Journal of the Geographical Association of Tanzania, Vol. 35: 53–64

Human Impact on the Headwater Environment In the Uporoto Highlands, Tanzania

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Abstract

Headwater catchments are often perceived to be remote and peripheral, and are therefore neglected, least developed and economically backward. However, changes in headwater regions have repercussions far beyond their borders. The Uporoto highlands in Mbeya region form the headwater region for the Ruaha River and Kiwira River drainage systems that are of great significance to Tanzania. Village settlements development, population growth, and poor land management along the water divide have contributed to gully erosion that is a potential hazard. Using a case of Igoma, the largest village settlement in the region, this paper establishes the link between settlement growth and degradation of headwater catchments. It discusses the opportunities and hazards of the gullies to the local communities. The paper further draws lessons for rural settlement development, and gives recommendations for minimizing the negative impacts of degradation of the headwater environment. Lastly, it creates awareness on the apparently neglected potential environmental hazards in the Uporoto Highlands.

Keywords: *headwater management, gully erosion, mountain settlements and highlands*

Introduction

Headwater catchments are often perceived as remote and peripheral regions, and therefore are often neglected, least developed and economically backward (Haigh & Krecek, 1991:171). But land degradation in headwater regions has implications beyond their borders as they often affect populated and economically potential regions downstream. Land degradation is mostly linked to population growth and related activities. In rural areas, land degradation is associated with poor agricultural land management practices of smallholder producers (Mati, 2005). Settlement development is an important human element that influences the natural environment. Population growth and the associated physical expansion of rural settlements affect the environment not only through the pressure it poses on resources, but also its effect on runoff generation, a powerful agent of erosion in wet environments like those of Uporoto highlands.

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This paper identifies human-environment interactions associated with headwater environment degradation that has led to head-ward extension of gullies towards built-up areas, and suggests potential ways of minimizing the problem. It intends to create awareness among the academic, policy makers, environmentalists and the general public on the potential social, economic and environmental hazard of gully erosion facing communities on the Uporoto Highlands. Creating people's awareness on a potential disaster that is likely to occur from gully erosion is important for minimizing its impact on human life and property. The recent impacts of the landslides on Mt Elgon, Uganda (Knapen et al, 2006), caution on the serious consequences of the lack of awareness and preparedness for potential hazards.

This paper is based on information gathered through field excursions conducted by geography students between 2001 and 2003, as well as follow-up studies in 2007, 2008, and 2015. During these excursions and study visits, field observations and interviews with key informants and members of the local communities were undertaken. Despite the large-scale and potential risks, the gully erosion hazard on the Uporoto highlands has received little attention. The paper starts by giving a background to the Uporoto highlands. This is followed by a description of Igoma, the village that constitutes the case study. It discusses the distribution, extent of gully erosion and factors that induce its development, and elaborates on the local community's effort to control gully erosion. Finally, it gives suggestions on how to minimize environmental degradation on headwater catchments.

The Uporoto Highlands

Contrary to the general view that headwater catchments are sparsely settled, remote and peripheral to the mainstream economic regions, the Uporoto highlands (UHs) are densely populated agricultural areas that supply significantly to urban markets. Irish potato is the dominant cash earning crop (Sokoni, 2001; Anderson, 1996). The UHs are at a strategic position within a potential region of tourism development with various attractions, including the flora rich Kitulo National Park, Mount Rungwe (known for rare species of flora and fauna), Ngozi Crater Lake, and many reserved natural forests.

The UHs are located in Mbeya and Rungwe districts, and are part of the Southern Highlands known for their great agricultural production potential in Tanzania. They are dissected plateau with a steep slope ridge and valley topography. The altitude ranges from 1900m to 2700m above sea level. Rainfall is heavy, ranging from 2500mm to 3500mm annually. The rain season runs from October to May. Its temperate weather condition gives a crop-growing period of 8-9 months. The soils are made of volcanic ash (pumice), generally well-drained, but highly susceptible to erosion when exposed to heavy rainfall and runoff.

The UHs form a headwater region for the northeast Ruaha River and Southwest Kiwira River drainage systems. The main streams that feed the Ruaha River are Mwambalizi; Patagwa; Dugumila; Shirisi and Halanzi. Downstream are located land uses of national importance, including rice irrigation schemes of Usangu basin, the Ruaha National Park and the Mtera Dam for hydro electric power generation. Various streams feed into the two main rivers of Kiwira and Mwatisi that drain south-eastwards into Lake Nyasa. The road from Uyole southwards to Isyonje, and eventually eastwards to Kikondo village on the margins of Kitulo National Park, marks the water divide (Fig. 1).

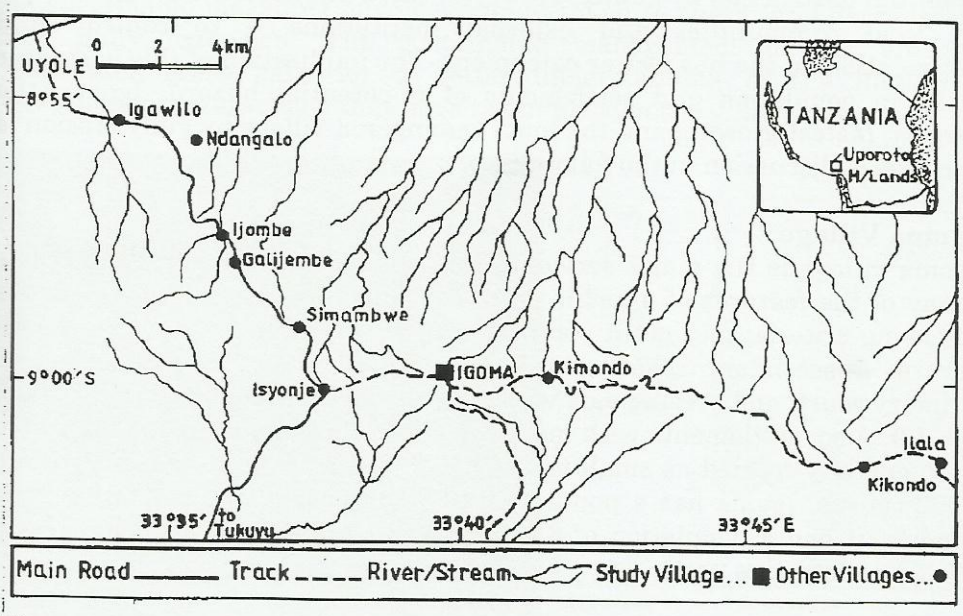


Figure 1: ***Location of village settlements along the water-divide of the Uporoto Highlands***

The villagisation programme of 1974-5 located nucleated settlements along the road to take advantage of easy accessibility. Starting from Uyole, the villages are Ijombe, Iwalanje; Hatwelo, Galijembe, Simambwe, Isyonje, Usoha Njiapanda, Igoma/Ngoha, Mwansazi, Kimondo, Nyalwela, Kikondo, Mwela, and Mashese. Each village has several headwater sources that have been sources of domestic water. As the stream valleys form natural drainage lines, runoff from built-up areas has encouraged the emergence, growth and head-ward extension of gullies. Population and settlement growth have disturbed and exposed headwater environments to agents of erosion. Apart from gazetted forest reserves, the UHs have no natural forest left. A significant part of the natural forest area was converted to a forest

plantation for the Kiwira Forest Plantation Project in 1973. Furthermore, this reduced communal grazing areas to pathways and stream valleys (Sokoni, 2001). Headwater areas and stream valleys are highly degraded and experience formation and head-ward expansion of stream gullies.

Gully formation and head-ward extension problem is increasingly posing a threat to people's lives, land use development for agriculture and settlement. Gullies threaten the destruction of the Uyole-Kyela highway as seen at Isyonje where the advancing gully is less than ten meters from the edge of the road. The road from Isyonje to Igoma has several sites of potential destruction by gullies. However, there has been little effort -- both by local communities and external institutions -- to control land degradation on the headwater catchment. The implication of this is greater risks to population and settlements of a potential hazard. Igoma, the largest, fastest growing and the most endangered village by gully erosion is the case of discussion in the following sections.

Igoma Village

Igoma village is the major service centre on the headwater region. It has many of the features of a small town. In Tanzania, a minor town has the following criteria: minimum population of 10,000 people, having a health centre, a secondary school, 20 licensed retail shops, a market place, primary court, and serving as a ward or a division headquarter (URT 2000: 69–70). Also, settlements with more than 5000 and less than 10,000 people are generally treated as small towns (URT, 2000: 63–68). According to the 2002 census, Igoma has a population of 6,388 people. In the 2021 census reports, it had a population of 6,310; and this probably due to changes in the administrative units.

The physically large entity of Igoma village is administratively divided into two villages that belong to different administrative wards of Igoma and Tembela. This means that statistical data for the village is split such that its characteristics are obscured.

Igoma is a transport, communication and administrative centre for Igoma ward. It has a daily market (that also serves as a periodic market for a wider surrounding area), a primary court, a health centre, many retail shops, milling machines, two primary schools, a church parish centre, a centre for teachers, a secondary school and a private dispensary. It is connected to the national electricity grid, although many households are yet to be connected. From the late 1990s the village receives piped water by gravity from reserved mountain forest areas.

Igoma village has a peculiar concern with regard to headwater degradation because of its size and central function as a growth centre. It started growing rapidly since the villagisation programme of 1974 that brought scattered homesteads from surrounding ridges to the village. It is located on the plateau and saddle with drainage on either side. This makes it the most vulnerable to stream gullies extension.

Headward Gully Extension Around Igoma Village

Figure 2 shows the structure, form and distribution of a greater part of Igoma village and the map shows the distribution of the main gully sites that surround and threaten destruction from all sides. Despite this danger no sustainable measures have been undertaken to check land degradation and gully extension. The sustainable management of the village's headwater areas calls for a better understanding of the human – environment interactions that have taken place in the village.

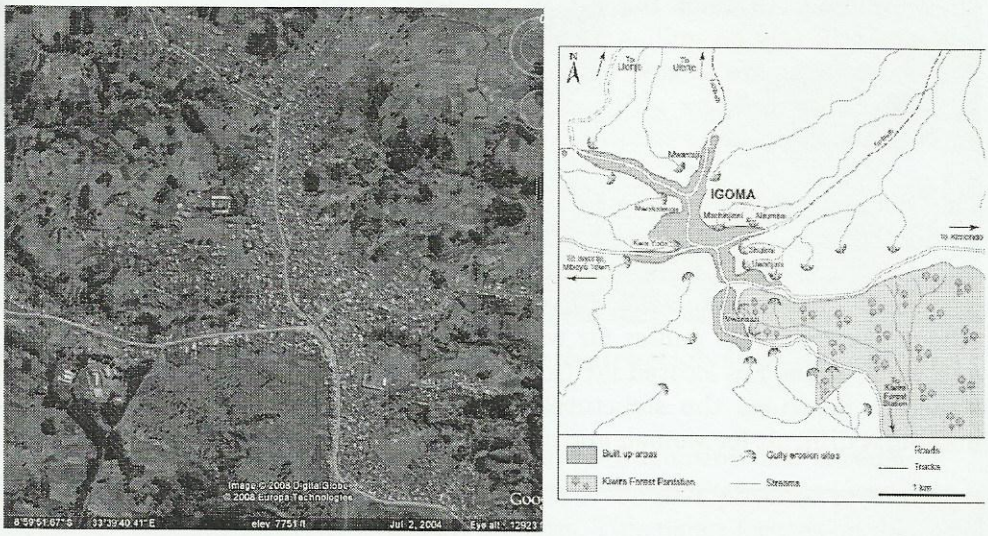


Figure 2: ***Aerial view of Igoma village and distribution of main gully sites***

Gully formation and its headward extension have impact on agricultural land and built-up area. Gully extension occurs through slumping of land at the gully head following heavy rainfall. Land suitable for agriculture and settlement is degraded in the process. Destruction of houses is reported at Kiwanjani area where landslides occurred on the sides of the gully several times (Fig. 3).

The distance from heads of gullies to built-up areas decreases though gradually, at Uwanjani, Kwa Yuda, Nzumba, Machinjioni and Mwantaji sites (Plate 1). At Uwanjani, the gully is only 60 meters from the local government

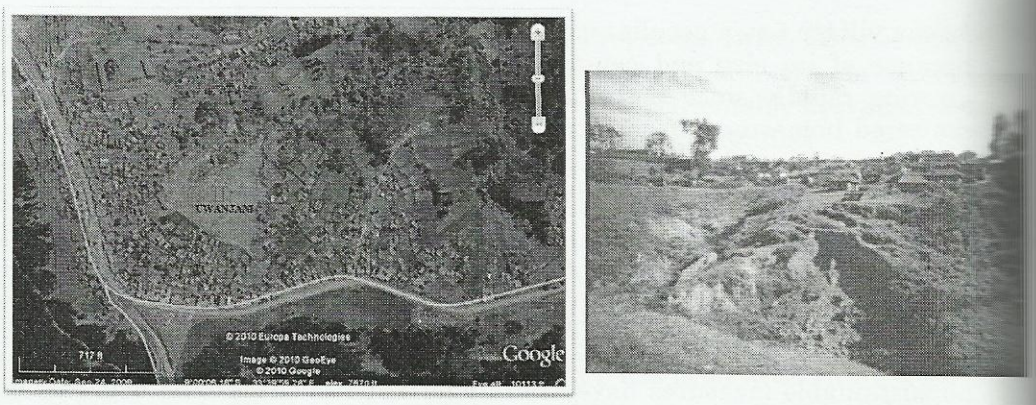
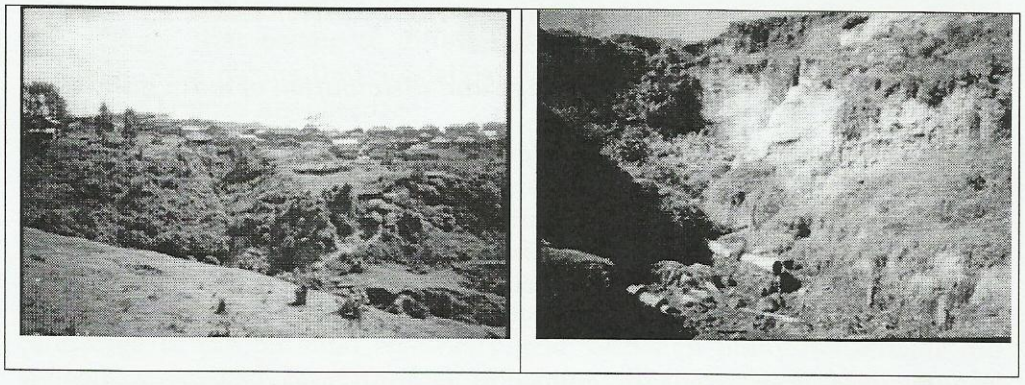


Figure 3: ***View of Uwanjani gully and built-up areas threatened by gully extension***

office building. Although the village has piped water supply since 1999, some villagers still rely on gullies for water because piped water supply is erratic and water tapes are located far from the homesteads. Slumping of gully head structure destructs the structures constructed for drawing water (Plate 2) making it difficult for women and children to fetch water.

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Plates 1 & 2: *Gully extension into built up areas and structures for water collection*

The stream gullies also are a threat to infrastructure. A gradual destruction of a bridge at Mwansazi eventually led to a diversion of the road that links Igoma with the Kiwira Forest Plantation station and serves as an outlet for sawn timber that reaches urban markets of Mbeya and Dar es Salaam (Fig. 4). Footpaths joining ridges are abandoned and farmers are forced to use longer routes to reach fields and neighbours. Gully erosion has gradually reduced the size of the football ground at Uwanjani (a 'natural stadium' as villagers could watch games from their homes) that has eventually been abandoned as it became too small and more risky to players (Fig. 3 above).

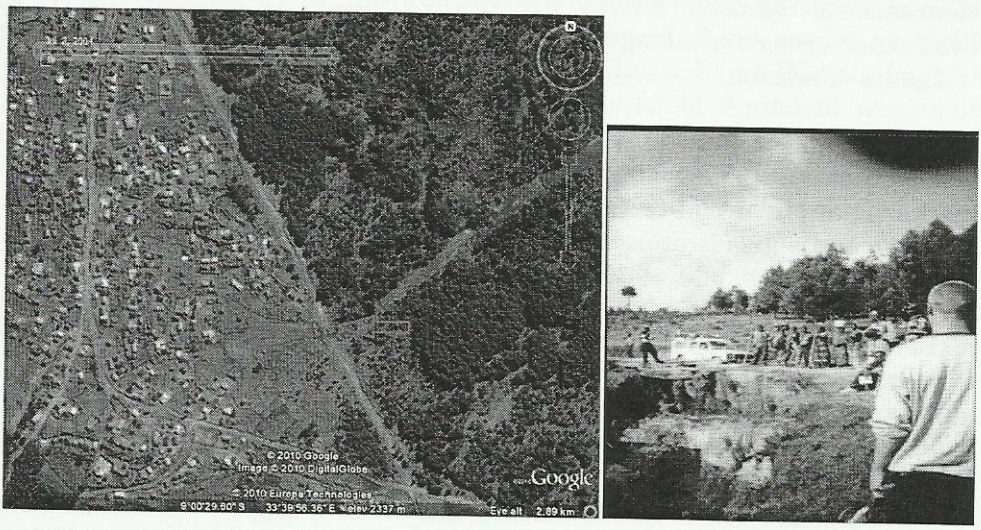


Figure 4: ***Road diversion after bridge destruction by gully extension at Mwansazi***

Influence of settlement development on gully formation and extension

Gully formation and head-ward extension is a complex physical process that has been widely described in physical sciences. This paper focuses on the socio-economic aspects related to the process. The villagisation programme compelled scattered homesteads from Nzumba, Mwantaji, and Ikeka to shift to Igoma, making the village grow more rapidly. The haste nature of the exercise created a high demand for building materials for incoming households. Bamboo poles became the most suitable material for construction of house walls and roofs within a short period of time in this wet environment. This exerted greater pressure on bamboo forests nearby Igoma village.

The growing population also demands more land for house construction, often achieved through filling in space between prevailing buildings and by outward extension of built space. Unfortunately, the boundary of the Kiwira Forest Plantation limits the extension of the village south and

southwest wards. Slowly the construction of houses started encroaching stream valleys. The increasing density of houses and growth of a compact settlement, and the loss of vegetation cover reduced infiltration and increased runoff that drained following natural gradient into numerous stream valleys that surround the village.

The UHs have relatively low temperature that reaches freezing point in June and July. As bamboo houses often allow inflow of cold air from outside, house heating meant a greater pressure on energy resources. The clearance of bamboo forests drastically reduced vegetation cover on headwater areas and along stream valleys, making them more susceptible to agents of erosion.

The impact of reduced infiltration is seen in the reduced volume of water discharged by springs at the headwater areas. The streams no longer discharge abundant water and, throughout the year. The village relied on the numerous headwater springs for water until the late 1990s. Each headwater stream source served its respective side of the village. Tracks and footpaths leading to the springs developed. Headwater areas became places for various household activities associated with use of water. Queuing for water became a common practice during the dry season.

Reliance on gully sites for water changed in the late 1990s when a project to tap water by gravity from upper mountain forest was implemented. However, the widespread deforestation on the upper mountains has reduced the capacity of the environment to recharge water at source, and therefore gully sites are still important alternative sources of water.

The construction of bamboo houses was unsustainable. The bamboo houses have a life span of three years after which reconstruction is necessary due to the wet environment. This proved costly in terms of time and effort for farmers who have a tight yearly farming schedule. Also, the alternative of using grass for roofing was no longer feasible as the highland grasslands had been converted into a forest plantation. The earth brick-making industry was conceived as a good alternative for the construction of durable and better houses because of its relatively low cost. However, the top black soils of the UHs are not suitable for brick making. To reach the more suitable red clay soil requires digging deep into the soil. The stream gullies offered a natural opening for accessing the soil material, and brick-making became a major activity at headwaters and along stream valleys. The village runs projects for construction of school buildings and dispensary on self-help basis, and demands households to participate by making bricks. This made it difficult for the village government to restrict the activity.

The construction and maintenance of road infrastructure in these wet highlands involves making drains and culverts that concentrate water runoff. Cost is likely to encourage road engineers to design fewer drainage ditches, and this tends to concentrate rather than spread runoff. Where concentrated runoff is led into an unprotected stream valley, it has the potential to cause erosion. At Isyonje village, along the Uyole-Kyela/ Kasumulo highway, the largest of such gullies is found less than ten meters from the edge the road. At Igoma town, several gullies, including that of Ngoha and Uwanjani, are growing faster because concentrated runoff from roads is directed to the headwater areas without proper management. The impact of inappropriate management of runoff from roads on gully formation has also been reported in Hedaru village, Same District (Hatibu et al, 2000). Improper termination and direction of drains to weakened valleys enhance gully erosion in headwater areas. The road along the water divide has many of these roadside drains that channel concentrated runoff into already weakened headwater sites.

Land use for agricultural production on the vicinity and within the built-up area has relevance to headwater management. Unless well-managed, agricultural land generates many times more runoff than forested areas (Moges & Holden, 2009; Billi & Dramis, 2003). Although most households continue to farm on fields located in their former residences, demand for land for agriculture near the village has been growing. Conversion of land around the village into agricultural use has further exposed land to runoff. Agricultural land management has been poor, including farmers' abandonment of terracing and ridging associated with a change from pyrethrum and peas growing to Irish potatoes that uses flat tillage (Sokoni, 2001). Farmers give priority to survival rather than present and future environmental concerns. Land management selection by farmers consider more contribution to immediate livelihood needs by increasing crop output per unit of land and minimizing labour than control of land degradation (Mwanukuzi, 2010). Increase in frequency of field use per year further gives greater exposure of the soil to agents of erosion. Agricultural field encroachment into headwater sites and valley streams have led to a loss of bamboo dominated rain forest vegetation cover.

The traditional livestock keeping system in the area involved migration of livestock to pasture lands on highland areas during the wet season and back during the dry season. But this arrangement is no longer possible due to the conversion of the mountain grasslands into a forest plantation. The headwater areas, stream valleys and road and foot paths became grazing lands and sources of water for livestock. This has contributed to further erosion in stream valleys and increase of head-ward extension of gullies.

There has not been any effective land management intervention to check the problem. By-laws to ban brick-making, livestock keeping and cultivation near the valley streams came very late when most of the gullies were in an irreversible stage. Moreover, there has not been a strict enforcement of the by-laws as the village government was a player in degrading the headwater areas through brick making. Some natural bamboo vegetation has remained intact at Mwantaji gully area, but it is highly degraded and numerous gullies are formed following intense use of the area for brick-making.

Local Community Effort and Measures for Controlling Gully Erosion

The physical scale of the gullies around Igoma village depicts the threats they pose to human life and property of the local communities. Surprisingly the process of settlement development continues without adequate precaution. New houses are being constructed near gullies in Uwanjani and Nzumba sub-villages. Suitable land for housing is becoming scarce, and no proper village planning is in place.

The village government is aware of the increasing threat of gully erosion to built-up areas, infrastructure and agricultural land. Loss of buildings occurred after heavy rains at Uwanjani. The low response from local community to hazards and risks from gully erosion manifests a lack of preparedness, and therefore the use of ad-hoc measures when a hazard occurs, making its impact on people and property disastrous.

The neglect of headwater degradation on the UHs, and at Igoma village in particular, confirms the traditional view that headwater regions lie on the margins of socio economic systems, and are neglected. There is no single land management programme in the UHs. The local community tried to redirect runoff from its natural drainage line by constructing a diversion channel at Uwanjani area. But this led to the formation of a new gully side by side to the previous one. The gullies surrounding Igoma village require expertise for intervention beyond the village level. Unless some engineering works are undertaken to control the head-ward extension of the gullies, the risk to people's life and property is eminent.

Planting of trees at gully heads has not been successful as it was too late for most of the big gullies. Also the 30m area restricted from use on either side of water sources and streams is not designated to anyone for proper management, and therefore turns to be a free access resource area such that grazing of livestock destroyed most of the trees plated. The Tanzania Environmental Management Act of 2004 designates the responsibility for proper management of the environment at village level to the Village

Development Committee and a Village Environment Management officer. But this management structure is not yet in place at the village level. Tree planting, especially replanting bamboo trees, is still an important measure for many other potential sites of gully erosion, but its success depends on the enforcement of the ban to graze livestock in the stream valleys. The use of the gullies for brick-making has stopped, and has led to improvement in vegetation cover in some stream valleys.

As the density of the settlement increases, there is greater concentration of runoff along the natural drainage lines that worsens the already weakened gully heads. Runoff management is an important area for intervention. Harvesting of rainwater could reduce some amount of runoff. Construction of drainage lines that would control erosion and divert away from weak gully heads to allow for other control measures, such as infilling and planting vegetation to function, is important. However, such highly technical and expensive measures surpass the capacity of the local community of Igoma.

Conclusion and Recommendations

Using the case of Igoma village, this paper has unveiled the potential hazard facing villages in the headwater area of Uporoto highlands. The formation and development of gullies at the numerous headwater springs is precipitated by the process of settlement growth and poor agricultural land management practices near village settlements. Contrary to the traditional belief that headwater regions are remote and isolated, the Uporoto highlands are densely populated and have potentials for agriculture and tourism development. Yet, the region has received little attention for studying and improving land management practices. The existence of Igoma village, despite its central function in the region, is threatened by head-ward advancing stream gullies. Immediate measures and external support are required to rescue the village from an imminent hazard.

A better management of runoff from pavements, roadsides, roof tops and fields is necessary. Land management practices that enhance infiltration or detention will reduce the volume of storm water runoff during heavy rainfall. Naturally runoff follows natural drainage lines and lead into headwater springs. Construction works to divert storm water would enable already damaged sites to respond to measures for vegetation recovery.

Replanting vegetation, especially bamboo trees, at gully sites and along the stream valleys, is important for the protection of the headwater catchment. This would trap runoff and allow more infiltration. Areas surrounding gully sites and along streams should be conserved. Ensuring availability of adequate and reliable tape water will reduce the use of gullies as source of water. It is

important to enforce restrictions of unsustainable use of the stream valleys. Intervention through settlement physical planning is important. However, in Tanzania there is no physical planning machinery at village levels. Since Igoma meets most of the qualities for designation to a small town its re-categorization would enable the establishment of institutions and access to resources for its physical planning and management. The improvement of agricultural land management practices requires immediate attention. The local communities need to be economically empowered to enable them give priority to environmental conservation practices.

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