racha and Lechkhumi (3 species of landscapes), in spite of the fact that it is in the first place Georgia by the number of vine species.

From the rest of the regions Abkhazia, Samegrelo, Guria and Ajara are distinguished by the large amount and the quality of the production. In some microzones vine growing has an industrial character and produces rather high-quality wines [6]:

Ojaleshi, Chkhaveri and others are received. It is known from history that nigh-quality wines were made and are received in Kakheti on the slopes inclined to the river Alazani nowadays too, in Imereti –on the inclined slopes of the ravines of the rivers Rioni, Kvirila,Dzirula.

It is interesting to note that the vineyards of the wine-making areas of the Western Europe are set at the following heights above sea level:

Tab. 2. Setting wine-making of western Europe above sea level

#	**area**	**Height(m)**
1	BOrdo (France)	10-100
2	Sharante (France)	50-100
3	Burgundia (France)	200-300
4	Champagne (France)	150-200
5	Rain (Germany)	150-300

High-quality wines are produced in Imereti at a height of 150-200 m above sea-level, in Racha and Lechkhumi at 400-500m, in Kartli (Aten Ravine and the field of Mukhrani) at 600-700 m and the field of Alazani at 500-600 m.

Vineyards are set in the soils of different character. That′s why it′s growing and development and fruitfulness pass in conditions of providing humidity. As we noted above soil conditions have decisive importance for growing, development and productivity of vines. The root systems of vines are placed in the soil complicated processes of absorption of water and feeding substances go in the plants. Vines grow in different types of soils, beginning from the sandy soils (Dnieper, Dniester) and the sandy soils of the sea dunes – vineyards of Anapa) ending in heavy clay soils. In the areas of high-quality wine-making, soils are mainly clay and very skeletal. The cases are frequent where vines giving high-quality wine making soils are mainly clay and very skeletal. Herewith, the cases, when vines giving high-quality production grow well in such soils where other plants can neither give high-quality fruit nor even grow [7].

Sandy soils with chemical mineral composition mainly consist of (less than 60%) pure flint. In such soils planting vines is possible only in condition of using organic fertilizers in great doses. Demand for water in vines and other cultural plants is high here for great water conductivity and little moisture capacity of these soils. Using them for vines and other cultural plants is not recommended without artificial irrigation. Sandy soils become hot very soon in summer and they become cold very soon in Winter. Such thermal processes certainly make direct influence on vital processes of vines. On sandy soils the species of vines, which give us white wine, grow better, these vines, are tender, strong and are used for courage.

In clay soils vines grow well. From the total reserve of moisture, productive moisture is rather great here and there is harmonic relationship between the quantity of water and air. That′s why the process of productivity of vines in them goes normally. In such soils of mechanical composition plants are better provided with feeding substances and give not only heavy harvest but high quality production together with the other favorable ecological conditions.

Heavy clay soils satisfy demands of vines less. In such soils vines spend much energy for making roots. In heavy clay soils harmonic relationship between the quantity of water and air is broken more often. Providing vines moisture is fallen down. The result of it is that general development of vines is limited. Using such soils for vineyards demands organizing expensive land-improving measures. Demand of vines for feeding substances and water is satisfied better in light and average clay soils.

According to the statistical data it is confirmed that just vineyards set in the skeletal soils give qualitative wines. In the soils of the soils of the best vineyards of the province of Champagne there is 55-60% skeletal of limestone′s and flint In Georgia the vineyards giving Teliani, Napareuli, Vartsikhe and other qualitative wines are arranged in strong skeletal (60%) soils. Skeletal placed in vineyards has other negative technological features too. The reason of it is that cultivation of superficial skeletal soils is difficult and the quality of wearing out of working tools is high. In those soils where – is 20-70% and consistence of limestone is 75%, Rkatsiteli gives best branded wines in Kakheti (Mukuzani, Telaini, Napareuli and others) [8; 9; 10].

The base of data which unites more than 500 aboriginal species of vine is compiled as a result of analyzing literary sources. Besides, it includes non-local, imported and hybrid species, all the species which have ever spread on the territory of Georgia (about 700 species of vine). Many species of vine are known under different names in different regions of Georgia. That′s why the database unites more than 900 names of vine species (including synonyms).

Ability of renewal of data, their choosing and arranging by certain criteria is one of the advantages of the geoinformation systems and it is very important for improving the database of ancient and modern species of vine. On the basis of, it the series of thematic maps can be made that would give us possibility of seeing ′invisible′ from the text or the box.

3. Conclusion

Finally it can be noted that in Georgia peculiarities of spreading the culture of vine first of all depends on the agroclimate peculiarities and hypsometrical spreading of the territory. In Georgia the culture of vine grows well up to 1200 meters above sea level. These hypsometrical steps of spreading vines gets into different classes, types and species of the landscapes. In conditions of Georgia species can be met in 41 from 71 species of the landscapes which is 2/3 of the landscapes. Within low lands vines can be met almost everywhere except hydromorphic andarid-deplantingnudative. And in the mountainous landscapes vines have been spread from lower mountains in the landscapes of average mountain forest. Racha and Lechkhumi were distinguished by the least bypsometrical range.

As a result of analyzing the statistical data it can be said that the species of vines spread in skeletal soils give the wine stuff of high quality. The maps of dividing into zones of vine-growing are presented in the article which adequately reflect geographical peculiarities of spatial spreading of vine species.

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Analysis of Regional Armed Conflicts Using Spatial Clustering Methods

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Abstract. The paper considers approaches to conflict analysis in the regions of the world by means of the geospatial clustering of a set of data on world armed conflicts and the development of software tools for visualization on the virtual globe. The re-search methods are computer modeling, data mining, a method of hot spots geo-spatial analysis. Scientific novelty consists in applying the method of hot spot analysis for clustering geocodes of data on armed conflicts, as well as WebGL Globe technologies as a means of visualizing the results of geospatial analysis. As a result of the work, the UCDP GED data set on armed conflicts was analyzed and the software as a web application that provides access to data was developed.

Keywords. Conflict, Geospatial Analysis, Visualization, 3D-Globe, Clustering, Data Mining

1 Introduction

Over the last few years, the number of regional armed conflicts has increased in the world, and the question is raised about the reasons for their origin and the dynamics of proliferation. The most conflictual regions of the world are the countries of the Middle and Middle East, the African continent. Even after a large number of bloody conflicts, it is still difficult for experts to determine what factors increase the risk of armed conflicts and wars, which contributes to the resolution of the conflict and which, on the contrary, worsen the situation. By analyzing databases, you can trace many relationships, processes, and find new factors that provoke conflicts, as well as find ways to prevent them. Therefore, the analysis and visualization of data on military conflicts is an actual topic in the process of studying them.

In projects aimed at the study, prediction and prevention of armed conflicts, the use of intellectual analysis of data is an integral part of the work process. By analyzing databases, you can trace communications and processes in military conflicts, find new factors that provoke them, as well as ways to prevent them. Using geo-visualization data tools as a tool for modeling military conflicts, data mining and creating hypotheses, creating interactive maps is a modern and effective approach that simplifies data access and access to it for all project stakeholders.

2 Background

The study of military conflicts is developing on the basis of political, military and international research on the foreign policy situation in the world in relation to Ukraine and the main macro regions. Similar studies were carried out in the works of Kostenko T. and others [1]. Methods of the spatial data mining and visualization of spatial data are presented in the research [2-5]. The spatial analysis of the data was based on the use of databases, the methodology of which was developed by Wang Yu, Yin Z. [6-7]. The development of tools for 3D visualization of spatial data and the creation of various services on their basis is now an actual area of research [8-10]. The question of geospatial data clustering is researched in works [11-13]. The study of databases on military conflicts, their analysis in terms of clustering in the topological space and visualization require a separate development.

The purpose of the work is to develop information tools for analyzing and visualizing geospatial data on armed conflicts.

The main tasks of the work are to analyze existing sources of information on armed conflicts, to choose interactive tools for rendering geospatial data, to conduct spatiotemporal clustering of the data set on military conflicts using the Hot Spots method and to display its results in the form of interactive 3D visualizations.

3 Input data

The Uppsala Conflict Data Program Georeferenced Event Dataset (UCDP GED) - a collection of geocoded conflict data from the Department of World Affairs and Conflict Studies at Uppsala University (Sweden) [14-15] was taken as input data. The purpose of this project is to provide the academic community with the most complete structured data on the events of organized violence in the world since 1989, meeting the need for geographically and temporally detailed data. Geo-referenced event data can be used for a variety of purposes, from the desire to illustrate the behavior of conflicts geographically, using the software of geographic information systems, to the study of causative relationships through the use of various methods of statistical analysis.

The UCDP GED is manually compiled by automated data retrieval, data filtering, storing and manipulating, and validating data.

The initial reporting underlying the UCDP GED is comprised of three sets of sources:

1. global reports of news feeds;
2. global monitoring and translation of local news by BBC;
3. secondary sources, such as local media, reports from non-governmental and intergovernmental organizations, field reports, books, etc. with the greater part (about 60% of the data set) of all events.

The data set contains 128 264 events. This is a global data set covering the entire globe, with the exception of Syria. The contents of the dataset can be divided into 7 categories:

- Event IDs
- Participants
- Sources of event information
- Geographical data
- Time
- Accuracy
- Number of victims.

Data is available in CSV, Shapefile, Rdata, Excel, and SQL formats (Postgres, MySQL, and Microsoft SQL Server).

For the clustering of geospatial data, the task of converting data into geodatabase format, geocoding, clustering and visualization with the help of modern software libraries was solved. MySQL was chosen as the database for data storage, and the geodata processing environment - QGIS.

Clustering of geospatial data was performed on the basis of the method of "hot and cold" points, based on the analysis of geospatial statistics.

4 Hot spot analysis method

Most statistical tests begin with the definition of the null hypothesis. Zero hypothesis for tools for the analysis of structural laws is a complete spatial chaotic or the objects or values associated with them. P-value is a probability, Z-score are standard deviations. Z-scores and P-values obtained as a result of the analysis of structural regularities indicate that a null hypothesis can be rejected or not. As a rule, one of the tools for analyzing structural patterns is used, assuming that the Z-score and P-value will indicate a possible refutation of the null hypothesis. This will say that the objects under study or their associated values reveal statistically significant clustering or dispersion. Whenever there is a spatial structure, such as clustering of the landscape (or spatial data), one can see evidence of the work of some of the main spatial processes.

The key idea is that values in the middle of the normal distribution represent the expected result. When the absolute Z-score is large and the probabilities are small (in the tails of normal distribution), an unusual distribution is observed. For the "Hot Spot Analysis" method, this means a statistically significant "hot" or "cold" point.

The Hot Spot analysis method calculates the statistic for each event in the data set. The final P-value (probability) and Z-scores (standard deviations) indicate the extent to which the region of the space clustered events with high or low values [13]. The method works by analyzing each event in the context of the neighboring geography of events. To be a statistically significant hot spot, the event must have a high value and be surrounded by other approaches with also high values. The local amount for the event and its neighbors is proportional to the sum of all events; when the local amount is very different from the expected local amount, and if this difference is too large to be the result of a random process, a statistically significant Z-score is obtained.

Hot spot analysis method of uses the formulas:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}\, x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n \sum_{j=1}^{n} w_{j,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad (1)$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \quad (3)$$

where xj is the attributive value for the event j, wi, j is the spatial weight between the events i and j, n is the total number of events, X is the mean of the arithmetic values of the events, S is the dispersion.

The statistical variable G * i, for each occurrence in the data set, is an Z-score. For statistically significant positive Z-scores, the higher the Z-score, the more intense clusterization of high values (hot spot). For statistically significant negative Z-scores, the smaller the Z-score, the more intensive clusterization of low values (cold point). On the way out we get a new set of data about events with Z-score, P-value and level of reliability of Gi_Bin for each step in the input array.

To adjust the statistical significance for multiple testing and spatial dependencies, an FDR correction is used. The FDR correction reduces the critical threshold for the P-value shown in Table 1 to be used in the test set and in spatial dependencies. Decrease, if any, is a function of the number of input objects and the environment structure used.

Table 1. Confidence levels

Z-score (standard deviation)	P-value (probability)	confidence level
<-1,65 Or> +1,65	<0,10	90%
<-1,96 Or> +1,96	<0,05	95%
<-2,58 Or> +2,58	<0,01	99%

Inferential statistics are grounded in probability theory. Probability is a measure of chance, and underlying all statistical tests (either directly or indirectly) are probability calculations that assess the role of chance on the outcome of your analysis. Typically, with traditional (nonspatial) statistics, we work with a random sample and try to determine the probability that our sample data is a good representation (is reflective) of the population at large.

The Randomization Null Hypothesis—Where appropriate, the tools in the Spatial Statistics toolbox use the randomization null hypothesis as the basis for statistical significance testing. The randomization null hypothesis postulates that the observed spatial pattern of your data represents one of many (n!) possible spatial arrangements. If you could pick up your data values and throw them down onto the features in your study area, you would have one possible spatial arrangement of those values. (Note that picking up your data values and throwing them down arbitrarily is an example of a random spatial process). The randomization null hypothesis states that if you could do this exercise (pick them up, throw them down) infinite times, most of the time you would produce a pattern that would not be markedly different from the observed pattern (your real data). Once in a while you might accidentally throw all the highest values into the same corner of your study area, but the probability of doing that is small. The randomization null hypothesis states that your data is one of many, many, many possible versions of complete spatial randomness. The data values are fixed; only their spatial arrangement could vary.

The Normalization Null Hypothesis—A common alternative null hypothesis, not implemented for the Spatial Statistics toolbox, is the normalization null hypothesis. The normalization null hypothesis postulates that the observed values are derived from an infinitely large, normally distributed population of values through some random sampling process. With a different sample you would get different values, but you would still expect those values to be representative of the larger distribution. The normalization null hypothesis states that the values represent one of many possible samples of values. If you could fit your observed data to a normal curve and randomly select values from that distribution to toss onto your study area, most of the time you would produce a pattern and distribution of values that would not be markedly different from the observed pattern/distribution (your real data). The normalization null hypothesis states that your data and their arrangement are one of many, many, many possible random samples. Neither the data values nor their spatial arrangement are fixed. The normalization null hypothesis is only appropriate when the data values are normally distributed.

5 Application: clustering and 3D globe

For the analysis of data and their clustering using the Hot spot method, the UCDP GED sets was used in the format Shapefile "ged50-shp" and as a dump of the MySQL database "ged50-mysql". During the data procesing, open source QGIS software and ESRI's commercial ArcGIS application were used. From the ArcGIS toolkit to obtain clustered data, the built-in Python interpreter, the “arcpy” library, the GenerateSpatialWeightsMatrix_stats space-time weighting function, and the HotSpots_stats function itself, have been used to generate clustering.

The syntax of the HotSpots_stats Python function in ArcGIS looks like this:

```
HotSpots_stats (Input_Feature_Class, Input_Field, Output_Fea-
ture_Class, Conceptualization_of_Spatial_Relationships, Dis-
tance_Method, Standardization, {Distance_Band_or_Threshold_Distance},
{Self_Potential_Field}, {Weights_Matrix_File}, {Apply_False_Discov-
ery_Rate__FDR__Correction})
```

The entire UCDP GED data set has been broken down to one of the 5 regions: Europe, Asia, North and South America, Africa, Middle East. For each region, the matrix of time-space scales with parameters of the time range of 5 years and the territorial distance from neighboring points up to 500 km was calculated.

Using the calculated matrixes of weights, new data sets have been created for the relevant regions that contain information about the presence of hot or cold spots.

The resulting data was exported to separate shapes, and then, with the help of free QGIS software, they were imported into the MySQL database. The resulting database has 2 tables: the actual data table of the UCDP GED "ged50-mysql" and the table of calculated z-estimates, p-values and the values of the accuracy levels of the distribution Gi_Bin. These tables are linked by the field of the unique identifier of the event id (Fig. 1,2).

Figures 1-2 show the location of events on the world map in 2015, as well as calculated clusters of hot and cold spots for relevant events of this period. In the clustering images, the "cold" points are blue in color, "hot" in red, and in the color gradation, intermediate values of the accuracy of the distribution of Gi_Bin are shown.

To visualize the results of the analysis and provide access to them through the Internet, the client parts of the open source WebGL Globe project and the three.js visualization libraries are used. This allows you to download data from the server in the JSON format and provide an interactive user interaction with them.

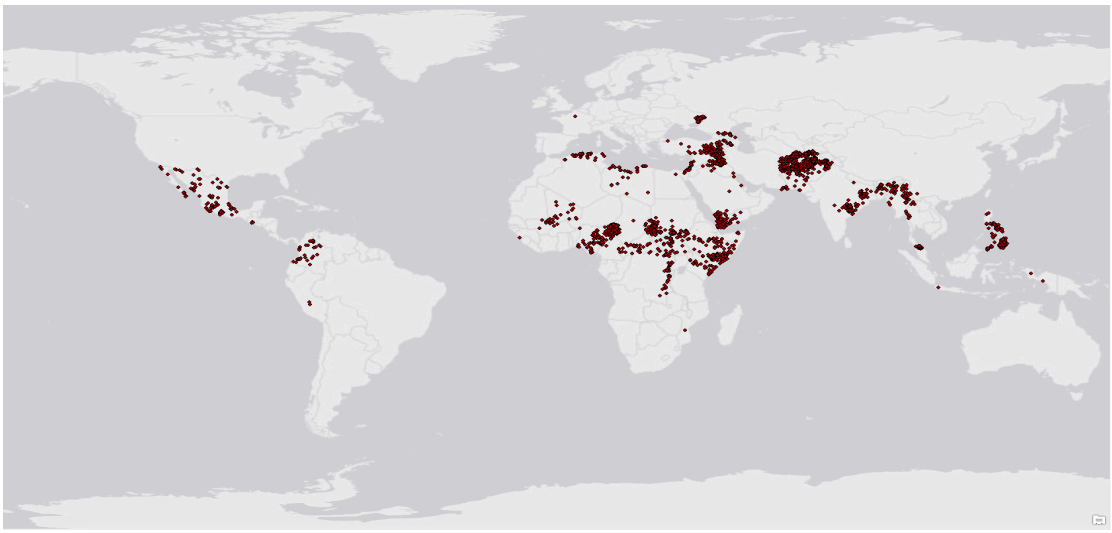

Fig. 1. Distribution of military conflicts in the world, 2015

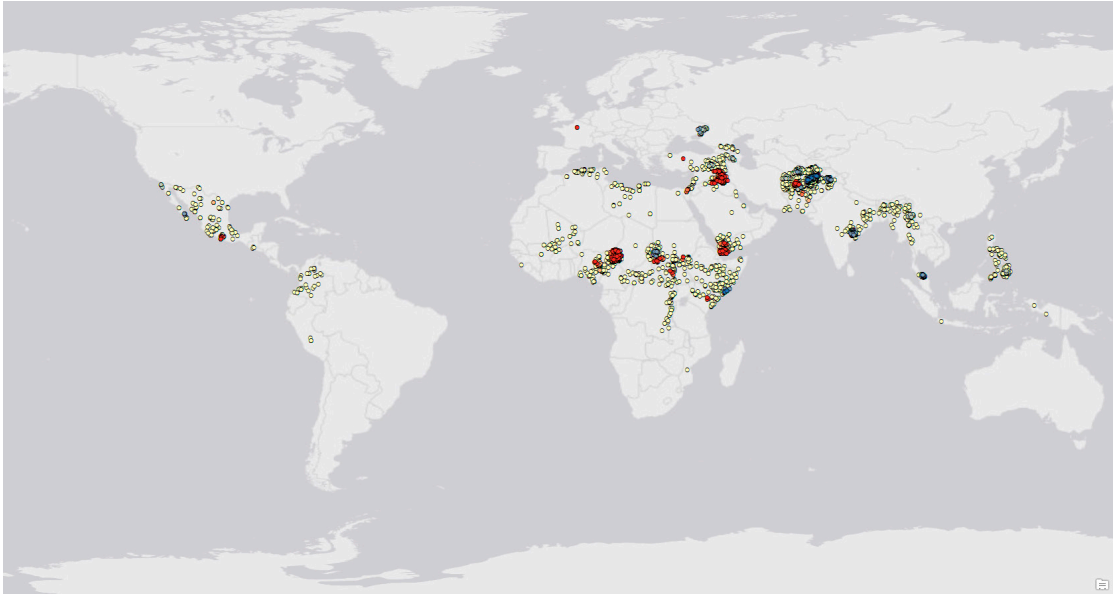

Fig. 2. Clustered military conflicts in the world, 2015

The server side uses the MySQL database to store the resulting dataset, the Apache web server to handle client-side asynchronous requests, and its own PHP language software that provides business logic to the web application. The view of the application is shown in Figure 3.

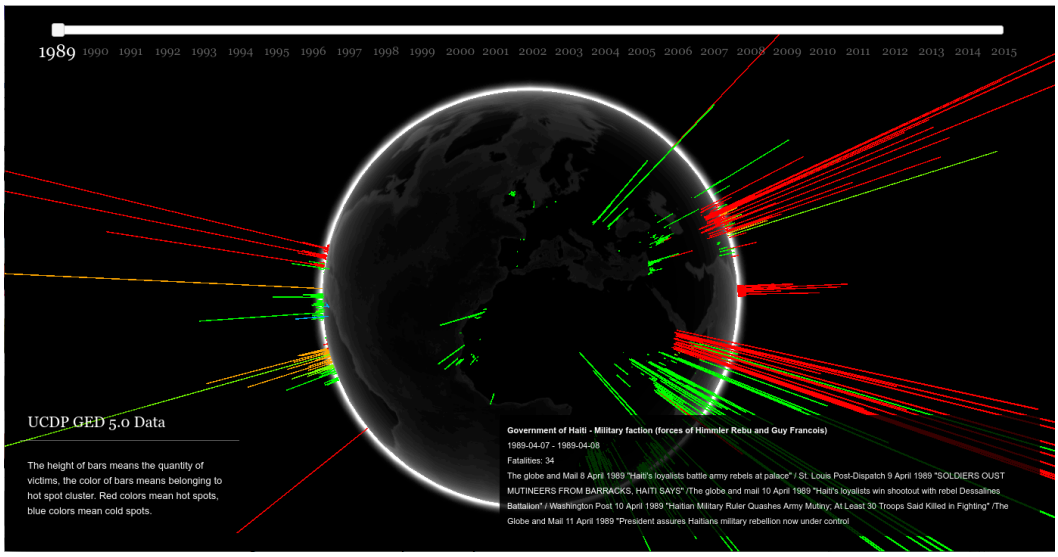

Fig. 3. Web Application Visualization of Analysis Results on 3D globe

To facilitate user interaction with the application, the way of switching between years was implemented as a slider. The events themselves are represented as geo-colored columns of different sizes. The column's height reflects the number of victims of the conflict, and the color - affiliation with hot or cold spots. When you hover the cursor over the column in the lower right corner of the screen there is a brief help on this event.

Interpreting the results of clustering can help in identifying spatial and temporal patterns of the emergence and development of conflicts. The applied approach allows to determine the "hot spots" of conflicts, which may serve as indications of the special danger of the development of incidents in the region. "Cold points," on the contrary, may indicate the possibility of rapid collapse of escalation. The analysis of data in the

dynamics over the past 30 years allows for a more detailed examination of the course of military conflicts in the regions of the world.

6 Conclusions

A clustering of the UCDP GED 5.0 Uppsala University databases using the method of hot spot analysis of were carried out. The analysis provides additional information on the nature and dynamics of world military conflicts over the past 30 years.

With the help of modern web technologies, a tool has been developed to visualize the results of the analysis and interact with them. Geocoded data on the nature of events in world armed conflicts and their implications were put on the three-dimensional globe. This approach will facilitate access to information and simplify the data process.

For the first time, an approach to cluster analysis of data on military conflicts was proposed, taking into account their geospatial position and topology of relations. This approach allows to take into account the mutual influence of proximity of territories with a tense military-political situation on the possibility of large-scale deployment of collisions. In the future, the space-time communications in the database will be considered.

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Public Heath Index in Regions of BRICS

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Abstract
Today public health is an important indicator of progress and social and economic development. There are many different methods of public health assessment, from public opinion polls to comprehensive medical examinations. In this paper, we continue research of public health using an integral index - the Public Health Index (PHI), which integrate most objective indicators of public health: infant mortality rate, life expectancy at birth for men and for women. These indicators have several important advantages: there is data for almost all countries, they do not require expert assessment and they are reliable. Previously, due to this methodology has been calculated the PHI in Russian regions (from the end of the Soviet period and the beginning of the transition to a new model of socio-economic development (1992) until the end of 2013) and for the world. This index clearly illustrates changes in the public health. In this publication, we will consider public health for the period from 2010 to 2014 in three countries of BRICS: India, Brazil and Russia.

Keywords: *public health, index, BRICS, Brazil, Russia, India*

1. Introduction

Problems of public health quality are the center of attention of scientists and politicians in many countries. Across the world, there are government health promotion strategies and reviews, statutory authorities and foundations, consumer interest groups, professional associations and journals. In 1986 in Canada the World Health Organization (WHO) adopted the "Ottawa Charter for health promotion", which emphasized that "good health is a major resource for social, economic and personal development and an important dimension of quality of life" (WHO 1986).

Individual health is a largely random phenomenon. It can depend mainly on the endogenous or genetic factors and a set of random processes and external events. Parameters of individual health cannot serve as a basis for decision-making at optimizing the living conditions of large groups of the population (Prokhorov et al., 2007). Public health assessment could give us more information about population than it seems at first sight. The diversity of health experience in developed countries over recent decades provides extremely rich material for exploring connections between social, political and economic institutions and policies on the one hand and health trends on the other. Public health is – the main feature of any human community (for example, people living in a given territory), its natural state. Public health shows both adaptive reactions of each individual and of the entire community, their ability to work most effectively, to defend the country, to help the elderly and children, to protect nature, etc., as well as reproduce and bring new healthy generation, to carry out their biological functions. (Prokhorov, Tikunov 2004)

Public health indicators synthesized the achieved level of quality of life and economic well-being of the country. Any noticeable fluctuations in the conditions of life very quickly reflected in the quality of health (Prokhorov et al., 2003). Conversely, improvements in public health are reflected in the state of the economy. In general, the loss of Russia's economy due to increased mortality of people of working age because of strokes, heart attacks, diabetes can make 2015 300 billion dollars, according to academician L. Boqueria. "In Russia, the average man dies before the age of retirement; extension of life expectancy of boys only a year would provide the country additional four per cent GDP growth, and business - more revenue,"- said the academician (Boqueria, 2009). So it gets more and more important to study public health within countries of the intermediate stage of economic development, such as India, Brazil and Rus-

sia. Their economic growth could unevenly affect public health within countries and it is important to highlight problem areas.

To assess public health at different stages of socio-economic development of the states or regions we need to develop an universal methodology, which will minimize possible distortions. Today there are many different methods of public health assessment. Experience of public health researches reveals different trends: shift assessments of public health in the direction of subjective indicators, derived on the basis of public opinion polls; estimation of public health on the basis of comprehensive medical examinations; the creation of newly integrated indicators; formation of systems based on international indicators. Most often used such figures as morbidity, temporary incapacity, disability, hospitalization, standardized mortality rate and so on. But the statistics of these indicators may not be accurate, the methodology may vary in different countries or part of data may be missing. Compare the quality of health of different regions on a large number of indicators considerably difficult, so you need to use compact indicators that are available in almost every country. The most objective indicators of public health in international practice are: life expectancy at birth for men and women, as well as infant mortality rate (the number of deaths of children less than one year of age per 1000 live births.). These figures are calculated and used in most countries of the world; the World Health Organization uses them.

We proposed to use the integral index - the Public Health Index (PHI), which integrate the most objective indicators of public health: infant mortality rate, life expectancy at birth for men and for women. This index was developed to asses and compare public health at all territory level – from cities to countries. Previously we use PHI to study public health dynamics in Russian regions from the end of the Soviet period and the beginning of the transition to a new model of socio-economic development (1992) until the end of 2013 (Tikunov, Chereshnya 2016). Next step of research was comparence of dynamic of public health development in Russian regions with world countries (Tikunov, Chereshnya 2016). It illustrated that huge differences among Russian regions can be compared with the differences between developing and developed countries (Figure 1). This led us to the need to compare the geography of Public Health Index in Russia with other similar countries. The most suitable for the study were the BRICS countries (Mujica et al., 2014). With economic growth, health inequity has remained a prominent issue in all BRICS countries. These five countries represent around 25% of the world's gross national income, more than 40% of the world's population and about 40% of the global burden of disease (World development…, 2013). Most of them have the same huge variety of natural and climatic conditions.

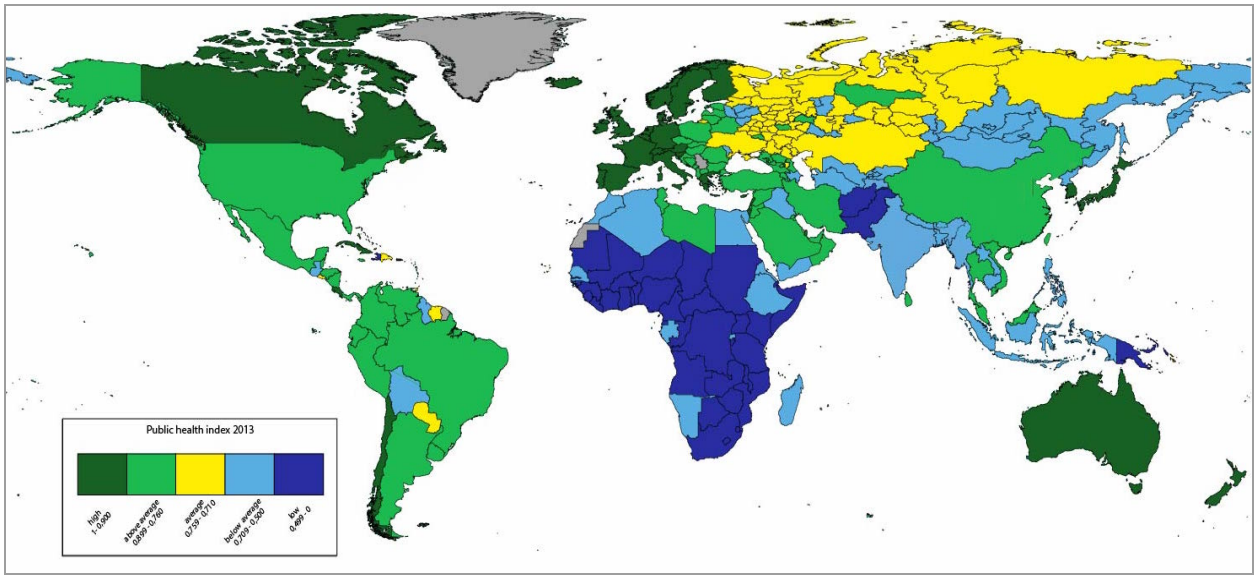

Figure 1 World PHI in 2013

2. Materials and Methods

Public Health Index integrates next indicators: infant mortality rate, life expectancy at birth for men and for women. For the calculations, we used "cube" of data of 138 regions of India, Brazil and Russia, considered as a single data set with the abovementioned 3 parameters. Health data on the regional level was available only for those three countries of BRICS. We couldn't get reliable official statistics for South Africa and China. This typology was constructed based on a diverse set of data sources. The following were used: the Demographic Census conducted by the Brazilian Institute of Geography and Statistics (IBGE) (www.ibge.gov.br); the Reserve Bank of India (www.rbi.org.in); and the Russian Federal State Statistics Service (www.gks.ru) (Rosstat).

We consider average public health indicators for the period from 2010 to 2014. For its calculation used the evaluative algorithm (Tikunov 1985, 1997). It includes normalization of initial indicators by the formula (1):

$$\widehat{X}_{ij} = \frac{|x_{ij} - {}^{0}x_j|}{|{}_{max/min}x_j - {}^{0}x_j|} \qquad i = 1,2,3,\dots,n; \quad j = 1,2,3,\dots,m;$$

where ${}^{0}x$ is worst value (for each indicator), in terms of their impact on the health of the population in the regions of Russia (the maximum infant mortality rate, lowest life expectancy); ${}_{max/min}x$ is the most different from the ${}^{0}x$ values of parameters, n is the number of territorial units, m is the number of indicators used for the calculations. The ranking is carried out by comparing all territorial units on a conditional basis, characterised by values of ${}^{0}x$. This is done using the Euclidean distance (d°) as a measure of proximity of all territorial units to a conditional basis. Processing of the array using principal component analysis for the purpose of orthogonalisation and a "convolution" system of indicators was then used. The values obtained for the vector d ° for ease further analysis were normalized using the formula:

$$\hat{d}_i^o = \frac{d_i^o - {}_{\min} d^o}{{}_{\max} d^o - {}_{\min} d^o}, \qquad i=1, 2, 3,\dots, n. \qquad (2)$$

The value of d^0 ranges from zero to one. Zero - the worst case a comprehensive assessment, and one – the best.

In the experiment, all the original indicators have equal weight, although it was assumed that weight meaning can be different and can change through history. To apply the weights we need a reliable basis, however, and today there is no such basis (Tikunov, Treyvish 2006).

The used algorithm can also allocate homogeneous groups of territories. This is achieved by partitioning the corresponding values of the series euclidean distances into the homogeneous stage. The procedure of steps allocation is multivariate and allows in each case to obtain the spectrum of options for grouping areas in homogeneous groups. Quality was assessed by the partition coefficients of canonical correlation (Tikunov 1997), as well as the coefficients of heterogeneity (Tikunov 1985), which allows you to select the final version, optimal from a statistical point of view.

3. Results

As a result, we get public health index for Russia, Brazil and India from 2010-2014. As can be seen from on the maps (Figure 2, 3 and 4), countries have much in common, due to geographical features and developing economy. In all countries, there are significant differences in the development of public health in the regions: from very high, like in developed countries to very low. At the same time, each country has its own specific features. In conditions of regional disproportion in the development of the federal subjects, it is much more important to study public health in the spatial aspect.

Public Health in Russia characterized by huge disproportion (Figure 2). For example, the infant mortality rate across the country differs by more than 3.5. **The concentration of low levels (4-7 cases per 1000 births) is mainly in the northwest and central Russia. Maximum values (15-20 cases per 1,000 live births) is fixed in some regions of the Far East and Siberia (Starodubov 2005).** There several main reasons, of such picture: geographic and climatic, socio-economic and traditional. It is natural that the best situation is observed in Moscow and St. Petersburg. The agglomeration and metropolitan effects provide them with a high level of quality of life and health care.

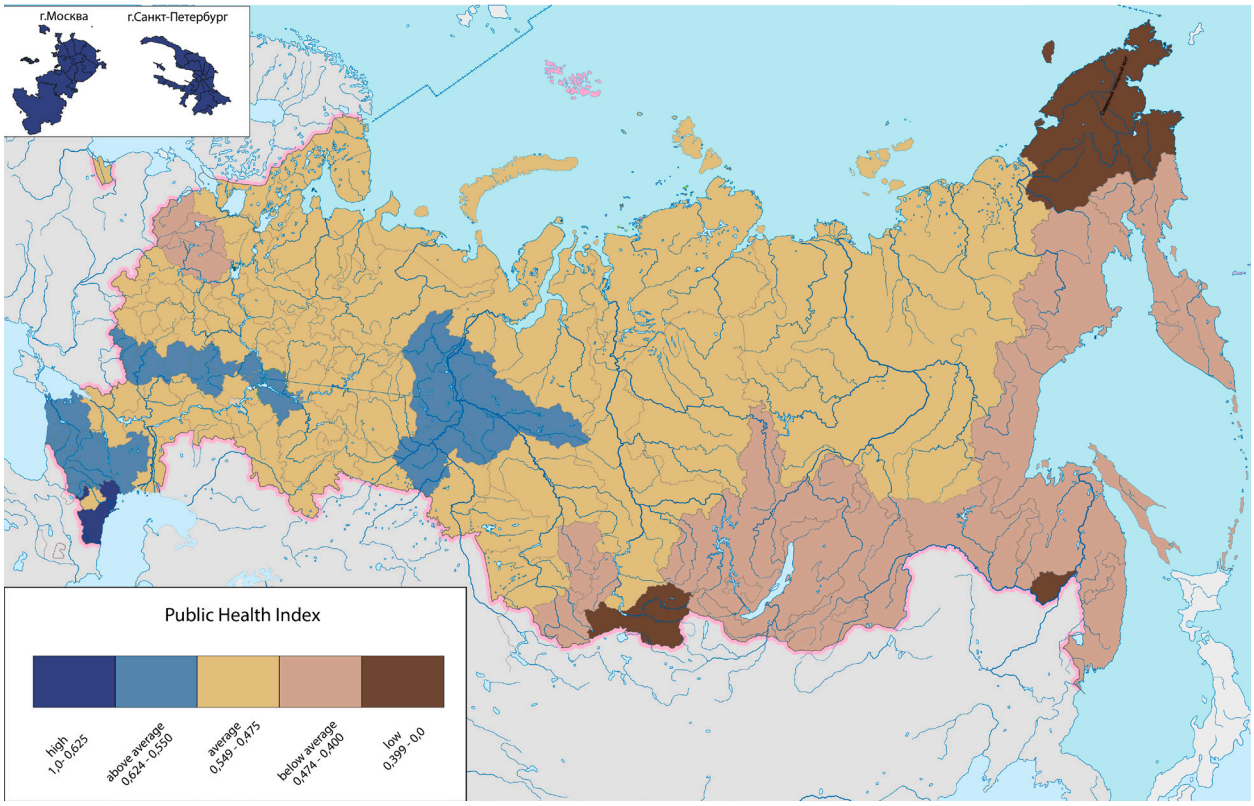

Figure 2. PHI in regions of Russia 2010-2014.

The worst situation is in Republic of Tuva, **Chukotka Autonomous Okrug** and Jewish Autonomous Oblast. These regions affected with all of the negative factors in the same time: there bad climatic conditions, a large proportion of the ingenious population who are more vulnerable because of their lifestyle, the bad economic situation leads to crime and alcoholism. In this regard, these regions are characterized by high male mortality in working age. **Their average life expectancy is 57 years for men and 67,7 for women, and their infant mortality rate is 17 cases per 1,000 live births.** We used to think, that Russian health situation is completely different from Indian, but these regions are at the same level of public health with the most of India regions (Figure 3). The fundamental difference between the situation in the regions of India and the Russian outsiders is that the rating of Russian outsiders is low because of dramatic male life expectancy, combined with an unsatisfactory level of infant mortality, while in India the average life expectancy of men is 8 years higher (66,4 years), but the infant mortality rate is catastrophic (42,4 **cases per 1,000 live births)**. Within BRICS, only the Russian Federation saw much worse life expectancy among males than among females. Gender inequality in health is a particularly important problem in the Russian Federation – largely due to cardiovascular diseases, violence, accidents, and alcohol-related causes (Meslé, 2004; Zaridze et al., 2014).

Of course, India has the worst health situation among all studied counties (Figure 3). Reasons are poverty, climatic conditions, epidemiological situation, overpopulation. In India, which accounts for nearly 18% of the world's population, 217 million individuals were estimated to be undernourished in 2012 [McGuire, 2013]. But in India, we can see the unique region – State Kerala. Its Public Health Index is much higher than in Dehli region (with only average public health index), that is untypical by world standards. Level of public health in State Kerala is close to Moscow and developed countries. This region is only on the 10th place in GRP per capita among Indian regions, it has one of the highest rates of population density in the country. But in 80th Kerala's government take the course to sustainable development, and one of the first goals was an increase in the literacy rate to 75%. Today Kerala has the highest literacy rate among all the states of India - 91%. This lead Kerala to the lowest fertility in the country: 1.7 children per 1 woman and lowest infant mortality: 14,1. Also, here is the highest life expectancy among the states of India (75 years for men, 78 years for women). This leads us to a very important conclusion, that education could be even more important to public health in developing than economic factors.

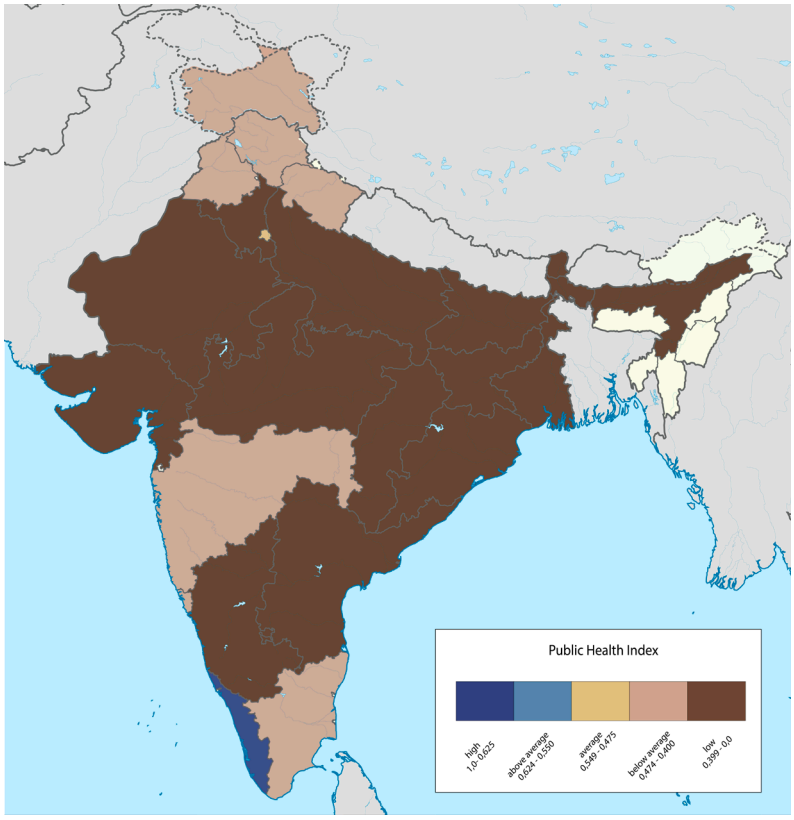

Figure 3. PHI in regions of India 2010-2014.

Brazil has the highest level of public health among BRICS. But it isn't homogenous too (Figure 4). Its Public Health Index varies very high from the South and Southwest, where are richest and most populous states, to the North and Northeast. It can be admitted, that geographically situation with public health in Brazil is more similar to Russian's one. There are problems with public health in rural areas and hard-to-reach Amazonian regions with severe geographical conditions and a large proportion of the indigenous population. For example, mortality among indigenous infants in 2000 was more than triple that of the general population (Coelho, 2011). This results in similar to Russian's picture when the infant mortality rate across the country differs by 2.5. **As to the life expectancy, we can admit, that differences between** males and females are not so dramatic, as in Russian regions. Life expectancy at birth for women and men living in the richest regions was 7-9 years longer than for those living in the less wealthy regions.

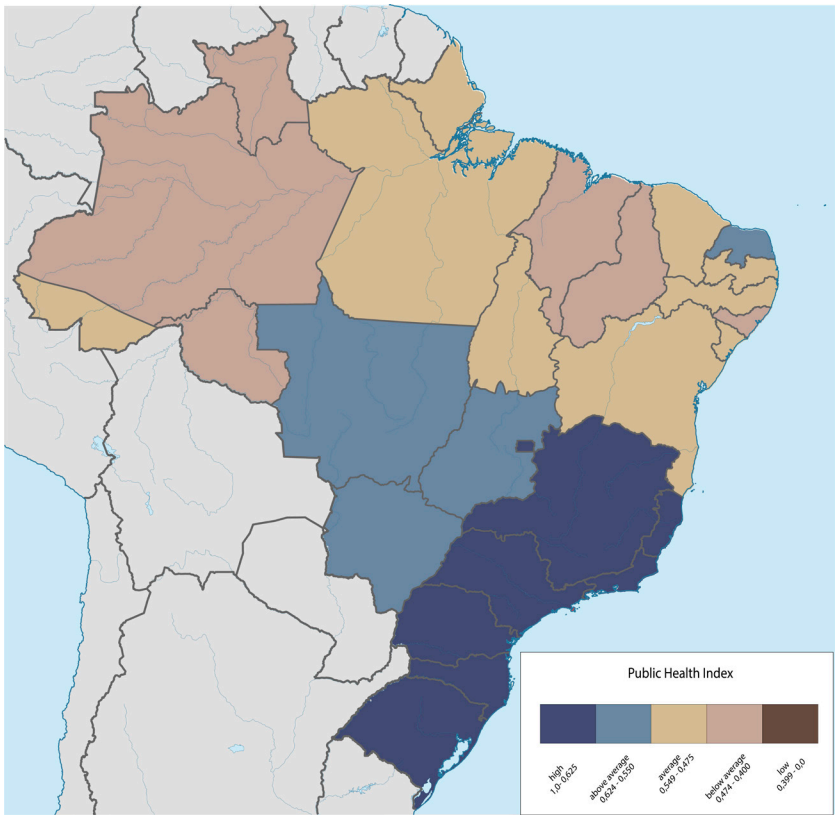

Figure 4. PHI in regions of Brazil 2010-2014.

4. Conclusion

In summary, it must be emphasized that in the studied regions have a noticeable difference in the level of health. This is countries of stark contrasts between their urban centers and remote rural areas, between richest and poverty. Fast development of their exacerbates differences. This contrast affects public health, medicine, and social sometimes in an unpredictable way. Of course, the quality of public health in the regions can't develop evenly, but there is still need to significantly reduce the gap between leading regions and the regions-outsiders. That is why the study of public health on regions level is important. Highlighting inequalities at the regional level proved to be especially important to promote actions and programs to decrease socioeconomic gaps. It helps to determine the direction of domestic policy, to improve public health politics and to increase public awareness of social problems. PHI clearly illustrates changes in public health balance and the dynamics of regions' development. The simplicity of this approach and the possibility of a clear visualisation of countries' development processes show the need for further study and improvement of the methods. In this context, the results presented here can be used as a baseline to monitor targets in healthy life expectancy and in regional health inequalities.

Acknowledgements

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Methods for Mapping of the Landscape-Ecological Framework for Purposes of Forest Management

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Abstract. The methodology for the research of the landscape-ecological framework and mapping is presented by the example of the study of stability of landscapes and large-scale mapping conducted in two regions of Western Georgia (Samegrelo and Guria) and in two districts of Shida Kartli (Khashuri and Kareli).

The final product of the research of the landscape-ecological framework and mapping is the map of stability of the territories which can be attributed to the class of complex maps as follows from its content. The basis for this map is a large-scale landscape map (in our case a map at a scale of 1:50 000) at the level of types. The type of landscape is the smallest taxonomic unit of the landscape classification schemes (according to the landscape taxonomic classification). Therefore, in order to determine the gradation of stability of the territories, a landscape map of analogical detail can be considered sufficient for taking of specific practical measures.

After analyzing the criteria of stability, for researching of the landscape-ecological framework and for creating the final product - the map of the stability of the territory, in conditions of Georgia, 5 degrees (gradations) of stability have been developed. In addition, after allocation of gradation (degree) it is specified the **form of use** of this territory (in our case of stable territories) from the economic point of view.

The above mentioned gradations are applied on the already formed landscape basis with the appropriate color, which, in its turn, is made according to the data of the NTC. In this way we get the so-called "Green" map.

Each gradation will have the corresponding color on the final version of the map:

Stable territories - dark green;
Average stable territories - light green;
Less stable territories - yellow;
Average unstable territories - pink;
Unstable territories - red.

The presented methods of mapping the landscape-ecological framework make it possible to manage a system of forest inventory purposefully. This method were initially tested in the realities of Georgia in 2000-2010, for similar studies throughout its territories, and were got the results with the practical importance.

Keywords. Mapping, The landscape-ecological framework, the stability of the territory

1 Introduction

The methodology for the research of the landscape-ecological framework and mapping is presented by the example of the study of stability of landscapes and large-scale mapping conducted in two regions of Western Georgia (Samegrelo and Guria) and in two districts of Shida Kartli (Khashuri and Kareli).

The final product of the research of the landscape-ecological framework and mapping is the map of stability of the territories which can be attributed to the class of complex maps [2;5] as follows from its content. The basis for this map is a large-scale landscape map (in our case a map at a scale of 1:50 000) at the level of types. The type of landscape is the smallest taxonomic unit of the landscape classification schemes (according to the landscape taxonomic classification). Therefore, in order to determine the gradation of stability of the territories, a landscape map of analogical detail can be considered sufficient for taking of specific practical measures.

2 Materials and Research Methods

The basis for mapping of the landscape-ecological framework is a landscape map. The basis of the named landscape map, for its part, is a map of the natural-territorial complex (NTC), which is created at the same scales and provides a detailed picture on the landscape features, such as: the migration regime and the surface slope, the types of vegetative formation (including undergrowth and grass vegetation), the type of vertical structure of the natural-territorial complex, the soil type and geological formation. On the other hand, for making the present map there are used both the existing cartographic database, and most important, the materials of landscape-ecological researches and large-scale mapping.

Composition of maps of territorial stability, maps of NTC and maps of landscape types is preceded by composition of so-called component maps at scale of 1: 200 000 or 1: 100 000. The following maps are created in these directions: geographical (topographic) map, hypsometric map (according to every darkened horizontal), geological map, map of types of relief, soil map, maps of vegetation cover and botanical diversity, distribution map of average temperature in July and January, distribution map of precipitation, map of types of climate, landscape map at the genus level.

As in our case it is envisaged to determine not only the degree of stability of the territories for forest areas but also for forestless areas, one of the components is also to determine the degree of population of the cartographic territory and to create maps for historical, architectural, archaeological and religious monuments. The latter one is a necessary component, since the area of such monuments is considered to be the protected objects, which to some extent influences on the assessment of the degree of stability of the territories. The above-listed component maps are a cartographic block of geographic information system of the relevant territory, which is an integral part of the unified system of the landscape-ecological framework.

The experience gained by similar field researches and mapping in different regions of Georgia created a foundation to separate 5 gradations in order to determine the degree of stability of the territories. New categories of stability were determined by the materials of landscape-ecological researches and mapping taken in 2000-2016. They are mainly separated considering the possible results of anthropogenic and technogenic impacts on the current state of natural landscapes and taking into account the quality of maintenance of the ecological balance of landscapes. The degree of stability (the corresponding gradation) is an individual criterion of each landscape (at any level), which is dynamic and depends on the characteristics of anthropogenic and natural impacts [1;4].

The main criteria for determining stability are: 1) The slope of relief, 2) The migration regime, 3) The geological structure, 4) The nature of intensity of geodynamic processes, 5) The exposition of slopes, 6) The state of landscapes, 7) The type and complexity of the landscape vertical structure, 8) The thickness, humidity and mechanical structure of soil, 9) The degree of humidity of the territory, 10) Type of relief. Below we will consider the essence and significance of each criterion for determining the stability of a region.

1) The slope of relief. This characteristic is an important factor for determining the stability of territories, as a number of processes (both natural and anthropogenic) are connected with the surface slope, which have a decisive influence on the state of the landscape and on its subsequent development. There are often cases when the surface slope determines the nature and degree of man-made and anthropogenic impacts, such are: road building, construction of power lines, hydro-technical installations, deforestation, forest cultivation, etc. The following gradations of surface slopes are used in landscape-ecological researches and large-scale mapping:

a) 0-4° – flat and almost flat surfaces;
b) 4-10° – *gently sloping* slope;
c) 10-20° – sloping slope;
d) 20-30° – average steep slope;
e) 30-45° – steep slope;
f) 45-60° – too steep slope;
g) 60-90° – rocky slope;

2) The migration regime. This characteristic is directly related to surface slope and implies the nature and quality of the movement of the surface mass (soil surface, the main part of plant material, surface lithomass). The determining of migration regime is important to determine the degree of stability of forest landscapes. Currently the following types of migration regimes are distinguished: autonomous (the top of a mountain or range), eluvial, trans-eluvial, eluvial-accumulative, accumulative-eluvial, superaqual, transsuperaqual and subaqual.

The above stated scale of migration regimes is constructed by the hypsometric principle from the top down. The eluvial mode of migration implies the beginning of the slope at the top,which has some inclination. The trans-eluvial migration mode is more typical for the middle part of the slopes. The eluvial-accumulative regime approaches the lower part of the slope, and the accumulative-eluvial migratory regime is characteristic of the foot of slope where the transported material is accumulated. Superaqual migration is typical for river coastal terraces, and transsuperaqual and subaqual migration regimes are characteristic of river floodplains.

3) The geological structure. One of the most important moments when creating maps of the landscape-ecological framework is the compilation of a geological map for the area of research. The geological maps at a scale of 1: 200000 are the most accessible in the course of such researches. These maps cover the entire territory of Georgia. The geological substrate determines the character of stability of the area. This is a particularly interesting parameter in the process of determining the stability of forest landscapes. Along with the slope of relief and migration regime, the presence of solid crystalline rocks provides relatively high stability of forest areas to natural and anthropogenic influences, and unconsolidated rocks, in contrast, determine less stable forest landscapes. A classic example of this is the region of Okriba in Western Georgia, South-Western slopes of which are represented by forest landscapes, built of limestone and are rather dampened. In this case, even with low slopes of relief anthropogenic impact will lead to activation of modern geodynamic processes that can be catastrophic for this area.

4) The character and intensity of current geodynamic (geomorphological) processes. This parameter has a critical importance in the researches of the landscape-ecological framework and the mapping process. Therefore, during field landscape-ecological studies, it's necessary to determine the kind of geodynamic process, its state and intensity level, which will be fixed directly on the map. The existence or absence of geodynamic processes is an important factor for determining the degree of stability of territories, as the processes are not man controlled, but they have natural genesis. Among the abovementioned processes, it should be noted: landslides (for micro- and macro-zones), mudflows, mudflow processes, snow avalanches, rock falls, surface washing (erosion), etc. Identification of these processes is an important tool, especially when determining the quality of stability of the forest area. This parameter is directly related to the previous three characteristics, and even is some kind of their result.

5) The exposition of slopes. This characteristic is connected with landscape-ecological barriers mainly with oroclimatic barrier. Orography includes exposure characteristics of slopes. Usually the exposition of slope is determined by the cardinal directions, but it can be said that this indicator is not decisive in determining the quality of the territory's stability, and to some extent it is controlled by indicators such as the slope of surface, migration regime and geological structure. For example: the slopes of South-West exposure in Georgia are usually rather wet. If the substrate is a solid crystalline rock, and the slope is average, this area can be considered as relatively stable.

On the other hand if in the similar case the area is presented by unconsolidated rocks the table will change and the stability of the territories will immediately take a tendency to decrease. The exposition is important in the territory of Georgia from the point of view of geographical location of the territory and hypsometric development.

6) The current state of landscapes. By the state of the landscape, first of all it is meant the state of the terrestrial and underground parts of the NTC. In modern landscape study and etiology of landscape there is a classification of the states of NTC by their time duration. From this point of view, the following are being singled out: short-term, medium-term and long-term states of NTC. The intraday state of the NTC (also known as the "stacks") is the most important for us during such researches. It indicates to the temperature regime, the degree of humidity and the tendency of changes of the NTC vertical structure. There are some kinds of "stacks",which directly point to natural spontaneous phenomena (fires, torrential

rains, floods, mudflows, etc.). Here we are already discussing the current state of landscapes for larger territories, thereby assessing and creating landscape-ecological situations and scenarios.

7) The type and complexity of the landscape vertical structure. These parameters play a certain role in determining the degree of stability of the area. During creation of a landscape map, the type of vertical structure is usually determined, from which we obtain results of its power. In case of forest landscapes the power is measured by meters. Complexity of the vertical structure of the NTC means the number of geohorizons (geographic horizons) in the vertical structure of its overground part. There are allocated several gradations of complexity.

6-8 geohorizons – very complex vertical structure;
5-6 geohorizons – complex vertical structure;
4-5 geohorizons – vertical structure of average complexity;
3-4 geohorizons – simple vertical structure;
2-3 geohorizons – initial vertical structure.

The complexity and power of the vertical structure have a certain influence on the degree of stability of forest landscapes. For example: the more complex and powerful is the NTC vertical structure, the more it is inclined to stable gradation, because the complexity of the vertical structure prevents the penetration of atmospheric precipitation into the soil which, for its part, causes the erosion processes and reduces the degree of the landscape stability. And vice versa, the more simple is the NTC vertical structure, the higher are the risks of intensity of geodynamic processes, which, for its part, reduces the level of landscape stability.

8) The thickness, humidity and mechanical structure of soil. The thickness of soil still has a leading role in these synthesized characteristics, as this parameter increases the level of stability of the area. The dampness along with mechanical structure of soil is one of the determining factors from the viewpoint of intensity of the geodynamic processes, namely: the higher is soil moisture and lower is clay content in the soil, the greater is the risk of activation of geodynamic processes, and vice versa. The 5 gradations of moisture are identified in the process of field researches of soil:

Dry – turns into dust. The soil does not feel the humidity, does not cool the hand. The moisture of soil is close to hygroscopic.
Slightly humid – it cools the hand, does not turn into dust, after drying it becomes a bit lighter.
Humid – humidity is well sensed by the touch. The soil humidifies the filter paper. After drying, it becomes significantly lighter and keeps the shape after pressing the hand.
Moist – when pressing, the soil becomes doughy, it wet the hand, but does not drip between the fingers.
Wet – when squeezing in the hands water drips between the fingers. The mass of soil reveals fluidity.

The mechanical composition of soil is its most important feature, since it depends not only on the composition of the parent material, but also on the character of the processes of soil formation. In order to determine the mechanical composition of soil in the field conditions, the soil is slightly wetted. The following gradations of mechanical composition are adopted:

Clay – a sample of the soil is turned into a tape form (diameter less than 2 mm) and it is possible to make a ring of it.
Loam – is turned into a thicker tape which doesn't break by bending.
Light loam – a tape falls apart from the very beginning.
Average loam – a tape falls apart after bending.
Heavy loam – a tape can be formed but is cracked.
loamy sand – is turned into a tape, only the ball is formed which has a cracked surface.
Sandy – cannot be turned in or molded
Skeletal soil – consists of cuttings (pebbles, grit, rock)

The gradations of the thickness of soil are:

Very powerful – more than 5 m.
Powerful – 3-5 m
Medium-powered – 2-3 m
Low power – 1-1,5 m.
Small-powered – 0,5-1 m.
Primitive – less than 30 cm

We can say that the soil factor is one of the most important factors in determining the stability of area, since it is a substrate where the plant is incubated and develops its vertical structure.

9) The degree of humidity of the territory. Humidity of the territory is directly related, first of all, to its exposure. It is known from geographic patterns that the slopes of the Southern and South-Western exposure receive more humidity from the atmosphere than the Northern and North-Eastern slopes. Therefore, the degree of humidity of the territory is often discussed along with its exposure. In this case, for determining the degree of stability of territories, it is more interesting to study and evaluate such complex characteristics as the territory characteristics (in our case, the microclimate of the landscape). As it is well known, it is the latter that determines the floristic composition of the territory, the type of soil and the intensity of geodynamic processes, that, as was mentioned above, also are the criteria for stability of the territories. The following types of territory humidification are determined in the landscape study:

a) Atmospheric;
b) Ground moistening without jet or with jet (the latter one is found when the source is located within the main area);
c) Deluvial (humidification occurs due to surface runoff);
d) Floodplain (humidification occurs due to flooding).

In fact we rarely meet such places in nature where only one type of humidification is common. Mixed types of humidification are more common. In some NTC the character of humidification varies throughout the year and depends on "stacks" (the intraday state of the NTC). For example: humidification during one "stack" can be "atmospheric" and during the other one "ground moistening".

The intensity of humidity also depends on the conditions of the NTC. In respect of this the following groups of humidity are marked out:

a) **Insufficient (deficient) humidity** – the soil is very dry, it stands out during arid, often in semiarid "stacks".
b) **Weak humidity** – the soil is partially humidified, it stands out during the semi-arid "stacks".
c) **Normal or sufficient humidity** – the soil is humid, it stands out during the humid "stacks".
d) **Plentiful humidity** – the soil is raw, it stands out during the humid "stacks".
e) **Excess humidity** – the soil is wet, it stands out during the extra humid "stacks".

The degree of humidification along with the microclimate is one of the supporting criteria for determining the stability of the territory.

10) Type of relief. One of the components for determining the stability of territories is the identification of a relief type that is closely related to the above mentioned two components –the surface slopes and migration regime.

The description of the terrain in the field conditions begins with the identification of a relief type. The following relief types are defined in mountainous areas of Georgia: a) Erosion-Denudation, b) Denudation, c) Erosion-Accumulative, d) Fluvioglacial, e) Eluvial-Accumulative, f) Terraced.

As you can see, the listed terrain types clearly show that the relief types are close to the names of the migration regimes, as the latter ones participate in the process of genesis of relief types.

After analyzing the above-mentioned criteria of stability, for researching of the landscape-ecological framework and for creating the final product - the map of the stability of the territory, in conditions of Georgia, 5 degrees (gradations) of stability have been developed. In addition, after allocation of gradation (degree) it is specified the **form of use** of this territory (in our case of stable territories) from the economic point of view.

1) Stable territories – The slope of surface - 0-10°; The migration regime - autonomous and superaqual; The geological structure - crystalline rocks; The geodynamic processes - are not observed; The exposition - north; The current state of the landscape - practically unchanged; The complexity and power of the vertical structure of the NTC - very complex and powerful; The power and mechanical structure of the soil - powerful and loamy; The degree of humidity - insignificant or insufficient; The relief type - low and mid-mountain accumulative.

Economic form of use – Any actions within critical-ecological limit of the territory.

2) Average stable territories – The slope of the surface 11-20°; The migration regime - trans-eluvial and eluvial-accumulative; The geological structure - crystalline and metamorphic rocks; The geodynamic processes - almost are not observed; The exposition - north and north-western; The current state of the landscape - slightly changed; The complexity and power of the vertical structure of the NTC - complex and powerful; The power and mechanical structure of the soil - medium-complex loam; The degree of humidity - insignificant or insufficient; The relief type - low mountain erosive-accumulative and mid-mountain denudation.

Economic form of use – Any action conditioned by a social need, with an average intensity.

3) Less stable territories – The slope of the surface 21-30°; The migration regime - trans-eluvial and eluvial-accumulative; The geological structure - metamorphic rocks; The geodynamic processes - is presented in form of small fragments; The exposition - north-western and north-eastern; The current state of the landscape - average changed; The complexity and power of the vertical structure of the NTC - average and medium-powered; The power and mechanical structure of the soil - medium-powered and loamy sand; The degree of humidity - normal; The relief type - mid-mountain erosive and erosive-denudation.

Economic form of use – Certain actions conditioned by a social need, with a low intensity.

4) Average unstable territories – The slope of the surface 31-45°; The migration regime - trans-eluvial; The geological structure - metamorphic and easy breakable rocks; The geodynamic processes - have been actively developing for 10-100 years; The exposition - south-western and south-eastern; The current state of the landscape – is too changed; The complexity and power of the vertical structure of the NTC - simple and medium-powered; The power and mechanical structure of the soil - low-powered and loamy sand; The degree of humidity - plentiful; the relief type - mid- and high-mountain erosive-denudation.

Economic form of use – Certain actions, with limitations, only in case of special need.

5) Unstable territories – The slope of the surface - above 45°; The migration regime - trans-eluvial, badlands and rocky intervals; The geological structure - metamorphic and easy breakable rocks; The geodynamic processes - have been actively developing for 10 years; The exposition - south; the current state of the landscape - practically transformed; The complexity and power of the vertical structure of the NTC - primitive and small-powered; The power and mechanical structure of the soil - small-powered and sandy; The degree of humidity - excess; The relief type - mid- and high-mountain erosive-denudation and paleoglacial.

Economic form of use – Without any actions.

3 Conclusion

The above mentioned gradations are applied on the already formed landscape basis with the appropriate color, which, in its turn, is made according to the data of the NTC. In this way we get the so-called "Green" map [3].

Each gradation will have the corresponding color on the final version of the map: Stable territories - dark green; Average stable territories - light green; Less stable territories - yellow; Average unstable territories - pink; Unstable territories - red. (**Figures 1, 2**).

The presented methods of mapping the landscape-ecological framework make it possible to manage a system of forest inventory purposefully. This method were initially tested in the realities of Georgia in 2000-2010, for similar studies throughout its territories, and were got the results with the practical importance.

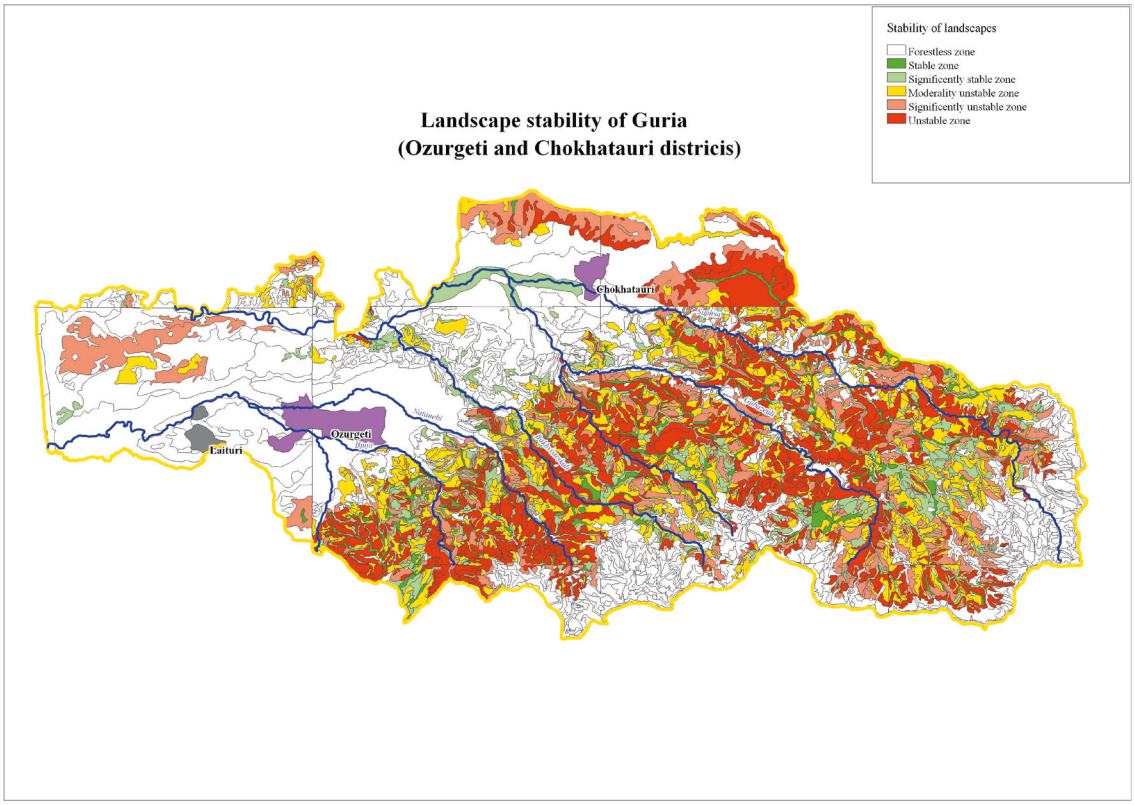

Fig. 1. The map of landscape stability of Guria

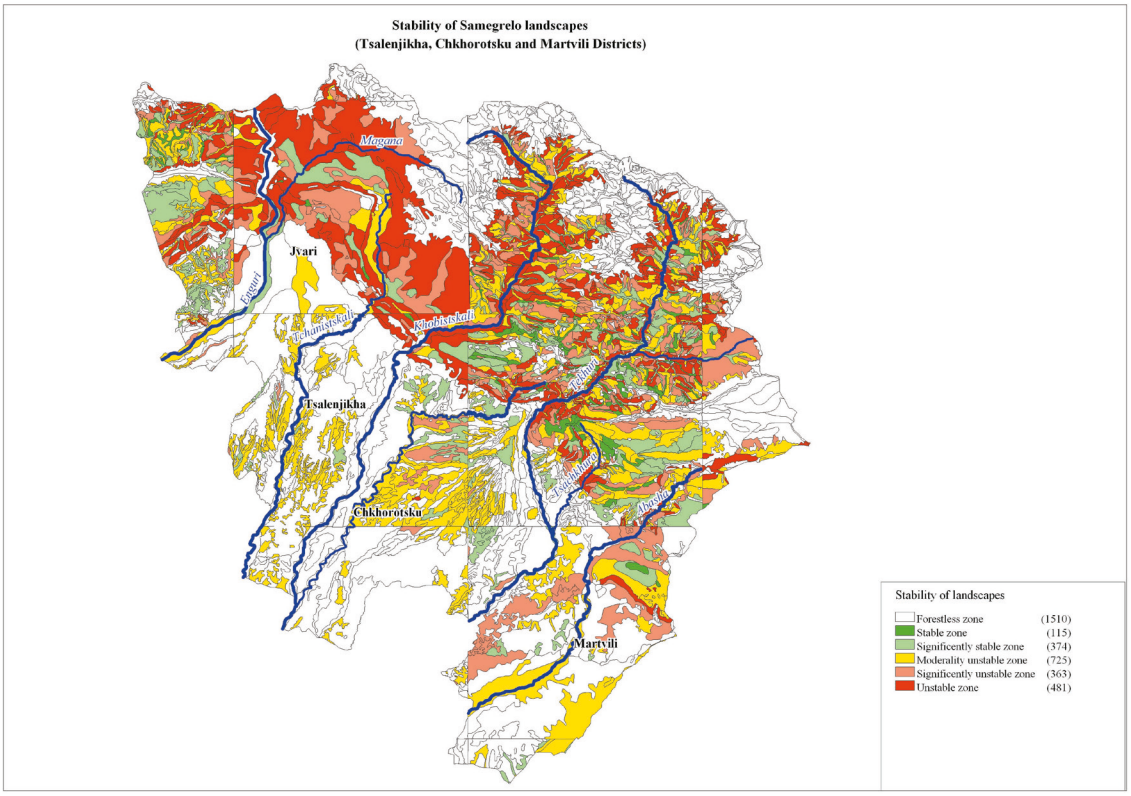

Fig. 2. The map of landscape stability of Samegrelo

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Global Programs and Conventions: Coherence and Mutual Synergies from Holistic Information Management

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Abstract. The UN Declarations and other UN Instruments texts increasingly enforce the demands for coherence and mutual synergies. This paper describes the basic elements of coherence, consequences for holistic information management across programs and conventions and rises awareness on key issues information governance needed to foster of cross-domain and cross-organizational national as well as international implementations needed for timeliness support of societal, natural, technical, humanistic and ethical aspects for the future of people and planet.

Keywords. UN Declarations and Instruments, Coherence, Information Management, Coherence, Interoperability and Information Infrastructures, Decision Support, Applied Semiotics, Situation Dynamics, Standards, Governance, Inter-Organizational Complexity Management, Ontologies, Organizations and Stakeholder Groups, Synergy effects, Clearinghouses, Observatories, Testbeds, Cartography for Operability and Abstraction, Formal Models, Implementations, Runtime Environments, Big Data, New Approaches in sustainable Planning, Implementation and Protection, Data Availability, vs. Data Demand, Data Quality Issues, Data Sharing with the Private Sector (Industries, Business, Insurances etc.), Complex Data Visualization for Decision Support and Operations Control, Comparability Issues

1 Introduction

The requirements for coherence are defined in the texts of the core and neighboring UN Instruments (Transnational Declarations, Conventions, Treaties, Frameworks and Directives) : UN HABITAT, UN Sustainable Development Goals SDGs, UNDRR Sendai Framework on Disaster Risk Reduction, UN Framework Convention on Climate Change, International Platform on Biodiversity and Ecosystem Services IPBES, Human Rights, Children Rights, IPCC, UNDP, UN World Food Program, and many others.

2 Coherence

On the operational level, syntactic, semantic and pragmatic coherence (full semiotics coherence, that is on syntax, semantics and pragmatics level [PEIR], [MORR], [KRE06], [SCOT]) needs to be achieved on local, regional, national and international levels. We know about the benefits of processes in technical agreement on specifications and semantic meaning ("are we talking of the same or of different facts") that also assist other levels of coherence to benefit from our technical diligence.

Pragmatics Models

- Processes
- Web Service Compositions
- Workflows
- Action Models
- Behavior Models
- Event Chains
- Dependencies

applied in the formal ontologies for the management concepts of dynamic situations and operational decision and action, as well as in modeling goal reaching

Fig. 1: Pragmatics Models

UN Instruments Coherence

- Textual / Legal / Policy Coherence
- Administrative Coherence
- Information Management and Technical Coherence (full semiotic interoperability)
- Cross-Border Coherence
- Coherence with state-of-the-art Professional Management Practices (interdisciplinary) and Standards

Fig. 2: Basic Domains/Types of Coherence

It would be more adequate if cross-organizational data demands for each of the specific requirements of the UN Instruments would soon find its adequate attention in comparison with the current statistics data discussions especially not only for operational but for strategic issues (indicators). The overlap between Geoinformation combined with Statistical Information and all the vast amount of data needed for operational management is marginal.

- Gaps in cross-organizational data availability, incompatible data quality and missing interoperability are well-known today to disable best possible decisions and services in all types of countries.
- The holistic view of Big Data availability and cross-organizational interoperability still needs to find adequate attention by UN Instruments Information Management Governance.

Initializing and implementing basic processes for cross-instrument information governance will start setting elementary boundary conditions (as required in the texts of UN instruments).

Besides the general way of procedure for accomplishing or approaching particular (selected) aims in a systematic way, much more attention should be devoted to all those situations, where suboptimal information management and, in consequence, avoidance of substantial deficits in natural, technical sustainability as well as in humanitarian disasters.

Future research and development in those areas will bring a significant contribution to all the cycle of sustainability analysis and the sustainability management areas only if the inherent complexity of interdisciplinary/cross-organizational data, data analytics, data transmission and use processes, and sophisticated ontology models for situation prediction along with consequences scenarios for all types of actors is based on standards and Information Infrastructure principles [BSD], [KOSO], [SOUS].

Infrastructure efforts are guided by joint commitment and requirements specifications of actor organizations (public administration, civil society and private sector). Transfer and adaption/extension of concepts that have been proofed adequate for large-scale information infrastructure realization are in due need for the corresponding elements of good governance [IGOB], [IGOV], [SMAL].

UN Instruments information in its complexity is in due need of very broad systematic integration, processing, evaluation and goal oriented applications of large amounts of data of heterogeneous origin in real time. Big Data offers the appropriate technology to integrate data from the various sources, to analyze it and to make it available for decision processes and operations support [LACH], [ZIEM].

Establishing Cross-Organizational Information Infrastructures

- Catalog of Information Sources Metainformation
- Improved Data Access (Time and Cost Savings)
- Enable and Improve Data Exchange between different Institutions and Application Domains
- Consistent and Efficient Use of Data
- More Efficient Development of Services using existing Data and Standards
- High-Quality Data for Action Alternatives and Decision-Making Support
- Service-Level-Agreements (Preparatory and Operational)
- Improvement of Strategic, Tactical and Operational Decisions
- Possibility of Decision-Making about Policies (Administration, Jurisdiction etc.)
- Including the Private Sector
- Facilitating the Development of Knowledge Generation, Communication and Comparison
- Comprehensive Documentation and holistic Ex-Post Analysis
- Analysis Across all Phases of Planning, Implementation, Operation and Control of Goal-Reaching Effects

Fig. 3: Establishing Cross-Organizational Information Infrastructures

Application of informatics state-of-the-art methods and technology that meet the demands of complex multi-actor and cross-organizational information management is urgently required for organizationally as well as technically implementing Treaties, Frameworks and Programs and for granting coherence in the required holistic way.

3 Information Governance Based on Management Principles

The complete set of management best practice methods especially supports the principles of "critical thinking", enabling extensive reporting, transparent analysis, compliance to regulations and other boundary conditions, and constructive goal-reaching control [SMITH]. These control obligations include phases of retrace, audit, reexamination, analysis, avoidance of malpractice, and indications on weaknesses/vulnerabilities.

Some of the core management procedures listed (e.g. audits) have to be assigned to independent organizations mainly because of the general public interest of consequences in Information Management accountability [AA99] (following basic principles of European Court of Auditors [ECA]).

Basic Management Principles

- critical thinking
- gaps and deficits analysis
- decision, action, and control cycle support
- transparent analysis
- control and extensive reporting obligations
- compliance to regulations and other boundary conditions
- consider phases and techniques in enabling of retrace
- include detailed financial structures, budgets and the use of financial instruments in reporting and control
- constructive goal-reaching and effectivity control
- guidance on human resources (quantity, future competence levels)
- operations concept
- reexamination, analysis
- avoidance of malpractice
- extend concepts of FAIR information principles [FAIR] to support transparency goals and accountability
- indications on weaknesses/vulnerabilities

Fig. 4: Basic Management Principles

One of the major complex interdisciplinary aims to accomplish is the development and implementation of good praxis of cross-organizational information flows, including detailed documentation (including standards for cross-organizational information storage and persistent/long-time accessibility).

Besides multi-stakeholder inclusion and discussion in the development of strategies, implementing a concept of follow-up roadmap / action-plan is to be anticipated already in preparatory phases:

- negotiate for standards for situation/action phases definition
- make Information Mangement elements a prerequisite of comprehensive reporting (cf. [DIER], [COOP]) and (annual) National Reporting (National Focal Points for UN Instruments)
- specify a priori documentation requirements according to UN Instruments extensive requirements,
- enable content search by timestamp, time period, content or actor group involved (define information management elements in strong anticipation of information use)
- check with all stakeholders for potential fraud in decisions and actions in operation [LACH] as well as in administration, financial and private sector domains
- implement awareness on best practice ethical principles

3.1 Information Governance Domains for UN Instruments Implementation

The basic an most pervasive requirement of achieving coherence between UN Instruments can be achieved technically by establishing semiotic compatibility [KRE05], [KRE6], [LOLL] between information systems as well as integration of different data cultures.

Information Governance Domains for UN Instruments Implementation

- Big Data
- Software Methods, Techniques and Use Cases
- Cross Border / Cross-Organization Data
- Cloud Computing and Hosting
- FAIR Information
- Compile R&D deficits and Shape Appropriate Funding Programs
- Web Services, Functions, Processes
- Human Rights
- Internet Ethics & Regulations

Fig.5: Information Governance Domains for UN Instruments Implementation

Information Governance Initial Boundary Conditions

- Improve Participatory Information Governance by applying basic principles, methods and techniques of Complexity Management.
- Current national focal points for national/regional Implementation of UN Conventions and other UN Instruments in many cases do not have adequate mandate and capabilities to address Information Management at the complexity level that is required from the UN instruments' texts.
- Clarifying the different levels of Multi-Stakeholder Information Governance (Strategy, Management, Operations, Standards, Compliance, Accountability, Decision Making, Politics, Media, etc.).
- Participation in the negotiations of structure, specification, running and multi-actor operational use of national / EU wide information system of disaster / safety / security research [FEFI].
- The term "Business Process" is not limited to the private domain. Any kind of command flow, workflow or information flow can be considered and modelled according to the principles of digital Business Process Modeling BPM [WESK].
- Managing the increasing speed and complexity of situations.

Fig. 6: Information Governance Initial Boundary Conditions

4 Challenges in Applied Informatics

In addition to current basic efforts in cross-instrument information coherence, future technical implementations have to clarify the decisions on choice and potential change of innovation levels as well as corresponding management methods and techniques in the fields of

- Cloud Computing and Hosting
- Situation Documentation
- Clearinghouses, Observatories, Testbeds
- Probabilistics, Fuzzy Knowledge, Error Propagation, Reliabitity
- Cartography for Operability and Abstraction
- Cultural Issues
- Formal Models, Implementations, Runtime Environments
- Synergy effects

Complex cross-domain information models typically comprise a large number of variables and complex dependencies of functional, analytical, and operational boundary conditions (resources, time, space, actions) [FARY], HEDE], [HL01], KOSO], [SOUS].

The appropriate complex model construct is situational [FARY]. Scenario techniques allow for the derivation of variations in decision alternatives and comparison of consequences [LACH].

The Complexity Challenge

- Complexity and Dynamics of Facts
- Complexity and Dynamics of Contexts
- Complexity of Actors
- Complexity of Organizations
- Data Capturing and Data Analysis
- Data-Driven Understanding of Our World
- Decision-Making Support and Control
- Thresholds, Triggers
- Signals, Alerts
- (Re-)Action
- Processes, Services, Workflows
- Goals Definition, Implementation and Goal-Reaching Control
- Consequences

Fig. 7: The Complexity Challenge

There are web-based scenario tools available that allow public users to vary facts and contexts for variation investigations, but it is not clear to what extent actors (being non-expert with regard to data and model) would be able to draw reliable information from such tools.

Information models underlying UN Instruments implementations must be communicated. The whole communication process requires substantially more investigation in order to become reliable and efficient enough to achieve the overall goal of better understanding, decision making, and action in cases of UN Instruments joint efforts for sustainability and humanitarian situation improvement.

Aggregates of certain parameters must be visualized in a more or less standard way (agreement on visual style and cartographic models) to prevent multi-actor and multicultural misunderstanding or misinterpretation.

Structural and algebraic properties have to be analyzed with respect to numerical / functional procedures of analysis may not be allowed within or between incompatible data subspaces.

Structural and Algebraic Properties of Data Spaces

- Dimensionality of those datasets that represent multiple models of the information spaces involved
- Conceptual differences in dimensionality of fact spaces dynamics in space and time
- Dimensionality refers to the degree of non-independence in the spatial or temporal variation among multiple measures
- Algebraic properties of data spaces (denseness, homogeneousness, isotropy, continuity, differentiability)
- Algebraic properties across different layers of abstraction
- Inverse problems

Fig. 8: Structural and Algebraic Properties of Data Spaces

4.1 Demands and Emerging Trends in Information Modeling and Analytics

Some of the demands of urgent innovation in information modeling and analytics are identified but lack information governance with respect to the complexity and very high interdisciplinarity of the Semantic Mapping problem space touched in this paper. One of the basic governance tasks is to create the appropriate management framework, implement the management framework, organize recursive control and give permanent guidance. This becomes especially evident in humanitarian support situations logistic support [CHON].

- The topic "Information Flow" was confirmed for need of much broader attention on all cross-UN-Instruments information management discussions and developments (all phases, all actors as well as law-enforcement agencies from local to global level)
- Currently there is insufficient (inadequate low) concern about intra-domain and cross-organizational logistics aspects
- "Logistics" is not limited to goods- and transport logistics. Cross-organizational / cross-domain logistics needs in humanitarian contexts comprise ensuring coordination, information management, and access to logistics services in all management as well as in operational tasks.
- Digital technologies are available but lack broad operational implementation. Strategic challenges from political and government domains (National/International Digital Agenda (e.g. [EIF], [DAE]), setting UN Data Revolution concept [REVO] into action etc.) have not yet been adequately checked and managed for operational implementation goals on national, international and global level.

- Command Support Systems: cross-level and cross-organizational integration is widely missing. Joint projects and development in the fields of civil-military cooperation can not only improve shared information processing but also raise awareness in the benefit of building on sound management principles [CONS], including prerequisite competences education and development especially for the huge variety of administrational / organizational public and private sector units involved.
- One of the fundamental prerequisite in support of information analytics, decision support and operational action is the uptake of details (bottom-up) to enhance semantic mapping (intra-domain and especially cross-domain / cross-domain and cross-organizational).

Information Systems Basic Components

- measuring, survey
- documentation
- provision of information
- transmission
- ontology generation
- semantic and procedural (semiotic) networks
- meta-models and implementation
- (large) ontologies mapping
- licensing implementation
- interoperability
- testbeds
- analytics
- processing
- decision support
- FAIR information
- archiving and access
- long-term availability

Fig. 9: Information Systems Basic Components

5 Recommendations and Urgency of Action in Terms of Information Governance

There are some key future demands in applying appropriate Information Management Principles for implementation of UN Conventions and other UN Instruments under requirements of coherence:

- The term "Coherence" needs to be treated in a really complex and scalable way.
- Private sector sensibility for benefits from joint preparedness, planning, implementation and protection of sustainable and humanitarian action operational guidance needs to be raised.
- "Accountability" / comprehensive Reporting needs to include financial transfers and use audit/control existing standard procedures.
- Documentation of liability risks (in anticipation and/or from practical experiences) enables fruitful discussions in all realization/implementation phases, all regional levels and between actor groups.
- Data privacy issues are of growing concern but can adequately be handled in the information systems specification, structure, design, implementation and operation.
- Current concepts of Science Data Information Infrastructure do not meet the various (full management) challenges of the complex structure of public sector and private sector organisations that since long time work on massive information on various levels of responsibility and obligation.

- Implementation of restrictions to information use and limitations of information validity / storage periods have to be considered from the start (holistic view guiding incremental implementation concepts), including appropriate formal ontological modeling, annotation and testbeds
- Information Governance is a process to be organized and implemented in a permanent, multi-stakeholder way. Information Governance coordination will essentially benefit from cooperation with National Focal Points for UN Instruments, especially in the domains of

    a. Foster exchange on best practices across stakeholders/practitioners and increase public awareness. Exchanging views, building alliances, identifying problems in implementation and possible actions to address them. Making available to public and private organizations, the existing practical tools, testbeds and approaches, guidelines and criteria; offering the opportunity to frontrunners to share their experience, including on key issues such as transparency and traceability; contributing to the development of guidance for implementation.

    b. Track progress, risks and opportunities, regularly taking stock of progress and reflecting on possible adjustments or additional measures to strengthen implementation and goal-reaching efforts.

The various levels of competences needed in organizations (especially in law enforcement agencies) as well as in guiding / reporting units (also including National Focal Points for UN Instruments) should be carefully considered and not be underestimated.

In terms of management there is also urgent need to estimate long-term consequences of current suboptimal information governance and coherence establishment with respect to regional/national/cross-national and global implementation of UN Conventions and other UN Instruments.

This it is mainly a challenging and creative task domain for practitioners and organizations in charge. Science partnership is essential in all phases.

It is Our Future: Multi-Stakeholder Governance guiding principles [COBA], structure, participation and practice for Implementation of Conventions and other Instruments is imperative. These efforts are not just for the operational demands of technicians and administrators, they are essential for Society at large.

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