- Plan for efficient maintenance of implemented technologies and measures should be developed;
- Recommended measures should be implemented in step-wise approach giving higher priority to the most vulnerable segments

Agriculture

Proposal II

Measures to combat soil water erosion in Adjara

Overview of the region

The Adjara region, with the territory of 2,900 km2, is situated in extreme South-Western part of Georgia at the slopes of Meskheti and Shavsheti Ranges. To the West it borders the Black Sea, and to the South-Turkey. 80% of the territory is occupied by mountains, 15%-by foothills and 5%-by lowland. There are 16 rivers and 5 small lakes in Adjara. The largest rivers are Chorokhi, pouring from Turkey and Adjaris-tskali, crossin the region in longitudinal direction.

Despite the relatively small area, the climate and landscapes of Adjara are very diverse. Lowland with humid subtropical climate is covered by thick wet forests with evergreen underbrush, foothills and mountain slopes - by deciduous and coniferous forests, at higher elevation transforming into alpine meadows. Mean annual air temperature varies between 10 and 15 0C, and the annual sums of precipitation-between 1000 and 2800 mm. At the top of Mt. Mtirala in 15 km from Batumi the annual precipitation reaches 4000 mm.

According to 2009 census, the population of Adjara is 380.2 thousand, and for the last decade this number has slightly increased by 2.5%. Adjara is most densely populated regions of Georgia. The average density of population makes 129 persons/km2. The territory of Adjara is devided into 5 administrative districts (municipalities) with centers in Keda, Kobuleti, Shuakhevi, khelvachauri and Khulo. The largest city is the capital of Adjara-Batumi with 32% of total population. A 48.4% of total population is rural population. The level of unemployment is 22.1%, and the poverty level-35.1%.

Adjara's economy is closely tied with its natural resources that are represented by the sea-shore recreation potential, subtropical climate favorable to citrus growing, forest and virginal landscapes, and vast water resources conditioned by the abundant precipitation. Correspondingly, main sectors of region's economy are agriculture and fishery, tourism and recreation industry, processing industry and construction. Agriculture and tourism are leading industries. A 16% of population is self-employed in agriculture sector which is third after processing industry and construction.

Forests occupy 162.2 thousand ha (56% of Adjara's total territory), that facilitated the creation of Kintrishi Nature Reserve in the central part of the region and Mtirala Nature Reserve in the western mountainous part. There are 42 registered mineral springs with the total daily output of about 1300 m3. Five hydropower plants operate in the region with total capacity of 23.5 MW.

Problem description

In spite of the diversity of natural resources and huge potential for their use, there are many still unresolved problems, hampering the successful development of Adjara's economy. According to the document "Regional Development Strategy of Adjara" prepared in cooperation with the UNDP main problems identified by the project are:

- Migration of population to other regions and countries. According to the data provided by the IOM (International Organization of Migration) more than 13% of population was migrated from Adjara region because of fragile geological situation in high mountains. Main reasons of migration;
- High level of unemployment and poverty of population;
- Land erosion in the seashore line caused by the permanent sea level rise;
- Increased frequency of landslides, affecting settlements and causing the mitigation of population;
- Land degradation caused by soil water erosion at the slopes in mountain zone;
- Inferior environmental legislation basis, among them in the field of land resources management;
- Absence of integrated management system for the sea coastal zone;
- Absence of the regional programme on land protection;
- Inadequate development of region's rich hydroenergy potential;
- Unsatisfactory state of problem water supply to population and treatment of waste water in cities.

Hence, it could be seen that majority of listed above problems are associated with the state of agriculture in Adjara, as it is one of the most vulnerable to climate change sectors of economy.

State of agriculture in the region

The variety of climate zones and soil types determines the diversity of agricultural production in Adjara. Main directions in agriculture are citrus-growing, fruit-growing, vegetable-growing and animal husbandry. Traditional directions are viticulture, fishery, grain-farming, bee-keeping, and auxiliary directions – tea-growing, silkworm breeding, tobacco-cultivation, medicinal plant-growing.

Citrus plants occupy 5200 ha in lowland and foothill areas of the region. In recent years the annual harvest of citrus made 105 thousand ton, from which 590 ton are processed for canning.

According to official Register, tea plants occupy 5700 ha, but most part of them is weeded and obsolete. In 2004-2006 about one thousand ha of plantations have been rehabilitated and 2 processing factors are put into operation.

Fruit plants take 4420 ha, from which average annual harvest for the last 5 years varied in the range of 9-16 thousand ton. Vineyards occupy only 88 ha, and the annual harvest makes 1200 ton on the average.

In the grain-farming segment dominates maize, the production of which in 2009 made 14.9 thousand ton. From leguminous plants most popular is haricot, the harvest of which makes about 350-400 ton. Annual production of vegetables varies in the range of 12-14 thousand ton, and the production of potatoes in 2008-2009 has reached 43-46 thousand ton.

In the animal husbandry segment number of cattle in 2005-2009 has varied around 112 thousand, reaching 113.5 thousand in 2009. In the same year number of sheep and goats made 8.4 thousand heads. Gross milk production in 2005-2009 has varied in the range of 48.5-54.5 thousand ton, and the total harvest of honey has reached 306 ton in 2009.

The analysis of current state of agriculture in Adjara and the potential for its development indicates that among the positive features could be singled out the following factors:

Favorable climate and soil conditions for the production of organic and bio agricultural produce;
Unique subtropical climate conditions;
Presence of arable land, proper for cultivation;
Constantly growing requirements on the local agricultural produce;
Presence of cheap labor force;
Favorable trading regime for exporting the agricultural produce;
Multi-profile structure of region agrarian sector.

Among the negative features are to be mentioned:

Small number of large and medium-sized agricultural works;

Shortage of new technologies and low level of agrotechnology, including the use of machinery;
Depreciation of perennial plants and their sparsity;
Soil erosion processes and high density of population;
Low level of rural infrastructure development;
Low productivity and high cost price significantly caused by land erosion;
Inadequate functioning of agricultural produce collection, keeping and selling system.

It could be seen from this list that soil erosion is one of the most pressing problems in Adjara's agriculture sector and it needs to be treated with adequate care.

Soil water erosion in Adjara

Water erosion is the washing off and washing down of the surface layer of the soil by temporary flows of water (rain and irrigation). The energetic basis for the development of water erosion is the kinetic energy of rain. It is established that the amount of washed down soil particles from the slope is directly proportional to the index called "Erosion Potential of Rain" which is the product of rain kinetic energy and the maximal 30-minute intensity of rain, expressed as

$$R_{30} = \frac{E_k \, I_{30}}{100}$$

where R_{30} is the Erosion Potential of Rain (EPR) for the maximal 30-minute intensity of rain, (m•t/ha•min);

E_k - the kinetic energy of rain (m•t/ha•mm);

I_{30} - maximal 30-mm intensity of rain (mm/min).

In Georgia the mean multi-year value of EPR varies in the range of 3-120 units. Its maximum values (40-120) characterize the humid subtropical zone of West Georgia, while in arid zone of East Georgia the EPR value varies from 10 to 30 units, and in high-mountain regions of the Great Caucasus and the Javakheti volcanic Plateau the EPR drastically decreases down to 3-5 units.

According to the objectives of water erosion protection activities, different measures could be identified. They include: basic cultivation of soil, cultivation before the sowing, sowing (planting) and booking after the plants. All forms of soil cultivation, along with the main task (prevention of erosion) should carry out the soil protection function.

As it has been mentioned above, 95% of Adjara's territory goes to mountains and foothills. At the same time, the region, neighboring the Black Sea, is rich in atmospheric precipitation, that creates favorable conditions for the development of soil water erosion (SWE) processes. According to official statistics, the area of total arable lands in Adjara is 8,800 ha from which 5,300 ha (60.2%) is eroded at different degree. For the whole territory of Georgia this percentage makes 30.5, indicating the urgency of SWE problem in Adjara.

In recent years some measures have been undertaken to combat the land erosion processes in rural areas of the region. In 2004 under the special programme of the Adjara Ministry of Agriculture 5000 saplings of nut-tree were planted at the erosion endangered slopes in different mountain districts. In 2005 this activity was continued with planting 5515 more saplings of nut-tree, known for its deep root system, preventing the erosion of soil.

Objective

Objective of the proposal is to implement the technology worked out in the USA and aimed at increasing the water erosion resistance of agricultural lands soils. Considered technology implies the identification of water erosion decreasing cultivation and sowing measures for arable lands and pastures. These measures will be further recommended to the farmers and households. Selection of measures is based on multi-parameter assessment methodology conducted for each concrete plot according to its inclination, environment conditions and climate feature. Technology could significantly reduce losses in agriculture, increase the productivity of agricultural lands and promote the adaptation of erodible soils to climate change.

This technology could be recommended for the entire territory of Georgia where the inclination of plots under crops exceeds 50 and suitable conditions exist for soil water erosion. Most of all it is recommended for the high-mountain villages in Adjara, where water erosion of soil creates particular hazard to local population.

For implementation the recommended technology requires information about various parameters such as: soil erodibility factor, inclination, (EPR - erosion potential of rain) and soil tolerance which is not easy accessible for ordinary farmers and in particular for small farmers. For the implementation and dissemination of this technology it is necessary to create relevant local services in the regions, which will provide local population with specific recommendation and at the same time carry out monitoring both of obtained results and parameters reflecting climate change to guarantee the maximal efficiency of technology implementation.

In the financial aspect the technology is accessible even for small farmers, as it is relatively inexpensive. The assessment method, which is necessary to work out recommendations, is free in Internet. Certain expertise on this subject exists in the country, that requires further development.

Description of technology

The Technology considers a number of cultivation methods, serving to protect soil from erosion:

Longitudinal – contour cultivation. This method is cheapest, but effective measure, in which the soil is cultivated along the contours of an inclined slope, and not in a cross-cut manner. It has been experimentally established that compared to the cultivation along the slope inclination, the longitudinal-contour cultivation 10-15 times reduces the soil surface runoff, increases the water content of 1m deep soil layer by 10-15 mm (100-159 m3/ha) and promotes the rise of cereals productivity by 0.15-0.30 t/ha.

Deep tillage of soil. The use of this method stipulates the increase in soil water permeability and correspondingly the decrease in slope surface runoff and relevant washing down of the soil. The ploughing at the depth of 20-22 cm is considered to be normal, and at 25-27 cm and more-to be the deep tillage. The deepening of ploughed layer by 1cm results in the lessening of liquid runoff by 0.8-4.0 mm. Such wide range is related with the peculiarities of winter season and the depth of soil cultivation. For the reduction of slope surface liquid runoff, most effective is ploughing at the depth of 27-30 cm.

Deep stripe loosening of soil. Deep tillage is highly effective, but very energy consuming measure. So it could be carried out once in 2 or 3 years, usually by turns with the ordinary ploughing. At the same time, to save the expenses, instead of deep tillage it is recommended to till with subsequent deep stripe ploughing. During the spring cultivation the width of stripes equals to 1.2-3.5 m, and the distance between them makes 10-15 m. The application of these measures lessens the washing down of soil 1.5-2.5 times and increases the productivity of corn by 4-16%.

Stepped tillage of soil. The idea of stepped tillage is based upon the use of stepped form bottom of the plough to create the consecutive furrows of different depth at the soil surface, that prevents the formation of intrasoil and surface runoff. Stepped tillage allows to retain at the slope 10-12 mm of water on the average, washing down of soil from 1 ha decreases by 5.8 m3, i.e. about 7 tons per hectare, and the yield of cereals increases by 0.24 t/ha.

Swelling of ploughed area. It has been established that at slope having the inclination of more than 6-70, the longitudinal-contour cultivation does not provide the reduction of surface runoff to the minimum. Hence, during the ploughing it becomes necessary to create small swells along the furrow. For this purpose a large wing is attached to the ouyward body of the plough, which creates during the tillage small swells of soil at some distance between each other.

Shooting of soil. Usually this method is applied ring the autumn ploughing. The depth of shoots can vary from 15 to 60 cm, and the distance between them – from 100 to 150 cm. Working bodies are shooting knives, attached to the frame of the plough. This device is particularly effective in the steppe (plains) zone. The described method allows to increase the water content of the soil by 30-35 mm, lessen the soil washing off and rise the productivity of cereals by 0.4-0.5 t/ha.

Arrangement of drainage furrows. In zones of intensive development of water erosion for the prevention of soil from erosion good results are obtained through the arrangement of draining or anti-erosion furrows in the longitudinal-contour direction to the inclination of the slope. Draining furrows can be arranged parallel to the sowing with mounting of additional body at the external side of the plough, or after the sowing, using ordinary or two-body tractor plough. The distance between furrows depends on the slope inclination and the intensity of water erosion development. The more is inclination and the water erosion development risk, the less should be the distance between them.

Broken furrowing of soil. This method is conducted to regulate the surface runoff of water flowing down the slope. It is applied during the autumn ploughing, or between rows of chooppered crops, at the rime of their cultivation. This measure reduces the surface runoff by 10-17 mm, the washing down of soil by 4 tons from 1 ha, and promotes the increase of cereals productivity by 0.1-0.2 t/ha.

Parallel to soil cultivation the following methods of sowing are applied:

1) Cross-cut sowing of crops. At broken down complex slopes most effective is cross-cut sowing, when the first stripe is sown in the direction of slope inclination, and the second – along the contour. This technology of sowing is reducing by several times the washing down of soil and provides the increase in cereals productivity due to the even distribution of plants.
2) Stripe sowing of crops. Plants sown in stripe are more resistant to soil erosion processes than usually sown plants. They provide the reduction of liquid runoff by 20-30% and of solid runoff (losses of soil due to erosion) – by 25-50%. At the same time the crop-capacity of cereals increases by 0.15-0.20 t/ha.
3) Stripe by turns disposition of crops is used for protecting soils from water and wind erosion. In case when the width of buffer stripes and the distance between stripes is equal, this represents another anti-erosion technology – the stripe disposition of plants and contour-stripe farming. In this case the width of stripes usually varies in the range of 30-40 m;
4) Arrangement of buffer stripe at plots under hoeing plants after harvesting the perennial and annual plants (winter wheat, rye, mix of cereals with leguminous plants). This measure is conditioned by small size of tilled land areas in mountains, and hence farmers avoid to apply technologies that restrict maximal use of the plot. The offered soil protection technology does not lessen the useful area of cultivated land and it promotes even the increase of the yield. At the same time the soil will be protected from degradation and the decrease in fertility. Furthermore, this technology does not require any additional expenditures from the farmer;
5) Sowing of interim crops. In the foothill and mountain zones of Georgia, particularly in Western Georgia, after harvesting plants in autumn, interim crops are sown to protect the soil from erosion. In early spring the biomass of these crops is tilled down into the soil, and later on the major plant is sown at the plot.

The combination of above listed cultivation and sowing methods allows to work out recommendations according to features of the plot and environmental conditions. The selection of recommended methods is conducted using the USLE equation.

The potential loss of soil resulting from water erosion is expressed as

$$A = RKLSCP,$$

where

A is the loss of soil, t/ha per year;

R – Erosion Potential of Rain, m.t/ha.min

K – Soil erosion factor, numerically equal to amount of washed down soil from the standard plot (length 22,12m, inclination 4,50), divided by the EPR. The plot should be the bare fallow through the year.

L – The slope length factor (dimensionless);

S – The slope inclination factor (dimensionless);

C – Factor, reflecting the vegetation, crop rotation, agrotechnics and soil cultivation system (dimensionless);

P – Factor describing the impact of erosion protection measures on the washing down of soil (dimensionless).

EPR- precipitation factor;

Some more details about the values of these parameters are provided in Annex I.

Barriers to the implementation and dissemination of technology

- The legislation does not exist on the protection of agricultural lands and on retaining of their fertility, which determines the rights and obligations of land owner in respect of soil protection.
- The monitoring is not being conducted of parameters, which are necessary for the assessment of soil erodibility and other quantities. Hence, the creation of this system requires additional expenses, that should not burden the land owners.
- The application of offered technology requires the determination of historical and projected trends of climate parameters (precipitation, temperature), the reliable forecasting of which using regional climate models is so far not possible. The resolution of regional models is higher than that of global models, but is still insufficient to assess the local trends, especially in high-mountainous regions. Models often produce contradictory results, that complicates to convince the decision makers of problem's urgency.
- The adoption of this technology requires to create additional local services, which will elaborate recommendations for each particular plot according to climate conditions and soil parameters. The climate change trend should be considered as well.
- The awareness rising of population, farmers and local officials on the economic efficiency of this technology and on the possible aggravation of climate change adverse impact is of paramount importance for the introduction of this technology and provision of its further sustainability.
- It would be necessary to train local expert

Activities to be conducted for implementation of pilot project and for removing the barriers

Nine most vulnerable villages have been selected during the site visit in the Khulo region. The list of these villages is attached as annex III. In total 2100 ha eroded arable lands will be covered by the pilot project. 700 ha of these lands are used for potatoes and the rest 1400 ha for maize.

Following activities should be implemented for demonstration of ways for removing the existing barriers:

Table: *Schedule and cost of pilot project activities*

Activities	Quarters								Cost of Activity
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
1. Assess the current status of erodibility of soils in the pilot villages	x	x							10,000 USD
2. Assess the current climate change impact on intensification of water erosion of arable lands and pastures in the pilot villages	x	x	x						30,000 USD
3. Assess the economical losses per ha caused by the aggressive water erosion of arable lands			x	x					10,000 USD
4. Prepare recommendations for each household and each plot on water erosion preventive measures		x	x	x	x				15,000 USD
5. Mobilize and train (awareness raising) the most vulnerable local communities for implementation of pilot measures and implement recommended measures	x	x	x	x	x	x	x	x	50,000 USD
6. Evaluate the demand on consultancy in agriculture and elaborate options of demanded service.							x	x	5,000 USD
Total									**120,000** USD

As a result of these activities minimum 8-10% will increase the productivity of per ha arable land.

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.