Landslide Management by Community Based Approach in the Republic of Armenia

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Abstract

The Republic of Armenia is a mountainous country. In mountainous area, around 40% of communities are situated on landslide-land. Landslide damages are reported from 12% of all Armenian communities. Yearly precipitation is commonly small (200 mm/year–1200 mm year). Therefore leakage/pouring from domestic and irrigation water supply systems may have caused big impact on landslide activation.

To mitigate the mentioned landslides and to promote community infrastructure development, working commissions composed of 2–3 community staffers, 3–5 resident volunteers and JICA study team members, were established in two small communities (600–1200 populations). The residents conducted drainage works that contributed to landslide mitigation and road improvement. The drainage works reduced landslide activity and improved passableness of the road which used to become muddy after rainfall and the melting of snow.

Keywords: landslide, community based management

Outline of the Study

In response to a request from Government of Armenia, the Government of Japan decided to conduct the Study on Landslide Disaster Management in the Republic of Armenia. The Japan International Cooperation Agency (JICA) selected a team which conducted the Study from March 2004 to December 2005.

Landslide Situation in the Republic of Armania

The JICA study team identified 2,504 landslides using maps, aerial photography and reports of damage (those which were too small to be identified using maps and aerial photography, and for which no damages had been reported, were excluded). Of these 2,504 landslides, 68, or around 3%, are causing progressive damage. Those which are dormant with past damage number 77, (also around 3%). No damages have been reported for the remaining 2,359 landslides (around 94%). Around 40% of Armenian settlements are located on land affected by these 2,504 landslides.

According to correlation analysis of the detected landslides, there are estimated to be 53,000 landslides of 1 hectare (ha) or more, covering a gross area of 2,500 km^2, i.e., 8% of the area of RA as shown in Fig.1 and Table 1.

Analysis of landslide distribution and movement shows that precipitation is the main factor of landslide activity as shown in Fig.2. Annual precipitation is commonly small (200 mm/year–1200 mm year). Therefore leakage/pouring from domestic and irrigation water supply systems may have been a major cause of landslide activation.

Landslide activation is also significantly associated with snowmelt, when the amount of precipitation on the ground increases.

In the previous studies in the RA, the earthquake was considered as the main cause of the landslides, and landslides were thought to be located more densely in areas near active faults. The area density of landslides in these areas is actually relatively small as shown in Fig 6. The submerged areas along active faults are generally sediment plans and lakes where there are no existing or potential landslide formations. The other, relatively upheaval areas are new slops where area density of landslides is small. However, there is the possibility of new landslides occurring due to seismic activity.

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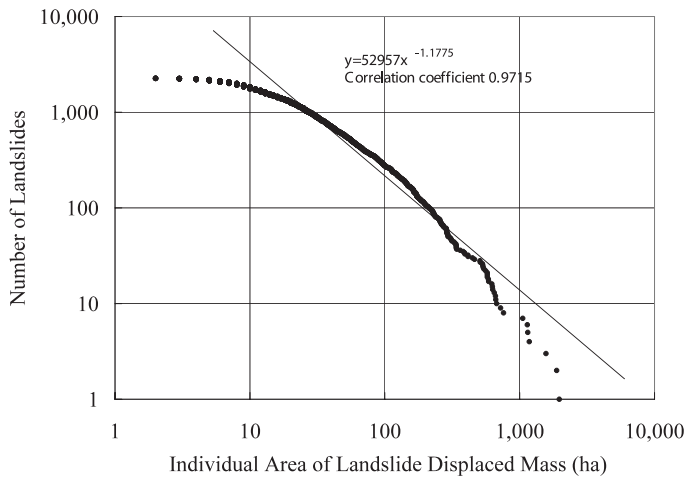

Fig. 1. Correlation of Area of Displaced Mass of Individual Landslides and Number of Landslides (Based on 2,504 Identified Landslides)

Table 1. Numbers and Area of Landslides Based on Area of Displaced Mass

Area of Displaced Mass	Numbers of Landslide	Accumulated Area of Landslides	Percentage of Area of Landslides to whole area of the RA
Identified numbers and area based on landslide inventory study			
Larger than 1000 ha	7	42,428	1.4%
Larger than 100 ha	276	68,442	2.3%
Larger than 50 ha	582	89,678	3.0%
Larger than 20 ha	1,296	222,780	3.8%
Estimated value according to correlation analysis based on the number and area of identified landslides (There are not identified landslides which are smaller than 20ha and damages are not reported, because they are too small for map and aerophotograph interpretation).			
Larger than 10 ha	3,500	140,000	4.8%
Larger than 5 ha	8,000	170,000	5.8%
Larger than 2 ha	23,000	210,000	7.1%
Larger than 1 ha	53,000	250,000	8.2%

Landslide Damages and Mangement Budget in the RA

Landslides in the RA are categorized into two types, depending on who are affected by the landslides:

- Community Landslide: Landslides that predominantly and directly affect the daily-lives of communities.
- Wide-area Infrastructure Landslide: Landslides that predominately affect inter-community/ inter-regional infrastructure.

More than 80% of the total sum of direct losses is generated by Community Landslides, while less than 20% is generated by Wide-area Infrastructure Landslides as shown in Table 2.

Landslide management budgets from 2003 to 2005 have been approximately AMD 90–150 million (USD 0.2–0.3 million), a very low proportion (0.02%–0.05%) of the total state budget. The benefit of a single purpose project for landslide managements is generally small and lower than its cost. This may be the reason for small investment in the landslide management.

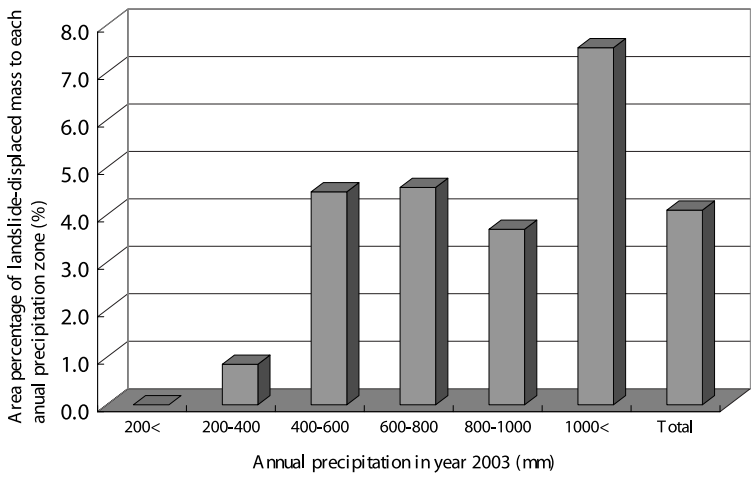

Fig. 2. Percentage of Area of Displaced Mass to Each Yearly Precipitation Zone of 2,504 identified landslides

Table 2. Damage due to Landslides

Sector	Existing Damage at August 2004 (USD million)											
	Community management/ private			Private company management			Government organization management			**Total**		
	Direct	Indirect	**Total**	Direct	Indirect	**Total**	Direct	Indirect	**Total**	Direct	Indirect	**Total**
Buildings 8.	0	1.1	**9.1**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	**8. 0**	**1.1**	**9.1**
Transport 15.	1	1.0	**16.1**	0.0	0.0	**0.0**	3.5	1.4	**4.9**	**18. 6**	**2.4**	**21.0**
Water, energy, and communication	0.0	0.0	**0.0**	2.2	0.1	**2.3**	2.1	0.1	**2.2**	**4. 3**	**0.2**	**4.5**
Agriculture 12.	2	0.0	**12.2**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	**12. 2**	**0.0**	**12.2**
Total 35.	**3**	**2.1**	**37.4**	**2.2**	**0.1**	**2.3**	**5.6**	**1.5**	**7.1**	**43. 1**	**3.7**	**46.8**
	Potential Damage (USD million)											
	Community management/ private			Private company management			Government organization management			**Total**		
	Direct	Indirect	**Total**	Direct	Indirect	**Total**	Direct	Indirect	**Total**	Direct	Indirect	**Total**
Buildings 30.	9	2.4	**33.3**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	**30. 9**	**2.4**	**33.3**
Transport 13.	4	1.3	**14.7**	0.0	0.0	**0.0**	5.7	1.6	**7.3**	**19. 1**	**2.9**	**22.0**
Water, energy, and communication	0.0	0.0	**0.0**	1.1	0.0	**1.1**	1.5	0.1	**1.6**	**2. 6**	**0.1**	**2.7**
Agriculture 1	.0	0.0	**1.0**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	**1. 0**	**0.0**	**1.0**
Total 45.	**3**	**3.7**	**49.0**	**1.1**	**0.0**	**1.1**	**7.2**	**1.7**	**8.9**	**53. 6**	**5.4**	**59.0**
Note The management division is judged in the outline according its sector for management and scale.												

Concept of the Community Based Landslide Management

Single-purpose projects for landslide damage reduction are generally not a priority due to the lack of cost/benefit justification. Perhaps landslide management projects, which would contribute to community infrastructure development, such as drainage construction for improving muddy road condition to insure passableness by vehicles, should be planed and prioritized. Such projects would generate higher benefits and assure the economic validity of the investment.

Each community plans and implements its own income-generating "community development project", with financial and a technological support from the government. Communities should reinvest the earnings to in the project and in subsequent "community development projects". Communities can then gradually expand the project's scale and its outcomes. The purposes of the projects (effectiveness of projects upon completion) are as follows:

- Reduction in casualty and damage
- Development of community infrastructure for livelihood and industry
- Increase of inhabitant's incomes and expansion of community budget

The State (managing authorities) is responsible for nationwide landslide management and for providing

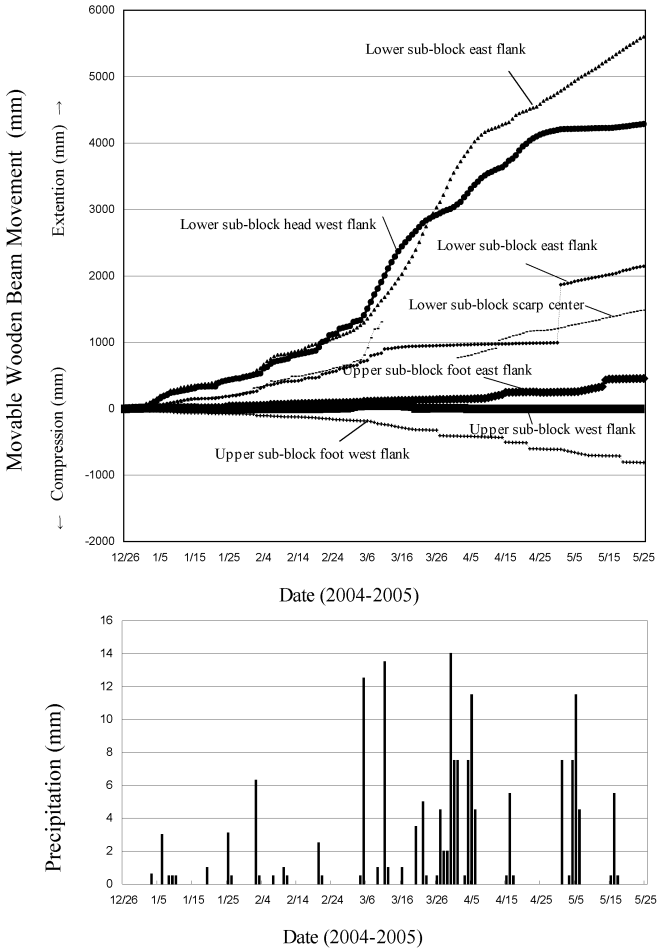

Fig. 3. Landslide Movements in Gosh Village (December 2004 to March 2005)

financial and a technological support to community. Ministry of Urban Development (MoUD) accumulates information and technologies, and disseminates the information and knowledge to all landslide concerned organizations and personnel.

With very limited finances, communities can implement projects using the Community Based Approach (CBA: planning by communities and implementation by inhabitants' participation). The merits of CBA are the following:

- Inhabitants have much knowledge about the landslide and damage it causes (risks).
- Inhabitants are the ones who know what resources are available in the community.
- To plan for landslide management and community infrastructure development, it is necessary for inhabitants, who are the ones with the knowledge of the risks and resources in the communities, to formulate ideas for managing those risks.
- Inhabitants can check and maintain community infrastructure such as water supply and drainage facilities, on a daily basis after they receive technical guidance from the specialist. They can also attend to daily landslide monitoring. These performance of these tasks by residents increases efficiency and decreases cost.

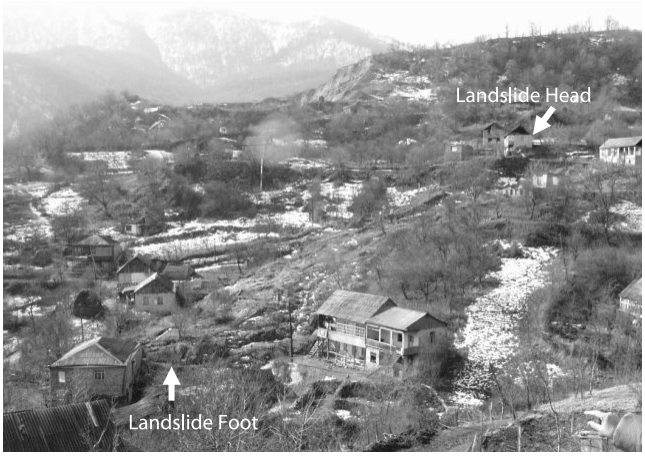

Fig. 4. Active landslides block in Gosh Village on 20th of February 2005

Fig. 5. Muddy Community Road by Snow Melting Water in Gosh Village on 20th of February 2005

Concept of Crisis Manageent for Landslide Hazard

Community public offices organize the landslide monitoring teams for early stage detection of any disaster signs. Heads of communities warn inhabitants and recommend the evacuation of concerned inhabitants depending on the "index value (threshold)" for landslide monitoring, including precipitation levels, and signs, etc. When a disaster occurs, the safety and/or recovery of victims are attended to under the supervision of the head of the community, with support from the Armenian Rescue Service (ARS), Regional Government Administration (Marz) and local inhabitants.

MoUD and ARS will provide the technical support for the setting of the "index value (threshold)" for landslide movement, precipitation, and other signs for early warning, recommendation of site evacuation, and limitation on the use of facilities.

Outline of Pilot Projects

Three Pilot Projects were conducted from May to December 2005 in Gosh Village, Martuni Village and Kapan City supported by the JICA Study Team The purpose of the pilot projects was to test and confirm the effectiveness of the 'Community Based Approach (CBA)'. Pilot projects have become multipurpose projects, which contribute to community infrastructure development. The participation of inhabitants reduces construction costs, resulting in possible transformation of the pilot projects into economically feasible projects.

'The landslide management and community infrastructure development' and 'the community development concept plan for acquisition of project resources' were formulated by the working commissions in the communities.

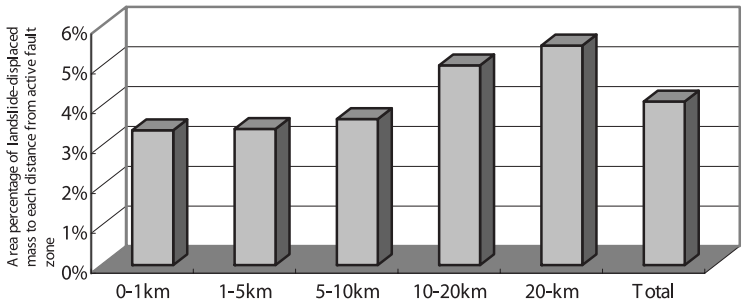

Fig. 6. Landslide Area Density of Each Distance Zone from Active Faults

Table 3. Plan of Gosh Village

Item	Outline
Feature of landslide, risk resource assessment	-It is 1000m wide, 500m long, and is divided into 15 sub-blocks. Risk objects are houses and community roads. The roads across H block which is important for access to pasture and tourism. - H block (100m long, 50m width) is active. During Jan-Sep 2005 (before drainage works), landslide movement was approximately 10mm/day. In snow melting season, Mar 2005, the movement was 75mm/day. In winter, inhabitants were watering using domestic water to prevent frozen of water systems. This aggravated the landslide activity. H block damaged 4 houses and the important community road. - C block and J block are also active (1mm/day to 10mm/day movement), other blocks are not active (less than 1mm/day movement). - Resources are itemized (farmland, sand and rock mines, and lake and monastery for tourism).
Landslide Management and Community Infrastructure Development	- As project resource acquisition, tourism development (tourist home, eco tourism, agriculture and stockbreeding development (juice, meat, dairy processing) were planned. - Execution system (landslide monitoring team, working commission, and community staff) was formulated. - Drainage works against assumed main causes (precipitation, thawed water, watering) was planned. It will be installed as community road drainage, will prevent the road becoming muddy, and ensure running of vehicles all year. (This pilot project and forward plan: 770m length open ditch with conduit, 160m long conduit, 1,480m long open ditch, 570m long horizontal drainage boring, 1,830m long road stone pavement)
Executed Activities	- In Sep-Dec 2005, 470m long open ditch with conduit, 160 meter long conduit, 400 meter long horizontal drainage works were installed at H block. Activity of H block is reduced. Boring and material procurement were input by Japan with local contractor. Community input is general workers (Japan assisted about 1/3-of market price AMD1200 =USD 2.6 /day as reward), and supplemental material (sand etc.)

Parts of plans, including community road drainage works, landslide monitoring and an early warning system, were started through the participation of the local inhabitants.

Stakeholder meetings (advisory committees) were chaired and held by the MoUD and technical support such as conduction of environmental assessment was provided through these committees.

Plans for "landslide mitigation works which contribute to community infrastructure development" formulated from the Pilot Projects of Gosh and Martuni Villages, were assessed as economically feasible. The Pilot Project in Kapan involving hazard recovery works (opening of 2-lanes of Harutyunyan Street) was economically beneficial in keeping regional traffic safe, including the flow of bulky international cargo, which is the major means of trade across the Iranian border. The project is highly recommended for implementation.

The Study Team together with communities in the area, undertook landslide monitoring. Monitoring technologies were transferred to the communities and monitoring systems were established and put into operation.

Simple Landslide Management Plan of Gosh Village Pilot Project

Plan of landslide management and community infrastructure development is shown in Table 3.

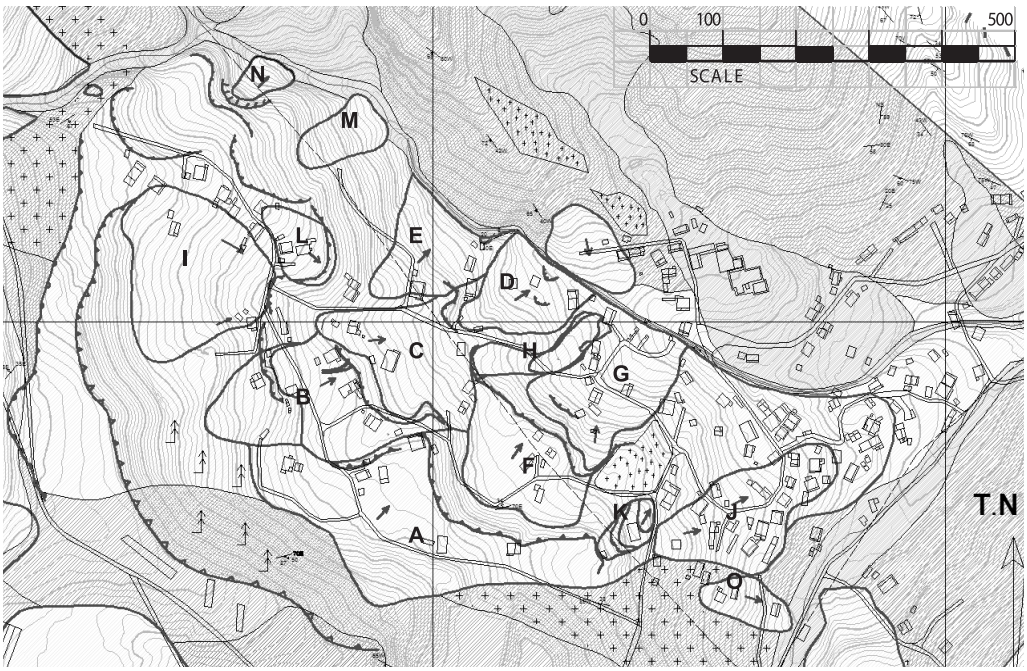

Fig. 7. Landslide Sub-blocks in Gosh Village

Table 4. Estimated Benefits in Pilot Projects

Item	Kapan	Gosh	Martuni
Direct Damages	AMD 0 USD 0	AMD 235,905,000 USD 519,000	AMD 482,506,000 USD 1,062,000
Indirect Damages	AMD 3,300,000 USD 7,300	AMD 41,155,000 USD 91,000	AMD 61,613,000 USD 136,000
Willingness to Pay of the Whole Community Inhabitants	AMD 14,411,000 USD 32,000	AMD2,375,000 USD 5,000	AMD 1,463,000 USD 3,000
Total	AMD 17,711,000 USD 39,000	AMD279,435,000 USD 415,000	AMD 545,582,000 USD 1,200,000
Percentage of Willingness to Pay to Direct Damage	-	1.2%	1.1%

Economic Evaluation on Community Based Landslide Management Projects

Estimated benefits of the three pilot projects are summarized in Table 4.

'Willingness to pay of the whole community inhabitants' in Table4 was calculated by a simplified Contingent Valuation Method (CVM). This survey was conducted in three sites using a questionnaire asking "Willingness to pay (WTP)" for the projects, which potentially represents the project worth for the residents. The result of WTP in each site is outlined in Table5.

The CVM result is an estimation of monetary value of regional economic effect taking into consideration upgrading of the land use, improving regional roads, expected budget saving for villages, and incorporating landslide management into multipurpose programs of regional development. Therefore, willingness to pay includes the benefits of the project.

Costs of the implementation of engineering countermeasures are estimated based on the basic design prepared by the communities and unit costs per construction work obtained under the pilot projects in the respective sites, are shown in Table 6. Engineering countermeasures are planned with inhabitants' participation. Therefore costs are cheaper than contractor's estimates.

With the above project benefits (quantified) and costs, cost-benefit analysis was carried out and the results are presented Table 7.

The results for Gosh and Martuni show positive Net Present Value (NPV) and higher Economic Internal Rate of Return (EIIR) than the discount rate of 10%. This indicates that these projects are economically viable for implementation. The earliest implementation will be required to protect the village properties and avoid

Table 5. Result of CVM in Each of the Pilot Project Sites

Item	Kapan	Gosh	Matuni
Annual Income/Household	AMD 882,000 USD 1,940	AMD 582,000 USD 1,280	AMD 576,000 USD 1,267
Willingness to Pay/Household (Weighted Average)	AMD1,550 USD 3	AMD5,951 USD 13	AMD8,083 US 18
Percentage of Annual Income to Willingness to Pay	0.2%	1.0%	1.4%
Whole City/Village	AMD 14,411,110 USD 31,704	AMD2,374,504 USD 5,223	AMD1,462,937 USD 3,218

Table 6. Construction Cost

	Kapan*	Gosh	Martuni
Construction Costs	Plan II: AMD 98,293,000 USD 216,245 Plan III: AMD 344,549,000 USD 758,008	AMD115,579,000 USD 254,274	AMD 628,796,000 USD 1,383,351

* At Kapan, Plan II is securing 2 lane traffic of Harutyunyan Street, plan III is complete removal of landslide-dumped soil

Table 7. Results of Economic Evaluation for Three Pilot Projects

	Kapan	Gosh	Martuni
Economic Internal Rate of Return (%)	N/A*	12%	10%
Net Present Value	Plan II: -AMD 62,005,000 USD 136,411 Plan III: -AMD 280,861,000 USD 617,894	AMD 15,766,000 USD 34,685	AMD 7,383,000 USD 16,243

Note: * Because the costs exceeded to calculated internal rate of return, the value is not available.

the economic losses incurred by landslides. Although the Pilot Project in Kapan shows a negative NPV, it is extremely important for the Armenian economy to secure regional safe traffic and moreover international large cargoes, which are the key means of trade through the Iranian border. The project is highly worthy for implementation with Plan II, which offers a much less negative NPV than Plan III.

Conclusion

One issue which prevented the RA from undertaking landslide mitigation projects has been the insufficiency of public funds due to severe constraints in the state budget and the small benefit generated by existing projects that aim solely at landslide mitigation.

The pilot projects became economically feasible by expanding the benefit streams and by transforming them into multipurpose projects which contribute to community infrastructure development. Costs were also reduced through the participation of local inhabitants in project implementation. Residents' awareness of self-help and mutual aid were markedly improved along with the improvement of community infrastructure and settlement of landslide activities.

These positive experiences should be shared, new projects formulated and public finance allocated. 'Community Based Approach (CBA)' has been proven as useful for effective project formulation. While the initial investment requirements and specialists in communities are still scarce, public participation and inputs in the technical and financial aspect are needed to insure the sustainability of the pilot projects and implementation of new projects.

Therefore not only CBA is important but also the responsibility of State (management authorities) to nationwide landslide management and the provision of technical/ financial assistance to implementation bodies of landslide management (communities and management organization for wide area infrastructure).

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References

Japan International Cooperation Agency (2006), *Final report of the Study on Landslide Disaster Management in the Republic of Armenia*, p.1–165.