Agricultural Journal 2 (4): 471-477, 2007

Soil Erosion Problems in Upper Ala Watershed, Southwestern Nigeria

Olatunji Abiodun Johnson
Department of Geography and Planning Science, University of Ado Ekiti,
P.M.B. 5363, Ado Ekiti, Ekiti State, Nigeria

Abstract: Soil erosion problems at the headwater of Ala watershed which drains a rural community north of akure, southwestern Nigeria, was investigated. The watershed was listed as one of the focal points of UNDP's programme on Sustainable Agriculture, Environment and Rural Development in Nigeria. Baseline survey of the watershed reveals that the following environmental factors contributed to the observed erosion problems: Long, gentle to relatively steep slopes; low infiltration capacity; heavy and prolonged rainfall; highly erodible soils; inadequate and blocked storm drains and unplanned land use types. Indicators of soil erosion identified in the area also include: Detrital materials and coarse sand deposits; bare unvegitated surfaces devoid of top soil; stone capping of soil pedestals; exposed building foundations. These factors and indicators have combined to produce rapidly incising gully systems along some long slopes. At some midslopes and southern basal positions currently being opened-up for various developments, small and few storm drains have promoted sheet erosion and street floods that often inadequate built-up areas. On the basis of baseline data collected, good management practices and strategies for soil erosion control and conversation that also fosters social awareness on the problems were suggested with the hope that they will help restore the degrading land to a more productive use.

Key words: Soil erosion problems, baseline, survey, watershed management, erosion factors and indicators, good management practices

INTRODUCTION

Accelerated soil erosion in the humid tropical regions of southwestern Nigeria has contributed to observed present day environmental degradation and starvation in these regions (Laflen *et al*., 1990, 2000). The works of Lal (1995, 2000), Babalola and Chheda (1975) and Lal (1976) further provides elaborate account of soil erosion in the region.

From the view of soil and agricultural systems, Pimental *et al*. (1993) work and the results presented by Liu *et al*. (2000) supports the conclusion that soil erosion has affected soil fertility degration, decline of land productivity and deterioration of soil quality. Lal (1994a) results also indicated that there has been a sizeable decrease in per capita arable land areas in Africa south of Sahara, due to soil erosions (Eswaran, 1982).

Old man and Hakkeling (1990) presented stunning statistics that a total of 321 Million hectares in Africa as a whole was moderately to excessively affected by erosion and land degradation. Sanchez and Salinas (1981) also presents a figure which shows that 316 million ha of acid, tropical soils are leached, while 43% of total land areas in the tropics is covered by association of Oxisols and Ultisols (i.e., Ferrelsols) with 39% in tropical Africa. Scoones and Toulmin (1999) in their review of land degradation and soil erosion assessment in some African countries also drew conclusion that soil erosion assessment is not an easy task to achieve since most erosion control techniques often adopted has never proved sufficient in themselves.

The study area is a community located within upper Ala watershed, north of Akure and one of the areas currently experiencing soil erosion in southwestern Nigeria. The watershed falls locally within the framework of Benin-Owena River Basin Development Authority (BORBDA) which has long been selected for planning purposes. Due to the persistence of the erosion menace, the watershed was recently listed as one of the UNDP'S focal points on Sustainable Agriculture, Environment and Rural Development.

The programme was instituted to conduct baseline surveys and suggest ways of controlling the devastating of several agricultural areas and settlements by soil erosion, including the study area.

In spite of several millions worth of ecological funds committed to these projects, the erosion problem persist and poses a direct threat to social, economic, environmental and agricultural developments of the affected areas. The situation is also becoming worse under the harsh economic reform policy currently being implemented in Nigeria. Soil erosion problems in this area should therefore be studied in more details and accorded adequate attention.

This study identifies the factors, processes and indicators of soil erosion and attempts to foster social awareness about the necessity of good agricultural practices and strategies for land conservation in order to reduce the problem of erosion.

Site characteristics: The study site is located on the shoulder of a big scarp slope within the watershed bearing the head-waters of River Ala north of Akure, a city in southwestern Nigeria. The area lies within the geographical coordinates from Longitudes 5^0, 10^1 to 5^0, 13^1 East of Greenwich Meridian and Latitudes 7^0 12^1 to 7^0 16^1 North of the Equator (Fig. 1).

The area was underlain by the Nigerian basement complex rock of the old-suite, pre-Cambrain origin which covers about 59% of the land in southwestern Nigeria. Major rocks are impermeable granite gneisses, migmatites, quartzite complexes, coarse biotite granites, medium-grained biotites, muscovites, charnokites and coarse porphyritic granites. The soils that have developed over these rocks belong locally to 'Ijare series' which are Ferralsols (FAO/UNESCO, 1974; USDA, 1974; Dudal, 1977; Muller-Samann and Kotschi, 1997; Njos, 1983). Relief of the area shows three distinct levels of height of the terrain due to variations of the resistant and often crystalline rocks to erosion. Surfaces which produced differential erosion were classified from various heights shown on the contour lines of the topographical map of the area. This intermediate topography varies in elevation from 300-400 m above sea level and it is separated from the upland surface by the irregular scarp.

Highest elevation within the watershed is 455 m above sea level at the northwestern part. The land slopes southeastwards of the areas and rises again to an elevation of 411 m above sea level at the northeastern part.

The uplands and some intermediate surfaces are composed of massive inselbergs developed on granites and charnokites. The relatively softer gneisses and schists are the rock types in the lowlands. The inselbergs often constitute interfluves in the watershed and influences the hydrology of the area appreciably. Rainwater incident on them flows into the footlopes and later into the stream channel rapidly during storm-runoff events. Landforms in the area also include different types of valleys and erosion residuals such as tabular and dissected hills which reflect the signature of underlying rocks or relics of older inselbergs.

The study area falls within the rainforest belt in the humid tropics. Rainfall distribution is 5-10 months and is characterized by marked dry season of 3 months with 1400 mm average annual rainfall. Average monthly temperature is less than 20°C but can be lesser in some months. Relative humidity varies with season with 70-100% in the wet season and 60-90% in dry season. However, natural vegetation has been adversely cleared and modified in many places to give way to farmlands and contemporary settlement sites.

Seasonal bush burning is also rampant in some parts of the area. Except for the bare surfaces such as inselbergs, the vegetation of the hilly areas have been modified by human activities and climax vegetation can only be found along steep slopes where human activities (such as building construction and agriculture) are difficult.

Woody shrubs and riparian vegetation covers most part of the hill tops of softer rock materials and valley slopes respectively, while the lowlands are covered with secondary forest. Dominant plant species are *Panicium maxima* (Elephant grass), *Sida acuta* (Goat weed), *Eupatorium odoratum* and scattered woody plants.

Landuse types in the area are predominantly agricultural interparsed with fallow and settlements. While the northern dip scarp part of the watershed is occupied by human settlements (i.e., built-up areas), the lower basal parts are dominated by scattered farmsteads and agricultural lands with *Zea mais* (maize), *Discorea species* (Yam), *Manihot species* (cassava), as the major food crops.

MATERIALS AND METHODS

The topographical map of the study area was acquired from the State Ministry of Lands and Housing and used to delimit the watershed (Fig. 1). This was however inadequate for details required but provides information on relief, basin area, drainage network, contours, generalized landuse, as well derive terrain indices relevant to soil erosion survey in the area. Some of these information's were provided in Table 1.

Alternatively, site-specific field investigation was conducted and dealt with several slope plots obtained in traverses ranging from $5\text{-}28^0$. Inventories of erosion features amendable to being recorded on a recording sheet on a present or absent basis were also prepared. Simple field measurements of physical properties of erosion elements were made for lengths, average depths, widths, cross sectional areas and spatial coverage of erosion features. Other slope parameters such as gradient and average slope lengths were also derived. Erosion channels that are still in various stages of development (i.e., active) or not (inactive) were observed and recorded accordingly.

Vegetation cover and types were observed and noted in the watershed. Extrapolation was made for mean monthly rainfall data for Akure a near-by city, with standard rainfall interpolation method. All measuments and recordings take into consideration of processes at the interfluve, midslope and basal slope sections of the topography in the watershed.

Table 1: Terrain characteristics and factors of soil erosion in the watershed

Main stream	: Upper Ala
Maximum elevation	: 455m
Relative relief	: 168m
Relief ratio	: 0.029m
Average slope gradient	: 19
Range of slope length	: 30-315m.
Soil type	: Oxisols, Alfisols, Utilsols (Ferralsols)
Rock type	: Mainly coarse grained granite-gneisses
Vegetation	: Mainly bush regrowth.
Terrain type	: Moderately rugged
Infilteration capacity	: 13.7(mm Hr^{-1}) bare surfaces
	: 24.1(mmhr-1) bush regrowth areas.
Annual rainfall (mean)	: 1400mm

RESULTS AND DISCUSSION

Factors and indicators of soil erosion: Table 1 shows some terrain characteristics and factors of soil erosion in the watershed. The main environmental factors that predispose the soil to serious and accelerated erosion are long, gentle to relatively steep slopes, degree of slope, heavy and prolong rainfall, high erodible soil, inadequate storm drains and unplanned landuse types in the built-up parts of the watershed.

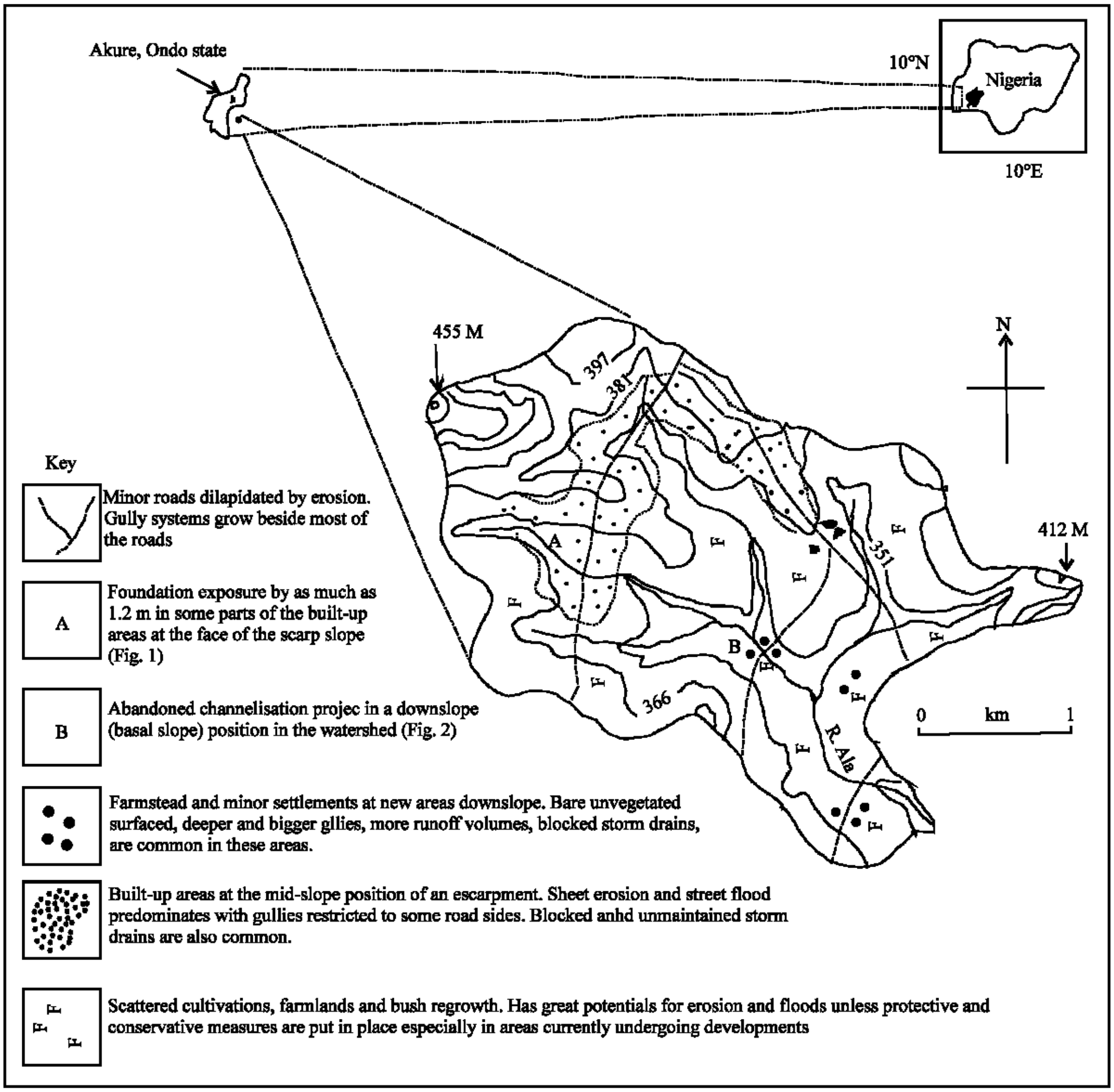

Fig. 1: The upper Ala watershed

Slope lengths within the watershed vary between 30 to 315 m. Slope gradient also vary from 5-28 with a mean of 19. Generally, the area is dissected by erosion with incisions varying in size from very small rills with channels that are hardly discernible to gigantic gullies characterized with near-vertical sides and measuring more than 1.7 to 5 m deep in some locations (Fig. 1 and 2).

Most of the built-up areas within the community suffers from sheet and rill erosion problems and are the most serious of the environmental hazards in the area. They are often imperceptible or difficult to notice, but are responsible for the loss of great quantities of top soil. A sizeable part of the community is located on the long southeast facing scarp slope side of a ridge approaching 20^0 at some traverses.

In the built-up parts of the community, indicators of soil erosion are detrital materials and coarse sands, deposits of fine sediments at the basal slopes and bottom of fields, bare unvegetated surfaces devoid of topsoil, stone capping of soil pedestals, exposed bed rocks and tree root and exposed building foundations.

Discrete, snap shot measurements of exposures of tree root and building foundations are good indicators of soil loss and ground surface lowering by sheet erosion. This is more prevalent within the built-up areas of the community where exposed building foundations averaged 20 cm and are only delicately supported by outcropping duricrust concretions (Fig. 2). In some locations root exposures also vary from 20-30 cm.

Next in importance to and closely associated with sheet erosion is street flood which is widespread and severe within the built-up areas of the community. Factors that promotes street flood are extensive bare surfaces, low infilteration capacity of the soil, long and moderately steep slopes, absence or inadequacy of storm drains.

Within the watershed, the midslope positions where most of the built-up areas are situated are the most proned to erosion. Several types of guilies at different stages of development with differing shapes and sizes were observed especially beside major roads. Depending on the dictates of the prevailing factors and processes of erosion, depths of most gully systems are small at the upslope positions where erosion processes begin and advance. Gullies attain active and rapidly incising depths towards the midslopes positions. They then reduce towards the basal slopes where some deposition has taken place. In some mid-slope positions, especially beside roads development of gullies are much more prevalent spatially than sheet erosion. Towards the basal position in the study area, some arable agriculture are practiced and recent expansion of the community is in these ecologically fragile zones. At the time of baseline survey, there were only few protective practices or strategies for erosion control and elimination.

Fig. 2: Foundation of a mudhouse exposed by 1.2 m (shown with arrow) by sheet erosion and street floods over duricrust concretions within the built-up areas (site A in Fig. 1)

Fig. 3: An abandoned chnnelisation project overtaken by gullies in a downslope position currently undergoing various developments (site B in Fig. 1). An exposed pipe and the author were shown at the background

At some locations within the built-up areas of the community, the only engineering structure designed to convey and dispose storm-runoff water are the storm drains and culverts. However, the storm drains are few and are too small for the huge volume of runoff generated during storm-runoff events.

This phenomenon is accounted for by high rainfall depths (1400 mm average) and intensities, degree of surface imperviousness and relatively low infilteration capacity (averaging, 13.7 mm hr^{-1}) of soil within the built-up areas.

Most of the storm drains are constructed along gentle down slope positions and only few are constructed in the relatively steeper midslopes positions. The storm drains are not usually maintained and are often chocked-up with sediments, vegetation and refuse. These factors have combined with continued seasonal deposition to reduce the efficiency of the storm drains to carry water during storms with the attendant displacement of the water to adjacent areas. The displaced water often inundates built-up areas and promotes sheet erosion and street floods.

The result of the baseline survey show that the study area is moderately eroded by gully, sheet and rill erosion as well as street floods. The most affected area is the down slope position of the built-up parts of the community. It is also important to stress that if adequate control and conservating measures are not taken, all parts of the community have great potentials for serious erosion and flood in varying degrees. This underscores the urgent need to develop strategies and good practices that will effectively address the problems.

Suggested good management practices and strategies for soil erosion control: In order to work-out good practices and strategies for sustainable soil erosion control, the spatial and temporal distributions of different types of erosion in the watershed must be well understood. Factors, processes and indicators of accelerated soil erosion in the area must be used to construct a virile environmental database for planners, agriculturist, developers, geographers, scientist/researchers and other professionals. It is then that the practices and strategies for erosion control can be effective.

Soil erosion control is often expensive, time consuming and requires scientific approach for it to be sustainable. Lal and Singh (1995) suggested that cost-effective and simple methods need to be developed especially for developing countries. There is need to facilitate widespread adoption of improved low or medium input technology that involves input from affected people.

In some midslope parts of the built-up areas for example, local bamboo, pegs, logs, stones and mounds have been used as check-duams to eliminate run off, but still requires that they be upgraded to a more scientific approach to make them effective. Drainage systems that have been blocked must be reactivated and maintained to discourage sheet erosion and street floods. More drainage and channelisation systems must be put in place to ensure undisturbed routing of runoff water during storm-runoff events (Olatunji, 1998a).

Table 2: Pactices and strategies that can help mitigate soil erosion problems

Practices contour stripping method on long slope.
Construct cellular or storage dam where appropriate.
Raise erosion horizon and stabilize gully bank and bed.
Construct tie ridge where and when necessary.
Practice agroforestry technology to reduce soil erosion and dampen runoff.
Level fields on the bank terrace to retain silt and water.
Practice sustainable agriculture (organic farming, biodynamic farming, conversation farming, ecofarming, ecologically sound agriculture)
Use and improve Indigenous People's Practice (IPP) such as pegs, stones, logs, mounds, bamboo. These should be studied and upscaled into standard erosion control strategies (e.g. use of gabions).
Encourage Participatory Technology Development (PTD), synergism, environmental education, low and medium input technology and other sanitation programmes amongst all stakeholders on the environment.
Concentrate eroded soil in gully patches, valley gardens and bound terraces.
Improve and maintain stream drains, culverts and channellise runoff waters.
Increase plant cover where necessary to increase infilteration and reduce surface runoff.
Improve landuse planning efforts

In parts of the midslope and basal positions where some agriculture is being practiced, good practices that will ensure slope protection, stabilization of gully advances and enlargement and system construction should be adopted. This, according to Olatunji and Ibimilua (2001) should be done without endangering, damaging or destroying the natural resource base. Increasing plant cover and adjusting agricultural practices (such as organic farming) that will improve soil fertility and soil protection should be encouraged (Olatunji, 2001).

More strategies and practice that can help restore the degraded land increase vegetation cover and mitigate erosion problems are suggested in Table 2.

CONCLUSION

The baseline data revealed that rill erosion are prevalent at the upslope sides towards the interfluve. Sheet erosion and street flood are more widespread within the built-up areas of the watershed. Gully erosion are more localized and occurs at; the midslope positions especially along roadsides and at new sites being opened-up for various developments.

However, all parts of the community have great potentials for erosion and flooding in varying degrees, but the most severely degraded area is part of midslope and downslope positions of built-up. The imposition of alien technologies to solve indigenous problems in developing countries may be novel, but have often proved incapable of improving the livelihood of the people in many cases. Based on the baseline data collected, there may be the need to experiment with approaches that conutenounces indigeneous values, knowledge and aspirations. Good management practices, strategies and technologies that are site specific, takes the aspiration of the indigeneous people in to consideration, considers social and economic systems as well as being non-injurious to the environment, could be desirable as universally acceptable solutions are often rare.

In spite of the consensus regarding the controlling factors and indicators of soil erosion in conjunction with their causes and effects, the mechanism responsible for sculpturing the degraded landscape usually vary both spatially and temporally. Hence, good and sustainable practices proposed for their mitigation is also expected to vary in space and time.

For example, while gully control or runoff elimination may be part of the practices proposed for midslope positions where long slopes, runoff volumes, are some of the erosion factors, improved storm-drains, culverts and channelisation of runoff water may be more appropriate within the built-up areas. In a similar vein, since soil erosion often start from almost imperceptible micro rills to gigantic gullies within a time frame, strategies and practices for their control is also expected to improve with increasing vigour over time as the area expands.

Further, the strategies and practices adapted should be amenable to local social, economic and environmental dictates that is affordable by indigenous people rather than the often ostentatious governmental projects that engulfs millions of ecological funds but have little or no impact, nor input from target people. It is then that good practices and strategies for soil erosion control can become more culturally authentic and technologically humanistic.

Based on the baseline data collected, simple cost-effective management practices can be suggested to control the erosion problems. It is hoped that if the suggested practices and strategies are adopted, the watershed's environmental conditions can be improved considerably.

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