Runoff erosion control for a sustainable water supply in Niamey, Niger Republic

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Abstract Runoff erosion is very detrimental to soils and their use, especially in semi-arid countries, and controlling it is a day-to-day preoccupation of people and governments. The flowing water erodes farmland and destroys infrastructures. Also, overland flow transports silt and deposits it in depresssions. Silting is one of the most important causes of flow reduction in the River Niger, which serves as the source of domestic water supply for Niamey and other riverside towns and villages. In order to protect this river and its riparian communities, the Niger Republic and the Niamey Urban Communality (CUN) governments adopted a number of measures to control runoff erosion so as to guarantee three million cubic metres of domestic water supply, the need of only a few days. These were mostly structural and/or agronomic methods. The present study examines the control measures in Niamey Township from 2000 to 2006. The methodology used included interviews with the local population, technicians and engineers handling the erosion control activities. Some field investigations were also undertaken to determine the sediments caught upstream of the constructions, and view the effectiveness of the control measures. After a critical examination of the techniques implemented, it emerges that not all were effectively constructed. The efficiency of any erosion control measure is conditioned by the total involvement of the local population. There is, therefore, a need for a large-scale campaign to enlighten the people of the importance of the control activities so as encourage them to fully participate in the control work and in maintaining the existing constructions.

Key words erosion control; River Niger flow; CUN (Niamey Urban Communality)

INTRODUCTION

Today's society often focuses on sensational news and the short-term crises which surround us. Many people ignore the long-term problems that develop slowly until they reach a critical level. One of the indefinite environmental problems that the world undergoes is runoff erosion. The flowing water erodes farms and grazing lands, and destroys infrastructure, such as roads, houses and bridges. In addition to these problems, the flowing water transports silt and deposits it into depressions. Silting is one of the most important causes of the reduction of flow in the River Niger, because the deposited sediments contribute to the raising of the valley floor level and consequently promote infiltration losses that lead to a further decrease in river discharge. Infiltration has a negative impact on runoff because higher infiltration reduces runoff, and *vice versa* (Anthony & Athol, 1999).

Niamey and many other settlements depend on the River Niger, so that controlling erosion, especially that caused by runoff, will make a significant contribution through:

1. minimizing the erosion and the deposition of particles on the bed of the River Niger,
2. moderating the damage to agricultural lands and infrastructure, and
3. protecting the River Niger flow so as to guarantee sustainable water supply.

However, in spite of the efforts that both the Niamey Township Office and the Niger Republic government are deploying, the problem of runoff erosion persists and the increasing population is facing recurrent freshwater scarcity.

Critical examination of the efforts made to control runoff erosion in the CUN is the focus of this study and will involve:

– examination of the runoff erosion control techniques used in the CUN, and
– critical assessment of the effectiveness of the techniques.

Although much research has focussed on Niamey, there have been few attempts to evaluate the effectiveness of runoff erosion control activities in the area, even though much interest has centred on preserving the river flow through the so-called *Programme Spécial du Président de la République.*

WATER PROBLEMS IN NIAMEY

The Niamey domestic water supply depends on the River Niger which flows through the CUN for 14.5 km. Great concern arose when discharge became less than 3 m^3/s for the first time at Niamey, causing disturbance to the Niamey water supply system and to the flood plain wetland farming projects along the river. The worst conditions occurred in 1985 when the flow fell virtually to zero on the 15 June and overnight (Beïdou, 1987). Two water plants at Goudel and Yantala, with a pumping capacity of 3 940 000 and 27 000 m^3/d, respectively, provide 90 000 m^3/d of drinkable water to the town (65 000 m^3 at Goudel and 25 000 m^3 at Yantala). Presently, in the case of an interruption to pumping, the water supply would be ensured for only three weeks.

METHODOLOGY

In this study, data were collected through:

1. interviews with the local population, the technicians and engineers handling the erosion control work;
2. literature review on the study topic and the socio-economic aspects of the study population; and
3. field investigation for observing and measuring the dimensions of channels and control works.

The fieldwork covered the Niamey Urban Communality territory, which is located in the southwestern part of the Niger Republic, astride the River Niger. The CUN covers an area of 239.26 km^2 and is subdivided into five entities (HCRAD, 2003).

Niamey is covered by a lateritic layer in the south and partially covered by sand dunes in its northern part. There are plateaus that reach an elevation of 263 m and cover areas sometimes greater than 200 ha (Bougoum: 296 ha, Léléyi: 214 ha, Gorou

Banda: 147 ha). The River Niger has three tributaries (Goroual, Sirba, and Dargol) and is the only perennial waterbody in Niamey.

Soils are mostly lateritic, tropical ferruginous, hydromorphic and vertisols. The tropical ferruginous soils are found on the plateau areas, while the vertisols are locally found on riversides (Lancina, 2000).

The climate is of the Sahelo-Sudanian type at the limit of the Sudan savannah. It is characterised by:

– temperatures rarely dropping below 22°C, but sometimes rising above 40°C, and
– torrential rainfall events, with a mean annual rainfall of 553.3 mm.

The vegetation is almost non-existent in the peri-urban zone due to uncontrolled cutting of trees. However, species including *Acacia*, *Balanites aegyptiaca*, *Hyphaena thebaica*, *Guierra senegalensis*, *Cassia italica*, *Eragrotic*, *Combreton* (*gluttinosum, micranthums*), and *Piliostigma recticulatum* are present (Issoufou, 2004). There is a dense urban vegetation of fruit and exotic trees, a luxuriant vegetation in the river valley, and an artificial forest or "ceinture verte" (green belt) of *Azadirachta indica* and Eucalyptus species which was created to serve as a 20-km-long wind-break.

According to the 2001 census, total population of the CUN is 674 950 people. This population is variously distributed within the communal area (CBR, 2001).

According to the 2006 projections, total population of the CUN is 725 030 people. This population is variously distributed within the communal area (RENACOM, 2006).

RUNOFF EROSION CONTROL TECHNIQUES

Traditional (indigenous) techniques

The local people, conscious of the phenomenon of environmental damage caused by runoff erosion, adopt some techniques in order to protect soils and promote infiltration. The techniques used include digging of "tassa" (cups) which are small cavities of 10 to 40 cm diameter and 10 to 25 cm depth created on bare soils for capturing running water. They serve as water pockets and are spaced at approximately 1 m intervals (Bouzou & Dan Lamso, 2004). Sand bags are also placed perpendicularly to the direction of water flow or along the channels' banks in order to reduce the runoff velocity and prevent channel enlargement, respectively. This technique is mostly used on agricultural lands and/or in inhabited areas. In addition, refuse may be dumped in rills and gullies in order to reduce headward erosion, especially in Niamey town.

The techniques implemented by governments

Governmental institutions are responsible for most of the runoff erosion techniques implemented in the CUN. These include streambank protection, stone walls, benches, trenches, "demi-lunes", retention walls, and dykes. These mechanical methods are usually employed in conjunction with the agronomic measures that involve tree planting. The planted trees species are mostly *Acacia* (*seyal*, *nilotica*, *tortilis*, *senegal*), *Prosopis juliflora*, *Bauchinia refescens*, *Parkinsonia aculeate* and *Ziziphus mauritiaca*.

Streambank protection starts with the setting of gabions along the banks, and is followed by tree planting on the channel banks. The disposition and dimensions of the planting varies greatly, but trees are often planted at intervals of about 3–4 m.

Trenches are succession of excavations designed to be filled by the running water. The trench (Fig. 1) can be either rectilinear or semi-circular in form. The middle of the trench is generally raised to allow the planting of a tree. The dimensions of the rectangular trenches are approximately 3 to 4 m long, 0.6 m wide, and 0.6 m deep. The semi-circular trenches are 0.3–0.4 m wide, 0.3 to 0.4 deep and have a radius of 1.5–2 m. The intervals between trenches may vary from 3 to 6 m along, and 4 to 6 m up or down, the slope.

"Demi-lunes" **(**from French, meaning *half a moon*) comprise small excavations (25 cm deep) of crescentic form, with a diameter of 2 to 5 m (mostly 4 m) (Fig. 2). In front of the convex part, a small dyke is often constructed. Demi-lunes are arranged in fives, with intervals between them varying from 5 to 8 m along the same contour, and from 2.5 to 4 m up and down the slope.

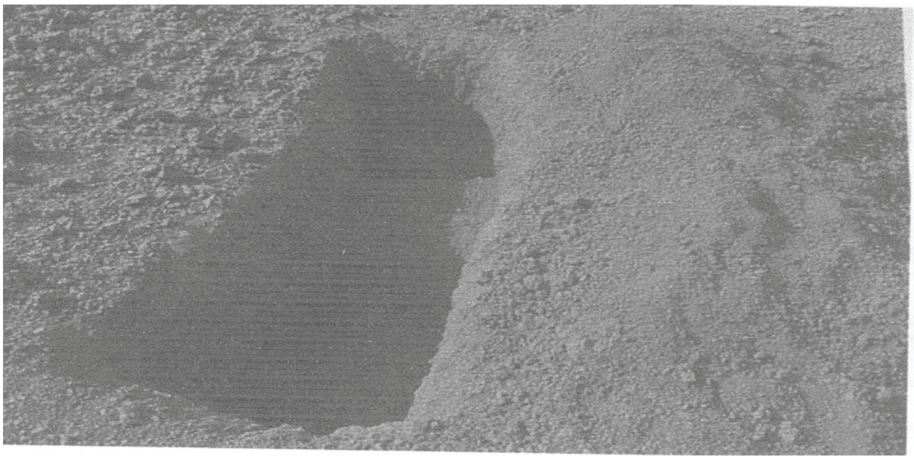

Fig. 1 An example of a typical trench.

Fig. 2 An example of "demi-lunes" filled with water.

Stone walls**,** consisting fully or partly of stone, and 0.3 m in height, 0.50 m in width and of indefinite length, are also constructed along contour lines. The interval between two stone walls depends much upon the characteristics of the terrain. Benches are small dykes made up of *in situ* soil material. The ones constructed on the Bougoum, Léléyi, Gorou Banda plateaus are 0.3 m high, 1.5 m wide at the base, 0.5 m wide at the top, and 60 m long. The benches have two small drains at a depth of 0.3 m, but the internal drain is wider (0.7 m) than the external one (0.3 m). They are arranged in alternating rows, with a spacing of 30 m up and down the slope, and 5 to 7 m laterally. The benches are subsoiled in order to enhance infiltration. These structures are associated with planting of 26 *Acacia senegal* trees and they may also be used for cultivating sorghum, especially the *Sepon 82* species.

Retention walls are made from gabions set across stream channels and along their banks. The size of the constructions varies greatly depending upon the flow discharges involved. Dykes are constructions of small height, built with stones or compacted materials across a low-lying ground. There are three types of dykes known as filtering dykes, built of pervious materials; bank protection dykes, made up of compacted materials covered with stones; and subsidence dykes, constructed from impervious material (Cheleq & Dupriez, 1984).

PROSPECTS

The most common indigenous practices in runoff erosion control are undertaken in order to halt the development of gullies as well as to promote infiltration. These techniques are commonly used by the Niamey town dwellers and the peasants of the surrounding villages. Digging of "tassa" or water pockets is a technique that captures not only runoff water but also transported soil particles. It is very useful in enhancing the infiltration rate of the terrain and the retention of soil nutrients removed by rain-splash or flowing water, and may eventually improve soil fertility and agricultural production (Bouzou & Dan Lamso, 2004).

The modern engineering structures have been constructed in order to capture the detached particles, reduce erosion, enhance infiltration, and to improve agricultural production as well as the quantity and quality of vegetation cover. The use of benches and "demi-lunes" on current or prospective agricultural land will be beneficial in 11 to 22 years when the cereal yield is expected to increase by 200 kg/ha (CIEH, 1981). Stone walls and retention walls are designed to capture sediments upstream, and to significantly decrease channel erosion downstream. The streambank protection delimits a waterway and will not allow the widening of the stream. The dykes are constructed to retain the flowing water, to enhance infiltration, and to make the retained water spread to other areas so as to increase the soil moisture content. The techniques involving tree planting are profitable in the long term. Trees promote infiltration, reduce flow velocity, and some (e.g. *Acacia senegal*) serve as a source of income to the population. All of the control measures are expected to increase perennial river flow.

POPULATION RESPONSE TO THE CONTROL ACTIVITIES

The population is conscious of the danger of runoff erosion on their lands including the jeopardising of water supply sources. However, the people are not fully convinced that the controls implemented are in their interest, or that they will work. It is suggested that 95 percent of the people working on the various sites, especially on the plateaus, are just interested in the money they earn or the plot of land they gain, and not in the controls. In addition, the structures are sometimes badly constructed by the labourers, and the designs not properly followed. The techniques are not fully efficient because of a number of factors:

– The indigenous techniques are not controlling erosion at its source and the disposal of refuse in channels is an important cause of water pollution.
– The measures implemented by government have overlooked some social requirements, such as high and quick financial returns and social acceptability.
– The people working on the different sites are just interested in financial return and not in the control techniques.
– The quantity of soil lost and sediments deposited in the area is not determined.
– On the plateaus where benches have been constructed, sorghum has been planted without studying in advance the chemical properties of the soil.
– There is no plan for the future management of the control activities, and they are under risk of damage by water and/or animals.
– The so-called "Special Programme of the President of the Republic" has no allocated budget for the control activities.

CONCLUSIONS

Runoff erosion control is an interdisciplinary activity requiring an understanding of the geomorphic processes at work and the factors controlling them. The control measures used in the CUN, broadly, are applications of soil and water conservation techniques. Hence, implementation of runoff erosion control techniques must be preceded by a scientific study of the erosion. This must be a prerequisite for implementing the techniques, so as to determine the volume of the detached soil and deposited sediments, as well as to determine the impact of the control activities. Erosion control is dependent upon good management, which implies establishing sufficient crop cover and selecting appropriate techniques. The population must be convinced that the techniques are in their interest, and that they will work. In fact, a participatory approach must be adopted, which would involve people in the control work and make them avoid indiscriminate refuse disposal and consequent river pollution. Therefore, a strategic communication programme must be developed for a collaborative and coordinated effort among all the stakeholders involved in order to address the issues of runoff erosion and the challenges of maintaining perennial flow in the River Niger. However, since river flow is very sensitive to variations in rainfall, moisture replenishment and evaporation, attention will also have to be given to the effects of climatic variability on the discharge regime of the River Niger.

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