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PEOPLE AND SYSTEMS FOR WATER, SANITATION AND HEALTH

# Strategic water resource management, Nigeria

*Frank Simpson, Peter P. Hudec, Enuvie G. Akpokodje and Meshach O. Umenweke, Canada*

THE RESEARCH PROJECT, Gully erosion, Nigeria, involved cooperation between the geology departments of the University of Windsor and the Nnamdi Azikiwe University, Awka, Anambra State, and the University of Port Harcourt, Port Harcourt, Rivers State. Research teams from the universities worked in partnership with rural people in Abia, Anambra, Enugu, and Imo States from 1993 to 1997. Political events intervened and the project participants next were reunited in 1999. The extended project term came to an end in 2000. The goal was to reduce gully erosion in southeastern Nigeria. The purpose was to discover reasons for the large numbers of gullies in the region and to design a strategy for the control and prevention of gully erosion. The funding agency was the International Development Research Centre, Ottawa. Hudec et al. (1998) described the geological engineering properties of those materials that are especially susceptible to gully erosion. The present account relates some aspects of project research to concepts of water resource management. Use of "strategic" in the title draws attention to the importance of this to the national security of Nigeria.

## Background information

The project area is part of the Anambra-Imo basin region of southeastern Nigeria. The bedrock comprises mainly siliciclastic strata, exhibiting different degrees of lithification. Upper Cretaceous sandstones and shales in the north and east give way to Tertiary clastic rocks and sediments in the west and south and Quaternary sands farther south, beneath a soil cover of variable thickness. Laterite development is widespread in the surface materials. Kogbe and Mehes (1986) summarized the age relations of these deposits.

Steep-sided gullies are carved into the hillsides of southeastern Nigeria by runoff from high-intensity rainfall events. Gully erosion brings dramatic changes to the landscape during a single rainy season. It is responsible for the isolation of communities, disruption of transportation and communication systems, loss of both agricultural and forested land, and migration of large numbers of the rural poor. At a number of locations, extensive gully formation has given rise to the treeless systems of knife-edge ridges and intervening, steep-sided gorges, typical of badlands.

The World Bank (1990) estimated the cost of soil degradation and loss to the sustainable net national product of Nigeria as over US $3000 million/year. The cost of gully erosion was thought to be about US $100 million/year. In southeastern Nigeria, there has been a significant increase in the degradation of the land, since Grove (1951) presented his findings on gully erosion. Should it remain unchecked, the resulting, devastated landscape will hasten future incorporation of the area into the southward advancing Sahara Desert.

## Project research

Erosion committees were formed in the partner villages to assist communication between the people and the project teams. The rural people provided valuable information about the impact of gully erosion on daily life in southeastern Nigeria. They also assisted in the systematic collection of climatic data.

In each of the four states, the project teams made field observations on gullies at selected study sites. They discussed strategies for gully control and prevention, based on these observations, with the villagers. The people obtained funds from various sources for rehabilitation of eroded lands. The Nigerian researchers and the rural people monitored the sites under rehabilitation for signs of renewed erosion.

The project teams carried out field and laboratory investigations on the surface materials, affected by gully erosion. Some geological units are particularly susceptible to erosion by runoff. In addition, poorly cemented sediments flow readily down-slope, when penetrated from above by deepening gullies. Loss of the protective cover of vegetation sets the scene for localized erosion.

Another contributing factor is the variation in soil compaction, resulting from foot and wheeled traffic. This includes the creation of new footpaths through the forest by villagers and the movement of herds of livestock along the larger thoroughfares. Local approaches to agriculture, especially those involving shifting cultivation in forested areas, also tend to promote erosion by surface runoff.

Erosion by concentrated runoff also tends to be localized, where Earth materials abut against artificial structures. In particular, the faulty design and construction of roadside drainage is a major cause of gully erosion. The overflow of runoff, moving in drains and culverts, gives rise to localized erosion along the roads. As well, the additions to surface runoff from the roofs of dwellings and other structures increase its erosive power.

## Outcomes

The project outcomes are the results of multidisciplinary research and a strategy for the control and prevention of gully erosion. The project teams visited many of the study sites during the rainy season in August and September of

1999. Various technologies, introduced by village partners for the control of gully erosion, were seen to be for the most part successful. These measures mainly involved controlling the flow of runoff, in and near major gully systems. They arrested the advance of gullies that had threatened roads and dwellings at the start of the project term.

A strategy for the control and prevention of gully erosion, based on the results of project research, was presented at a one-day workshop in Owerri, Imo State, on September 2, 1999. It requires the implementation of technologies for water and soil conservation on the scale of a drainage basin. In general, these approaches are cheap, small-scale and easily replicated. They are related to the knowledge systems of the rural people in basic principle.

The conference made a contribution to pluralism in environmental awareness in southeastern Nigeria. Government officials from the four states and rural people from each of the partner villages attended the workshop. Senior administrators and also graduate students and undergraduates from each of the Nigerian partner universities were present. Several representatives of Nigerian private industry were also at the workshop. Local (Imo State) and national Nigerian newspapers and an Owerri television station assisted the project teams, by making the project results available to a wider audience.

## Monitoring and assessment

Strategic water resource management on the scale of a drainage basin in the context of southeastern Nigeria must include the introduction of technologies for water conservation that will minimize the uncontrolled flow of surface runoff. It must be accompanied by supporting technologies to reduce soil erosion. It also requires rapid response to unplanned conditions of water movement at and near ground level. This involves monitoring changes to surface materials during heavy rains, notably at sites with the potential for erosion of new gullies and also reactivation of pre-existing features. The use of satellite imagery for monitoring and assessment of hazards from gully erosion is essential in dealing with an ecosystem, so sensitive to climatic factors..

A list of requirements for satellite observation of landslide signatures was presented by Hidalgo (1999) for northern South America. These included considerations of spatial resolution, image frequency (repeat time and observation interval), radiometric bands and image format. Satellites, such as Landsat-7 and Terra, were considered most appropriate, in terms of accuracy and spatial resolution. The requirements and corresponding satellites at least provide a starting point for the use of satellite imagery in the detection of incipient gully erosion and related mass movement in southeastern Nigeria. Increased awareness of the relationship to local conditions will yield refinements.

Analysis of satellite imagery to locate linear ground features (lineaments) is viewed as an integral part of strategic water resource management. It is noteworthy that wrench faults with east-northeasterly (dextral) and north- northwesterly (sinistral) orientations occur in West Africa (Black and Girod, 1970). Simpson and Sohani (2000) outlined the relationships between lineaments, drainage and water-conservation measures in a dryland part of Maharashtra State, India. This approach to site selection and evaluation for small-scale technologies is likely to have wider application. Accordingly, it merits inclusion in any future feasibility study of possible applications of satellite imagery to water and soil conservation in southeastern Nigeria.

## Technology transfer

Examples of successful technologies at project study sites, with lessons on gully control for other parts of southeastern Nigeria, include:

- **Uturu, Okigwe-Uturu-Isiukwuato road junction, near Abia State University, Abia State.** The collapse of a roadside drain gave rise to a deep gully that threatened the highway and associated telecommunication systems. A soil fill was introduced and then graded. A concrete drain diverted runoff down-slope, away from the highway. A dense cover of grasses and shrubs was established.
- **Ekwulobia,, Anambra State.** The village and nearby highway were at risk from a gully, resulting from a collapsed, concrete drain. The villagers constructed a concrete spillway at the gully head. They also built concrete drains to divert runoff from the gully. Roof-water harvesting also reduced the amount of surface runoff in the vicinity of the gully. Commonly, water was piped from several roofs to the same concrete tank.
- **Amucha, Imo State.** The Nigerian researchers designed and constructed modifications to roadside drains, taking into account the volumes of runoff received. The road previously had been eroded below the level of the drain in places, but there was no undercutting of the new sections.
- **Ngwo, Enugu State.** Gullies near the Enugu-Onitsha Expressway became inactive, as a result of the combined effects of laterite development and new growth of vegetatio*n*.

The full range of technologies for water harvesting and spreading, considered by Simpson and Sohani (2000), is appropriate for use also in southeastern Nigeria. These include the excavation of terraces on hillsides, the construction of terrace-margin ridges (bunds) and contour trenches, the impoundment of runoff in reservoirs on the up-slope sides of check dams, the collection of spring waters in masonry tanks, and the harvesting of rainwater from the roofs of dwellings and roads.

In addition, the planting of crops and forestry trees must be carefully planned in relation to the water harvesting and spreading initiatives, so as to minimize the exposure of the soil to the impact of rain and runoff. The use of agroforestry techniques would ensure the systematic return of forestry trees to the denuded hillsides, with no loss to the farmers.

There is an urgent need to consider runoff volumes in the design of highway drains and culverts. Lining of these with aggregate and gravel would reduce the potential for undercutting by runoff.

## Learning from mistakes

Much that is said in the preceding sections could go under this heading. The main lesson is that localized erosion tends to occur at:

(1) textural heterogeneities and interruptions to the vegetation cover of granular surface materials; and
(2) unlined interfaces between such materials and artificial structures.

In the more restricted context of the project research, two sites are particularly instructive. At the village of Umuchu, Anambra State, initial success in gully control along a road turned into disaster, when the construction firm, hired for the work, ended its activities halfway. This incident indicates a role for Nigerian professional associations in maintaining ethical standards of practice. At the study site near Abia State University, water diverted down-slope, away from the active gully, was responsible for new gully erosion, albeit on a reduced scale. This underscores the need for strategic management of water resources on the scale of a drainage basin.

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FRANK SIMPSON, University of Windsor Earth Sciences, Windsor, Ontario, Canada.

PETER P. HUDEC, University of Windsor Earth Sciences, Windsor, Ontario, Canada.

ENUVIE G. AKPOKODJE, Department of Geology, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria.

MESHACK O. UMENWEKE^, Department of Geological Sciences, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.