Effectiveness of technology

One of the priorities of country's social development is the poverty eradication. Main result of land degradation is the aggravation of poverty among indigent part of population, resulting from the significant decrease in soil fertility. Hence, it's obvious that the offered technology could make important share in implementing the priority direction of country's social development.

The progress in agriculture always has been one of major priorities for the Georgian government. Latterly this traditional sector of economy has drown particular attention, resulting in the realization of different serious projects. However, in these activities less consideration is given to the problem of land degradation and to technologies of its prevention and holding up, getting particular importance at the background of climate change in Georgia. Implementation of this technology will contribute to the sustainable development of agriculture sector in Georgia.

The combat adverse results of climate change is one of priorities of Georgia's Environmental Action Plan-2. One of the most important resources endangered by climate change is the agricultural land. The project will facilitate the implementation of NEAP-2.

Proposal III

Proposal for rehabilitation, renewal and optimization of irrigation systems in Kakheti region

(River Alazani Basin)

River Alazani basin borders on Southern slope of Caucasus mountain ridge at the North and on Kakheti and Tsiv-Gombori ridges and river Iori plateau at the South and South-West. At the South-East the basin borders with Azerbaijan. Three types of relief can be distinguished within the basin: steep slopes of the bordering ridges, foothills, slopping parts of the valley, which are mainly built with external cones of materials brought down by the river tributaries, and plain parts of the valley.

River Alazani takes origin on Southern slope of the Caucasus ridge at the altitude of 2750 m. The segment from the source to the joining point of the tributary Samkuristskali is called Tsiplovnistskali by local population, while the rest of the river is called Alazani. Near village Kortabude, the river comes out from a narrow canyon and runs 18 km over the wide Pankisi ravine until joining river Ilto. After that it runs to South-East over the Alazani valley and after joining the river Agrichai it changes its direction and runs to the South, enters Azerbaijan territory and flows into Mingechauri reservoir. Dry gorges can be found in the South-Eastern part of the right side of the river.

Total length of the river is 390 km, total basin area is 16 920 km2, average altitude – 850 m, total dip – 745 m, average tilt – 2,12 %. The basin comprises over 500 rivers with total length of 1 770 m.

Significant tributaries: Ilto (length – 43 km), Khodashenistskali (31 km), Stori (38 km), Turdo (28 km), Lopota (33 km), Chelti (28 km), Kisiskhevi (37 km), Duruji (26 km), Chermiskhevi (35 km), etc.

Left tributaries of river Alazani, which flow down on Southern slopes of the Caucasus, are characterized by abundant waters, narrow and deep canyons, plural rapids, and waterfalls. They strengthen depth erosion processes, bring down big amount of sediments, develop external cones, and dividing into smaller branches, join river Alazani. Right side tributaries are less water abundant and characterized by lower dip.

Mountainous part of the basin is built by sand-stone material and clay-shale, which are most frequently represented on the left side of the river. Limestone and partly marl is mostly represented on the right side. Main rocks are covered with clay rocks and ground.

Water regime of river Alazani and its tributaries has been studied since 1912 at 26 hydrological stations. For the time being only one station is operational – station Shaqriani.

Feeding sources of the river are: ground waters – 40 %, rain waters – 31 %, and snow – 29 %.

Water regime of river Alazani can be described as: floods in springs, stable little water period – in winters, freshets – in springs and during rainfalls in summers.

Water flow of the river and its tributaries is not evenly distributed during the year: 37 % - in springs, 31 % - in summers, 21 % - in autumns, and 11 % - in winters.

Water resources of the river (within the territory of Georgia) are assessed as 3.10 km3 (570 mm). Module of water-flow along the river flow fluctuates within limits of 49.9 – 9 00 l/sec km2.

Left tributaries of river Alazani, which flow down the Southern slopes of the Caucasus, are distinguished by water abundance. Mudflows are common for both side tributaries of the river.

The whole basin is divided into 5 hydrological districts. The districts are defined by average altitude of the flow.

Water balance: precipitations – 800 mm, evaporation – 470 mm, water flow – 330 mm, ground water flow – 135 mm. River Alazani has a relatively favorable water balance structure. Losses (sum of the surface water flow and non-productive evaporation) are assessd as 66 %.

Orography of the river Alazani basin and the dominating directions of air masses (West, South East) define climate peculiarities of the area. The basin is surrounded by high ridges from three sides that protect the valley and foothills from entering of cold air masses. The basin area is open at South-East that allows entering warm air masses that influence its thermal regime and forms specific climate features in general. Air masses entering from both sides provide for development of abundant atmospheric precipitations.

Soil cover of the river basin is very diverse. There are represented laptosols of loamy and clay composition, dystric cambisols, brown forest acid soils, and eutric cambisols.

Alluvial carbonate soils are represented on the left side, while alluvial carbonate free are on the right side of the river. Meadow brown, brown, brown leached soils with heavy clay composition are represented on Tsiv-Gombori North-West slopes.

Water of the river is low mineralized and used mostly for irrigation.

Alazani region has one of the most significant economic potentials for Georgia. Viticulture and vine growing are the main profiles. Grain crops and animal breeding are also quite important for the region. As agriculture has a defining role in economy of the region, food production is also developed there, main sector of which is vine production. Oil and gas extraction should also be noted, as well as extraction and processing of limestone, marble-shale, woo, etc.

Kakheti region has a high potential of tourism development. It has rich and diverse natural and cultural-historical resources. Number of tourists and visitors and the related income has been increased by 50-60 % during the last several years.

Almost whole region is supplied with electricity. All municipal centers and a part of rural population (25 %) are supplied with natural gas.

Four hydro power stations are operational in Kakheti region: 'Khadorhesi' in Akhmeta district, which develops 24 megawatts in case of full-capacity operation; 'Intsobahesi' in Kvareli district with capacity of 1 megawatt; 'Kabalhesi' in Lagodekhi district with capacity of 1,5 megawatts, and 'Alazanhesi' in Gurjaani district with capacity of 1,5-2,5 megawatts.

Contemporary climate change during the last four-five decades has been revealed in East Georgia in increased temperature and decreased precipitations. River Mtkvari water flow has been decreased by 25-30 % to compare with 1940. Taking into account an increased pressure of anthropogenic factors, all above mentioned factors together contribute to desertification of arid areas of the region.

Though there are different data (often controversial) on hydrological processes, in case of global warming, the following scenarios could take place in the region: annual distribution of water flow will be enduring significant changes, rather than annual water flow total amount; water flow of comparatively low water period will be decreasing and the water flow of a high water period will be increasing; frequency of freshets will be increasing, while their intensity will be decreasing.

Based on forecasted trends in the frame of climate regional model – PRECIS, the climate change influence on water flow of upper Iori and Alazani rivers has been assessed according to changes of temperature and precipitations. In accordance with the obtained results, water flow of river Alazani will be decreased by 10% by the end of 21st century. Taking into account the last period climate changes in the region and due to the increased frequency of droughts, some preconditions for developing of desertification processes have been created in East Georgia (including Kakheti).

According to the developed forecast, by the end of XXI, a hydro-thermal coefficient will be decreased fro 11 to 0,7 in Southern part of Kakheti (Dedoplistskaro Municipality). Such changes can transform the dry sub-tropical region into a strongly arid category. Obviously, these changes will more or less cover whole Kakheti territory. Warming processes will affect (prolong/change) the duration of vegetation period and increase water consumption for irrigation purposes. Besides that, it should be noted that annual distribution of water flow in this region is not synchronized with the irrigation water consumption.

Desertification processes have been even more intensified due to destroying of irrigation systems, intensive use of winter pastures, and by cutting of wind belts. Rehabilitation of irrigation systems is one of the first priorities for detaining the above mentioned processes and one of the most effective adaptation measures to resist the climate change processes.

Since 90s of XX century in Georgia, the existed irrigation network has been significantly decreased and correspondingly, the irrigated areas. For the time being the system is being rehabilitated all over the country, but it is still very small to compare with 90s. For example, the upper Alazani irrigation system covers area of 22 464 ha, while in 90s it covered 44 300 ha. The lower Alazani system covers now 20 071 ha, while in 90s it covered 34 426 ha.

Kakheti irrigation systems in whole do not meet modern technical requirements. Efficiency output of the most of them do not exceed 0,4-0,6 values. Around 60 % of total water is lost due to filtration, 20-25 % - due to technical reasons, and 3-5 % - by evaporation from the surface.

Kakheti has a leading position in agriculture of Georgia. Main part of the population (> 80 %) is involved in agricultural activities and the region in whole is a typical agricultural region. Taking into account natural conditions of the region, it is necessary to provide its lands with artificial irrigation. Around 150 000 ha have to be irrigated in Kakheti, though actually, technical conditions allow to irrigate only 50 000 ha of lands. Besides that, due to expectable changes which could be caused by global climate change, necessity of the development of new types of irrigation systems and correction of existing technologies is quite evident. The trends of extension of areas which would need to be irrigated should also be taken into account.

Irrigation Systems Operational in Alazani Basin

Upper Alazani Irrigation System covers area of 22 464 ha. It is 78 km long. It takes start in Pankisi gorge near village Doe. The last point is located near village Velistsikhe of Gurjaani district. The roundabout 8 km long Kalaur-Velistsikhe pipe is destroyed and does not operate at all.

Naurdali Irrigation System covers 5 273 ha of irrigation area. It irrigates the villages of Telavi Municipality: Pshaveli, Saniore, and Napareuli. The system length is 11 km.

Lower Alazani Irrigation System covers 20 071 ha of irrigation area. It is 95 km long. It takes start in village Kondoli of Telavi district and ends near village Zemo Keda of Dedoplistskaro Municipality.

For the time being, almost all irrigation systems are more or less operational, but they do not operate with full capacity. The Lower Alazani Irrigation System is in comparatively better state. The Upper Alazani Irrigation System operates with interruptions and only as far as Gurjaani Municipality. In case of implementation of the mentioned project, up to 70 000 ha of the area of valleys vulnerable to droughts, such as Taribana, Eldari, and Iori, will be provided with irrigation. For the time being, rehabilitation of Upper Alazani Irrigation System is under way. A project on rehabilitation of Zilicha System, which would cover up to 2 400 ha of area vulnerable to droughts is already developed.

The most rational way of artificial irrigation for Alazani basin is arranging gravity flow channels with mechanic water-lifting facilities, artificial raining aggregates and droplet systems. For the time being only surface gravity flow technology is used. Main part of Kakhety plain is almost fully provided with gravity flow irrigation channels (including those to be rehabilitated).

The Gravity flow irrigation can be used in areas, tilt of which does not exceed 0.02-0.03. In case of mountainous relief, if the tilt is over the mentioned values, irrigation is connected with a number of difficulties. That is why a method of artificial raining is more feasible in such conditions. On the right side of river Alazani (for instance in the surroundings of village Bakurtsikhe), where the orientation of network of gorges complicates the use of mechanical droplet and surface gravity flow irrigation technologies, it is reasonable to use the artificial raining technology.

Measures to be taken for the rehabilitation and optimization of Alazani Irrigation System on the background of global climate change:

1. Completion on the project on Upper Alazani Irrigation System (Duisi-Arashenda-Ole Tba-Taribana-Eldari. Main channel length – 190 km);

2. Rehabilitation of 'Zilicha' irrigation system;

3. Inclusion of Alazani-Agrichai artesian basin ground waters into the irrigation network of southern part of the basin.

4. Establishment of automatized water management systems together with water supply control;

5. Rehabilitation or establishment of wind belts for the purpose of decreasing of wind power in the areas where artificial raining method of irrigation is used;

6. Providing of irrigation systems with collection-drainage network (central ways);

7. Cleaning up of the irrigation systems/canals;

8. Inventory, rehabilitation, and liquidation of the abandoned irrigation channels and boring wells;

9. Facilitate the community mobilization process for rehabilitation of farm-based or community-based inner-irrigation systems (through involvement of local population);

10. Revising of traditional agricultural directions with the aim of assessing of cultivation of less water-demanding plants;

11. Providing trainings in standards for operation of irrigation technologies and techniques, maintaining of irrigation norms and dates taking into account agricultural requirements of separate districts and zones.

12. Vertical shifting of natural zones due to global climate change (approximately 300-400 m) and the trends of increasing of areas to be irrigated, need to be reassessed and appropriate correction of types and technologies of irrigation systems should be done. For these purposes the following action should be done:

a) Prepare cadastral maps of Alazani basin agricultural lands;

b) Develop high resolution digital model of irrigated area relief;

c) Establish the bank of orthogonal photos of Alazani basin;

d) Zoning of the basin area according to vulnerability level;

e) Zoning of irrigated lands according to irrigation technologies and techniques used and preparation appropriate recommendations.

The above given information and data treated through geo-informative technologies would allow determining: optimal configuration of gravity flow irrigation channels, optimal water flow speed which would not wash out, nor leave the sediments. Besides that, it would be possible to select proper irrigation agglomerations, and to reveal the negative forms of relief in case of using artificial raining techniques.

Treatment through geo-informative technologies of the above mentioned information would allow:

a) selecting proper irrigation agglomerations;

b) defining optimal configuration of gravity flow irrigation channels;

c) defining optimal water flow speed which would not wash out, nor leave the sediments;

d) revealing negative forms of relief in case of using artificial raining techniques

Preliminary costs of these activities assessed through different sources are provided in the table below.

Table of activities for optimization, reHabilitation and renewal of irrigation systems in Khakheti region considering the ongoing and projected climate change featires in Georgia.

Activity	Time for implementation (Years)	Costs (in USD)
Completion on the project on Upper Alazani Irrigation System (Duisi-Arashenda-Ole Tba-Taribana-Eldari. Main channel length – 190 km)	3	2,720,000
Rehabilitation of 'Zilicha' irrigation system	2	2,200,000
Inclusion of Alazani-Agrichai artesian basin ground waters into the irrigation network of southern part of the basin.	1.5	2,000,000
Providing of self-flow irrigation systems with collection-drainage network Establishment of automatized water management systems together with water supply control	1	150,000
Cleaning up of the irrigation systems/canals	1	500,000
Facilitate the community mobilization process for rehabilitation of farm-based or community-based inner-irrigation systems (through involvement of local population)	3	150,000
Inventory, rehabilitation, and liquidation of the abandoned irrigation channels and boring wells	1.5	150,000
Revising of traditional agricultural directions with the aim of assessing of cultivation of less water-demanding plants	1	300,000 Feasibility study (could be covered by different sgricultural projects under the climate change)
Vertical shifting of natural zones due to global climate change (approximately 300-400 m) and the trends of increasing of areas to be irrigated, need to be reassessed and appropriate correction of types and technologies of irrigation systems should be done. The following actions should be implemented:	2	300,000 Feasibility study (could be covered by different projects under the climate change)
a) Prepare of cadastral maps of Alazani basin agricultural lands	2	200,000 Public Registry
b) Develop high resolution digital model of irrigated area relief	1	10,000
c) Establish the bank of orthogonal photos of Alazani basin	1	Included in feasibility study in (a) Public Registry
d) Zoning of the basin area according to vulnerability level	2	200,000 Feasibility study
e) Zoning of irrigated lands according to irrigation technologies and techniques used and preparation of appropriate recommendations	2	Part of feasibility stady above
Rehabilitation or establishment of wind belts for the purpose of decreasing of wind power in the areas where artificial raining method of irrigation will be recommended	3	2,000 (per hectar including the maintenance cossts for the first three years)
Providing trainings (including practical training on site) in standards for operation of irrigation technologies and techniques, maintaining of irrigation norms and dates taking into account agricultural requirements of separate districts and zones	1	50,000 Private services established locally and technology providers
System monitoring and annual monitoring		4,000-5,000

Barriers to the succesful implementation of the proposal

- **Information about market availability and technology standards**. Technical appliances for drip irrigation – water distributing and regulatory systems should be bought at the international market. Good technical knowledge and practical experience in operationalization of such systems is necessary for selection optimal for the specific site system. Such knowledge and service is not in country and therefore consultant from outside should be invited each time increasing with this the transaction costs of the project.
- **Operationalization of modern technologies**. Modern drip irrigation systems has irrigation process auto-regulatory functions as well which is very important in case of Georgia due to the negative attitude from stakeholders having in mind the negative (soil salination) past experience caused because of improper operationalization of systems.
- **Energy supply**. Irrigation systems using energy are not economically feasible in Georgia yet. Energy consumption in irrigation increases the production cost which affects the price and makes product uncompetitive at the market.
- **Ownership**. This is expensive technology and has high financial risk for one farmer.

Extreme Geological Events

Proposal IV

Long-term Forecasting (25-30 years) of Spatial and Temporal Development Trends of Hazardous Geological Processes (Landslides, Mudflows, Erosion) in Ajara region on the Background of Global Climate Change

Project Goal and Activities

On the background of global climate change and increased intensity of earthquakes all over the planet, the elemental catastrophic geological processes in Georgia, like in many other mountainous countries, impacted over 70% of the territory of the country, as well as all human activity fields – social and economical, demographical, ecological, etc. It became urgent to recognize that these processes should be managed at national level. For the management of catastrophes it became necessary, first of all, to create an effective early notice system. The system must have been based on reliable long-term forecast of the spatial and temporal development trends of elemental geological processes. For these purposes in 1997 the President of Georgia issued a special Order (N66) on the development of long-term forecasting of elemental processes. Unfortunately, due to lack of financial resources, this very important problem is still not solved.

Development of the long-term forecast of geological elemental processes depends on availability of completely different comprehensive information, such as geological, climatic, ecological, geo-physical, agrarian, urban, engineering-ecological, and etc. data. This information should be processed, analyzed and generalized, that require special knowledge in modern methodologies and relevant soft ware. It is evident that different specialists of different fields should take part in selection and processing of risk factors which can provoke natural and anthropogenic geological elemental processes.

As far as the development of long-term forecast for whole Georgia would take at least 3 years and cost around 300 000 USD (relevant soft ware not included), it would be reasonable to develop the long term forecast only for Ajara region, which is recognized as the most vulnerable region in Georgia towards elemental processes. Besides that the region is distinguished by heavy anthropogenic press and especially high sensitivity to climatic conditions, by large scale activation of elemental geological processes.

Taking into account that this region is under special attention due to its economic development potential from one hand, and due to actual risks to population, engineering and economic facilities from the other hand, minimization and wherever possible, avoidance of such risks gains special importance in the country general strategy.