ATTACKING SOIL EROSION IN AN INDIGINOUS ANDEAN COMMUNITY IN ECUADOR

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Introduction

This report focuses on the assessment of soil erosion problems in an Andean community in Ecuador and initial attempts to stabilize five sites affected by erosion. The indigenous community, Malingua Pamba (population approximately 720), is situated about 115km south-southwest of Quito (Ecuador's capital) and 30km west-northwest of Latacunga (the capital of Cotopaxi Province). The Malingua Pamba community is comprised of six sectors in an area of approximately six square kilometers. To the extent possible, this project follows a model of sustainable erosion control which incorporates community team work using local materials.

Several hundred years of clearing native cloud forest and páramo grasslands for settlement, cultivation, livestock grazing, fuel, and building materials has resulted in a loss of much of the original organic topsoil in widespread areas of the Andes. The remaining sandy volcanic soils are very susceptible to surface water erosion, especially when stripped of protective vegetation.

Since 2006, the Denver Professional Chapter of Engineers Without Borders (EWB-Denver) has been assisting the community with their potable and irrigation water systems. During a 2009 EWB-Denver trip to the community, Laura Backus (a Certified Senior Ecologist and Professional Wetland Scientist) observed ecosystem changes and erosion problems in Malingua Pamba. The community president expressed interest in controlling erosion, and Denver-EWB formed an erosion control team to assist the community in addressing these problems.

Supported by the International Erosion Control Association (IECA) SOIL Fund and EWB-Denver, Will Mahoney (a Professional Geologist and Certified Professional in Storm Water Quality) spent eight days in Malingua Pamba in July 2011 evaluating approximately 75 eroded sites. He produced a report evaluating the causes of erosion at 46 of these sites and suggesting possible mitigation measures [1].

In October 2012, the six members of the EWB-Denver erosion control team assisted community members in implementing erosion mitigation at five of the highest priority sites as detailed below.

Materials and Methods

During his July 2011 trip, Mahoney made a thorough survey (mostly on foot) of erosion and sedimentation problem areas within the community. For each site, he collected data including

GPS location, photographs, measurements of erosion feature dimensions, and slope. His report presented recommendations for low-cost and sustainable methods of erosion and sediment control that rely on locally-available materials or, at the least, materials that are available in Ecuador. Each site received a subjective rating for treatment priority.

Based on Mahoney's ratings and community priorities, EWB-Denver's erosion control team chose six sites where standard "best management practices" (BMPs) for erosion and sediment control would be implemented by *mingas* (a Quechua word meaning "community work teams") coached by the EWB-Denver team. These priority sites were chosen based on a subjective, qualitative evaluation of the seriousness of the risks posed by the erosion hazards, including risk of road closures that would require outside government assistance and risk to failures of the community's water delivery system. More immediate threats were given higher priority. Additional factors in site selection were geographic distribution, potential success, and cost. Backus reviewed the six sites in July 2012 during an EWB-Denver monitoring trip of potable and irrigation water systems.

Addressing erosion and sediment transport at sites in Malingua Pamba required implementation of both structural and non-structural BMPs and emphasized use of bioengineering techniques. Bioengineering is the combination of biological, structural, and ecological methods to control erosion and stabilize soil through use of vegetation or a combination of vegetation and construction materials. Biological/ecological measures included planting native trees and shrubs, transplanting native grass into vegetative barriers along the contour, seeding a rhizomatous grass species, and installation of locally-woven erosion control netting. When the new vegetation is well-developed, the root systems will hold the soil in place and promote storm water infiltration into the soil. Structural solutions included hand-grading of vertical stream banks, toe walls of tree trunks and riprap, plunge pools, check dams, slotted pipe to spread overflow from a water holding tank, and a roadway drainage crossing constructed with pavers [2].

Prior to project implementation, the community high school students, under the direction of their principal, Ignacio Sacatoro, planted more than 5000 native and naturalized trees and shrubs for use in the project. This nursery was funded by a local NGO, Centro Educativo la Minga. Additional native woody plants were purchased from Fundación Brethren y Unida (located north of Quito), hand-woven native jute fiber matting from weavers in a local community, and riprap from a Latacunga supplier. Bowman Construction Supply of Denver, Colorado donated additional erosion control matting. An international consulting firm, Environmental Resources Management (ERM), also provided project funding.

Results and Discussion

In October 2012, Malingua Pamba mingas assisted by EWB-Denver completed erosion and sediment control work at five of the six high priority sites. EWB-Denver emphasized that the community owns the project and is responsible for maintaining the sites. The school principal and EWB-Denver conducted several erosion control classes at the community school, including tree and shrub planting. Following is a summary of the work completed.

Site 9, Malingua Yaku: At this site, Quebrada Yanarumi, a potable water supply stream which originates in springs, flows through a concrete culvert under the road from Latacunga to

Malingua Pamba. High storm water events clog the culvert with rubble causing flows to overtop the road, jeopardizing the integrity of both the road and the culvert, and eroding the slope below the culvert outlet. The clogged culvert backs up flows resulting in stream bank erosion above the culvert inlet. Minga work accomplished the following:

- Removal of nearly all the rubble clogging the culvert except for one boulder greater than 1 meter in diameter.
- Placement of boulders and riprap directly below the culvert outlet to reduce the erosive impact of flows through the culvert and construction of a 4x2 meter plunge pool where flows overtopping the road were eroding into the bank at the edge of the road.
- Planting 70 willows along the creek above the culvert and placement of several dozen other plants approximately 3 to 20 meters away from the creek.

Site 16, Tanque Tingo: This water tank supplies potable water to the Tingo sector of the community. Water exiting the overflow pipe at Tanque Tingo was causing gully erosion. In addition, two adjacent actively eroding gullies were undermining the stability of exposed sections of an irrigation water line. The following work was carried out at this site:

- Attachment of a perforated PVC water spreader pipe to the tank's overflow pipe. This pipe is approximately 4 meters long and parallels the contour to spread overflow water over a larger area.
- Planting 100 trees and shrubs and seeding grass in the two eroding gullies below the exposed pipe and installing erosion control matting in the most vulnerable planted areas.

Site 18: Cachiyacu: This site is a steep, eroding cut slope above the road between two community sectors, Chimbusig and Tunguiche. The sandy soils of this sparsely vegetated slope are very vulnerable to slumping, and road closures are common during the rainy season. The following minga work was accomplished at Site 18:

- Planting approximately 350 native trees and shrubs on the main cut slope area, as well as a smaller eroding area to the east
- Planting trees and shrubs at the top edge of the cut slope to prevent further sloughing.
- No mats were installed due to uneven slopes and current development of volunteer native vegetation.

Site 20: Fagcha Chimbusig: This is a low area of the dirt road just east of the Chimbusig sector. Instead of passing through a culvert approximately 200 meters further up the road, storm water collects in this low area and saturates the soils. Both the road cut and fill slopes are very steep and eroding. Sediment eroding from the cut slope fills the roadside ditch further inhibiting drainage. Following is a summary of minga work carried out at Site 20:

- Construction of a roadway drainage crossing using concrete pavers left over from a previous community project.
- Hand-grading the road to direct storm flows to improved ditches at the toe of the cut slope.
- Construction of a rock-retaining wall at the toe of the cut slope.
- Construction of a series of plunge pools below the outlet of the paver crossing to slow runoff flowing onto the fill slope.
- Planting trees, shrubs, and contour vegetative barriers as well as placement of erosion control matting to stabilize the cut and fill slopes.

- Planting native tree poles to block animal access from the top of the cut slope.
- Planting trees and shrubs at the top edge of the cut slope to prevent further sloughing.

Site 63: Trail connecting Malingua Pamba and Tunguiche: A small, but actively eroding gulley is working headword into the well-used foot trail between Malingua Pamba and the Tunguiche sector. Additionally, the slope above the trail is actively slumping and clumps of newly sloughed soil and shrubs are partially blocking the path. No work was conducted at Site 63 due to confusion over the site location and unavailability of minga workers on the day the work was scheduled. However, the community has committed to future work at this site.

Site 96: Alcanterizado de Malingua: This site consists of an ephemeral channel below a road culvert approximately 100m from Malingua Pamba's community center and school. Due to its proximity to the center of community activities, it has become a demonstration site for erosion and sediment control practices. Mingas accomplished the following work:

- Construction of four check dams (cross vanes) to direct water to the center of the gulley and reduce erosion of toe slopes. Due to limited quantities of large rocks, mingas filled long tubes of chicken wire with cobbles to construct these structures.
- Construction of two plunge pools to stabilize the head cut within the gulley.
- Construction of a series of toe walls (approximately 22 meters in total) just below the culvert outlet.
- Hand-grading vertical eroding slopes near the culvert outlet to an approximate 2:1 slope to help insure positive drainage away from a house adjacent to the gully and armoring the house drip line with cobbles.
- Planting approximately 75 shrubs and trees and seeding grass along the gulley banks and adjacent to the upper edges of the gulley; installation of erosion control matting adjacent to the house.
- Excavation of an infiltration trench at the downstream end of the gulley to allow flows to seep into the porous soil. This treatment is intended to decrease the threat of high flows cutting a new gulley down the very steep slope 10 meters below the infiltration trench.

Following completion of the erosion control work, EWB-Denver provided a form, "*Monitoreo para Octubre 2012 sitios de control de erosion"* ("Monitoring of the October 2012 erosion control sites"), to be used for post-project monitoring by community members. However, consistent monitoring of the five treated sites has been problematic. Ignacio Sacatoro reports that plants are growing well, but the community has not sent photographs since November 2012. Using materials left over from the October 2012 project, mingas independently have conducted more plantings in high-priority areas.

EWB-Denver members Eden Recor and Geoff Elliot have taken photographs and made observations during their independent trips in early 2013.

Based on the January 2013 photographs at Site 20 by Eden Recor, the paved crossing, plunge pools, and erosion mats were still in place, and plants were growing well.

In March 2013, Geoff Elliot visited the community plant nursery and estimated 125 plants remained from the planting projects and more than 5,000 bags full of soil were ready for

planting. He noted that community members are now routinely planting erosion control nursery stock in numerous locations as a "best practice." Elliot noted that most plantings at Site 9 appeared to be surviving, and the plunge pool created to slow eddying high flows at the culvert outlet was still in place. However, a large boulder immediately above the culvert had not been removed and was continuing to partially block flows. The erosion area below the culvert continued to be a risk to the integrity of the road. He observed significant success of erosion control efforts downstream of the road at Site 96. All erosion control structures remained in place with no new down cutting or side erosion. Up to 25 cm of new sediment was apparent in the channel, and the lowest check dam was nearly filled with sand. He observed a high survival rate for vegetation planted along the sides of the channel, and a lower survival rate for vegetation planted above the channel.

EWB-Denver will analyze all information to help plan the October 2013 trip in cooperation with the IECA SOIL Fund and assist with on-going adaptive management to be conducted by the community. The 2013 trip will include training community members to plan and carry out independent future projects with both planting and structural components as well as research into growing and planting species with the highest local economic and cultural values.

Conclusions

Several factors have contributed to a successful start of erosion and sediment control efforts in the Malingua Pamba community:

- A thorough inventory of erosion problem areas in the community and identifying those areas which pose the greatest risk to natural and community resources.
- Early and continued involvement of a motivated community in prioritizing and carrying out erosion control work.
- Initial training and project guidance from erosion control professionals.
- Use of local materials and native species of plants to ensure that erosion control work will be sustainable and require minimal reliance on outside funding and supplies.

Over the long term, regular monitoring and maintenance will be very important to insure erosion control BMPs at current sites are maintained and work is replicated at additional eroded sites. Furthermore, the successes in Malingua Pamba need to be communicated to neighboring communities that can learn from, and become motivated by, the examples set by this preliminary project so that erosion control practices are conducted on a watershed basis.

References

[1] Mahoney, Will; Backus, Laura; and Zuber, Rob. 2012. *Erosion Problems in Malingua Pamba, Ecuador: A Preliminary Assessment for the IECA SOIL Fund and Engineers Without Borders – Denver Professional Chapter*. Unpublished report to the IECA SOIL Fund.

[2] Mahoney, Will; Backus, Laura; Zuber, Rob; Kettner, Albert; Giordanengo, John; Barbian, Matt; Walsh, Jennifer; and Sacatoro, Ignacio. 2013. *Erosion Problems in Malingua Pamba, Ecuador: Preliminary Assessment, Initial Mitigation, and Preliminary Monitoring.* In progress.