Proposal V

Landslide Preventive Measures for Minimizing of Risks to Population and Engineering and Economic Facilities in Ajara Region

According to investigations dedicated to the elemental geological risks existing in Ajara Region, population of this region live today in a critical geo-ecological phase. Beyond this phase the unrecoverable catastrophes can take place and the engineering and economic facilities will not operate safely. During the last period the geological situation in the region was seriously aggravated due to climate global changes and heavy anthropogenic pressure. Up to 80% of negative consequences are directly connected to the above mentioned factors.

Actually, the critical situation developed due to performance of hazardous geological processes needs the elaboration of complex scenario of adaptation measures, implementation of which must be based on integrated management principles. According to international experience, protection of population and agricultural lands from hazardous geological processes and safe operation of engineering and economic facilities needs the development of a special program which would optimally envisage potential risks. In particular, the program should provide comprehensive analysis of locations and types of natural phenomena or a chain of phenomena which have already taken place or are expected to take place; conditions, dynamics, mechanism, and geometry of generation of the mentioned processes; assessment of risks of their transformation into catastrophes; perspectives of activation of the processes which can cause the risks; determination of geographical risk areas.

Adaptation measures should be selected taking into account types of hazards (or a chain of processes) and the category of threatened facilities, as well as the level of possible damage. It is obvious that all territories damaged by large scale hazardous geological phenomena cannot be addressed by expensive comprehensive measures. Moreover, comprehensive measures for the protection from deeper deformations and large scale landslides often do not have desirable results. Such measures are carried out only in special cases to protect especially significant objects.

Taking into account that during the last period the development scale of hazardous geological processes in Ajara is increasing and on the background of climate change the recurrence intervals are significantly decreasing, constantly involving new areas, the palliative (preventive) measures have been considered as the more effective direction within the frame of this project.

Preventive adaptation measures allow protecting not only the areas under dynamic process, but also wider areas under the risk of geological processes. Besides that the preventive measures can be implemented much easier and they will be much cheaper. Local population can be actively involved that is one of the main directions emerged within the frame of this project as a new approach in this filed (new technology).

Risk minimization for wider areas through preventive measures allows addressing not only one particular phenomena but a complex of different dangerous phenomena. This kind of preventive regional scheme was developed for the first time for Ajara region in early 80s of last century aiming at risk minimization for the area of 1440 km$^2$. Government was fully responsible for the implementation of this scheme, while population was not involved in the process at all. After destroying of the Soviet Union, approaches for many different issues have been changed. This created new barriers in implementation even of those technologies, which used to be easily implemented by the Government during Soviet time (relevant knowledge existed). Lack of capacity and awareness to involve local population in implementation process of preventive measures is the main barrier in using of this technology.

Preventive measures

Description of different landslide preventive measures successfully implementable in Soviet time in Georgia and implementation of which for the time being need new approach for removing the barriers emerged under the market economy, is given below.

Landslide protective technologies being in use worldwide and widely used in Georgia:

1. Regulation of surface waters and arrangement of water pipes, preventing penetration of water into the ground;
2. Regulation of ground waters (catching of ground waters or lowering the levels);
3. Change of relief topography with the aim of improving of slope state;
4. Phyto-melioration;

5. Strengthen of slopes by supporting constructions (counter-banquet, counter-force; anchor, piles;)

6. Artificial improvement of rock features (resistance to sliding; stability; cementation of splits of landslide and other origin; applying of clay; applying of silicates; electro-osmotic draining; electro-chemical strengthening; covering with gunite and spray concrete; etc.);

7. Changing of landslade ground – arranging of so called ‘terramesh’.

According to the world practice, implementation of the comprehensive landslide protective measures such as technologies 5, 6, and 7, are very costly and difficult. Therefore such measures are implemented only for the protection of especially significant objects. The first four measures, such as regulation of surface waters, water drain pipes, prevention of water filtration, regulation of ground waters (catching of ground waters or level lowering), draining of watered rocks, changing of landslide topography with the aim of slope stability; removing of landslide masses, construction of river banks protective stone gabions and phyto-melioration belongs to a group of palliative (preventive) measures. These measures are quite effective and not very difficult in terms of implementation. These preventive measures are used for improving of wide areas of damaged territories, for the protection of so called “climatic landslides”. These measures do not require complex and expensive technologies and the local population and farmers who are standing in face of serious risks can be easily involved in the implementation process.

Actually, before the implementation of the mentioned measures, it is necessary to conduct proper assessment of engineering-geological conditions of the territory in question. The assessment should serve as a ground for planning of practical measures. Two main groups of technologies are used for the neutralization of “climatic” landslide phenomena. First group includes objects which require regulation of surface waters by following methods:

Regulation of surface waters by open shallow water pipes; in case of encountering of ground waters it will be necessary to deepen the pipes to the level of their appearance. It might be required also to strengthen the sides of the pipes with concrete plates and to arrange special brush revetment on the pipe bottom or to pour the drainage mining ballast for organized discharging of ground waters. Phyto-melioration (bio-engineering) measures are used for strengthening of surface landslide slopes and gorges generated in aeration zones. Surface water flows can be significantly regulated by using the phyto-melioration technologies. These technologies help preventing infiltration of rain and snow waters and removing of excess dampness of ground through transpiration; plant deep roots (6-20 m of acacia, oak, beech, etc.) not only can absorb significant amount of moisture, but also can strengthen the sliding slopes and protect gorges from washing out processes. The simple technology of the same group is - covering of splits on landslide slopes with high plastic clay.

The second group of landslide protective measures includes, from one hand, the regulatory technologies of ground waters which take especially significant and decisive part in generation of the landslide processes (catching of ground water horizon, lowering of levels, arranging of closed drainage), as well as directing of regulated ground waters into water receivers. From the other hand, these are passive measures for strengthening of endangered slopes – supportive walls, removal of landslide masses, or loading of landslide bodies with big amounts of mining masses.

It should be noted that depending on complexity of a landslide area, the technologies of both above mentioned groups of measures can be applied together. For instance, landslide protective measures were conducted on over 200 ha of right side of river Vere in one of the central districts in Tbilisi. As a result of these measures the territory has been recovered sufficiently to be used for urban construction. Though it is noteworthy, that quite big amount of mining ballast was used for loading of landslide slopes. Ground removed during the construction of subway was used for these purposes. One of the most frequent barriers in planning of such large scale measures is – a source of mining ballast.

**Preventive measures on pilot areas**

Several pilot objects have been selected for conducting preventive measures against elemental geological processes in different municipalities of Ajara region. 2 landslide areas have been selected In Khulo municipality, in particular, in Vashlovani Community – village Shurmuli and village Vashlovani (‘Sabauri district’). Both areas are located on the right side slopes of river Ajaristskali gorge. Actually, it is impossible to conduct any cardinal protective measures against landslide in the area of Shurmuli district (19 living houses and up to 100 inhabitants registered within the area of the landslide body), which would fully solve the existing problems. Though for decreasing of potential activation of the landslide processes connected with climate conditions, it would be possible to conduct some quite effective preventive
measures. For instance, regulation of surface waters through draining pipes and terraces (berms). These works would cost approximately 51 000 USD.

A landslide body of secondary generation can be determined within the limits of large active landslide area in village Vashlovani, which covers up to 80 ha. 50 families (over 300 inhabitants) live in the threatened area. The landslide basis is the motor road. The first generation landslide in Vashlovani is of tectonic-seismic-gravitational origin. It is almost impossible to conduct cardinal measures there due to high costs. Infrastructure in this area could be protected only in case of existing of state interest. The only technological measure for improving the actual situation and for the protection of population is regulation of surface waters in combination with arrangement of drainage system. Approximate cost of these works is 65 000 USD. At the territory of district ‘Lentorgi’ of Shuakhevi municipality, right bank of river Ajaristskali is being intensively washed out threatening 5 living houses. The problem can be fully solved by arranging of a 120 m costal gabion which would cost about 80 000 USD. It should be noted that the material for gabion can be obtained within the same riverbed.

Nearly whole territory of village Jalabashvilebi of Keda municipality is under risk of landslide processes (87 families). 21 families are under especially high risk. Especially risky area covers 25 ha. The landslide being in active dynamics takes origin at the bottom of watershed slope, in so called ‘Chanchrobi’ district. The landslide area is tectonic-seismic-gravitational, which has been activated several times. The basis of this landslide is also the motorway. Full stabilization of the landslide district of village Jalabashvilebi, like in the above mentioned case, is impossible. The only possibility to recover the situation and to slow down the process can be regulation of surface waters, draining of wet areas at the border of the landslide body and directing of waters into the neighboring natural water bodies through drainage pipes. These works would cost approximately 90 000 USD.

Intensive erosion takes place at the left bank of river Chakvistskali in village Chaisubani of Kobuleti municipality. During last 15 years about 7 ha of highly productive and valuable lands of different destination were lost due to erosion processes. Different constructions have been damaged and destroyed. Now the existing school-boarding house and the motorway are threatened. Damage of the motorway will lead to isolation of 995 families. To stop the process it will be necessary to arrange a 300 m cost protective gabion, which would cost about 200 000 USD.

As it was mentioned above, major part of the landslide preventive measures are comparatively affordable from economic and technical point of view. Maximum involvement of the local population in these processes is considered as a very important factor that must be ensured. The most complex and the most expensive among the considered simple measures is the arrangement of closed drainage pipes, which requires considerable amounts of mining ballast and which has considerable impact on the environment. This issue is discussed bellow in the assessment of ways for removal of existing barriers.

**Measures to be implemented**

Project proposal on the implementation of landslide preventive measures prepared within the framework of this project envisions implementation of the following measures for the pilot areas in Ajara region (village Vashlovani, village Shurmuli, village Lentorgi, village Jalabashvilebi, village Chaisubani).
<table>
<thead>
<tr>
<th>#</th>
<th>Activity</th>
<th>Time (months)</th>
<th>Cost (thousand USD)</th>
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<tbody>
<tr>
<td>1</td>
<td>Investigation of engineering-geological conditions of the pilot territories and selection of effective measures for each area under particular risks.</td>
<td>12</td>
<td>100 (one landslide area)</td>
</tr>
<tr>
<td>2</td>
<td>Intensive consultations with population on possible risks and the ways to avoid them for the awareness raising purposes</td>
<td>Continuously</td>
<td>50 (per year)</td>
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<td>3</td>
<td>Opening of local Service Centers (regional and municipal) or using the existing ones (for the time being such centers are established by the governmental initiative for the purposes of servicing the Agricultural Sector). Supplying of such centers with a package of effective measures for risk minimization of the dangerous processes.</td>
<td>1 year</td>
<td>500 (opening of one center), 100 annually</td>
</tr>
<tr>
<td>4</td>
<td>Mobilization of village population/communities around the mentioned problem and ensuring of their maximum involvement into the monitoring of the dangerous processes and to the implementation of preventive measures.</td>
<td>Continuously</td>
<td>50 (per year)</td>
</tr>
<tr>
<td>5</td>
<td>Landslide area of village Shurmuli. Regulation of surface waters through arrangement of drainage pipes and berms.</td>
<td>Single measure</td>
<td>51 (one-time)</td>
</tr>
<tr>
<td>6</td>
<td>Large landslide area in active dynamics at the territory of village Vashlovani. Regulation of surface waters in combination with arrangement of drainage system.</td>
<td>Single measure</td>
<td>65 (one-time)</td>
</tr>
<tr>
<td>7</td>
<td>Washing out of right bank of river Ajaristskali in Shuakhevi municipality (so called ‘Lentorgi district’). Full solution of the problem is possible by construction of a 120 m coastal gabion. It is significant that the material needed for the construction of the gabion is available in the riverbed.</td>
<td>Measure 6 months</td>
<td>80 (one-time)</td>
</tr>
<tr>
<td>8</td>
<td>Almost whole territory of village Jalabashvilebi is under risk of landslide processes. For the recovery purposes and for slowing down the process the following measures have been considered – regulation of surface waters, drying up of the wetland area located at the border of landslide, and directing of waters to the neighboring natural water bodies through drainage pipes.</td>
<td>Measure 6 months</td>
<td>90 (one-time)</td>
</tr>
<tr>
<td>9</td>
<td>Left side bank of river Chakvistskali in village Chaisubani of Kobuleti municipality endures intensive erosive washing. To neutralize fully this process it is necessary to construct a 300 m cost protective gabion.</td>
<td>Measure 9 months</td>
<td>200,000 (one-time)</td>
</tr>
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</table>
Barrier analysis

Among the barriers emerged during implementation of this kind of projects the most significant are: awareness rising among population and shifting of management of the processes to the regional level. Main goal of this project is the removal of these barriers, or at least minimization of them.

- Risk assessment and risk management processes are still centralized even in those cases when the state does not take financial responsibilities for risk minimization.

Actually, the mentioned risks often have local character and represent a priority for local authorities and local people. The mentioned barrier should be removed through decentralization of solving processes and mechanisms. The mentioned pilot project is aimed at discussing of ways of decentralization and solving the local priority issues at local level.

- Some of these technologies are quite difficult for implementation and require involvement of highly experienced specialists; lack of relevant specialists who have knowledge in modern technologies is one of the serious barriers.

Since transiting to market economy, many specialties which were considered as very prestigious and valuable during Soviet time, including geology and hydro-geology are not prestigious anymore because there is not relevant demand on them. During the Soviet period the State itself provided demand on geologists. The State was economically strong (the last period is not taken into account) and took financial responsibilities for different geological works. For the time being the State provides finances only for large strategic objects (mainly roads), while the private sector is still quite weak and is involved rather in relatively easy businesses, than in businesses which require continuous geological monitoring. Such monitoring and prevention are necessary for business safety and risk minimization, but private business representatives do not still comprehend it. There is still no demand on such specialties in population as well, because people do not still have appropriate awareness and information on possibility of doing something independently on the ground of consultations with proper experts, as these issues were subject to state management and the local population did not have any experience in taking part in these processes.

To improve this situation there should appear a demand on geologists and hydro-geologists at local, regional, and municipal levels, who would serve the local population. Actually, the decentralization of management process and relevant specialists must be conducted.

- Measures to be implemented are expensive;

Measures to be undertaken to avoid risks of landslides, mudflows and floods are quite expensive, though they are highly needed at the regional, municipal, and village levels. Locations where acute problems reveal must be addressed by permanent mobilization of particular funds using as the state finances, as private (population) resources. These local funds will mobilize, manage and provide target use of the financial resources to cover expenses for preventive measures.

Technical barriers

- One of the hindrances in implementation of preventive measures can be population density; dissatisfaction of population connected to cutting and destroying of agricultural lands and plantations;

An approach proposed by the project should presumably remove this barrier. In particular, when the state plans and implements something (notwithstanding serious consultations with stakeholders) the population quite often expresses resistance and dissatisfaction. If local population recognize the mentioned activities as their own task, than there is a chance to achieve the implementation of concerted and effective measures. Their awareness must be raised to the level when they would understand that by giving up something they would be able to achieve final success.

- Water losses in local springs and wells or lower inflows;

Sufficient knowledge of modern technologies is required for removing of this barrier. Information on the modern technologies is not available within the country. This problem cannot be solved only at national level. In this context it is
very important to establish regional consulting centers (Centers of Excellences) within the global process of 'technology transfer', where national experts would work together with international or more experienced foreign experts on technologies significant for each individual country. This will be especially important for adaptation technologies which are mostly very local and require taking into account a complex of local factors.

- Worsening of actual state of the environment due to cutting of slopes and soil plant cover, and removal of ground;

Neutralization of this barrier is important taking into account needs of population and the State (in case of big projects). If certain impact on the environment is inevitable, the relevant compensation as well as rehabilitation measures for neutralization of the caused damage should be provided. Principles of sustainability should be maximally taken into consideration while planning the relevant measures (to avoid other damages), implementation of which requires very good knowledge of modern technologies.

- Finding of mining ballast and excessive costs in case of necessity of transportation.

This barrier should be considered and discussed separately for each particular case. The measures should be selected taking into account conditions of each single case.