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## Soil Conservation Practices in Parts of Kenya and Their Application to Some Mountain Areas of Rwanda

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## SUMMARY

Soil conservation (erosion control and fertility maintenance) is a major concern of farmers, agriculturists and politicians in the highland region of Rwanda. Dominant environmental features are rugged topography with altitudes ranging from 1500 to >2400m, relatively high and regular rainfall, denuded hills with slopes exceeding 30% on most farmland and fragmented fields that are overly cultivated with apparent disregard to artificial fertilization. In principle, soil conservation practices (terracing, use of grasses and afforestation) are known, but they are not totally accepted and practiced on a collective scale to realize the desired benefits. Through research and extension efforts, farmers in a similar ecozone in Kenya are succeeding with widespread adoption of radical or bench terraces and other erosion control devices. From technical and socio-economic standpoints, the radical terraces may not be feasible in Rwanda. Other less expensive methods (fanya juu) and less complicated biological methods (alley cropping and grasses) may hold some promise. It is anticipated that regular nationwide campaigns to educate farmers on anti-erosion techniques followed by full-scale field programs in agro-forestation and allied mulch cropping systems, even though by no means a panacea, will help to stabilize conditions in the region.

## INTRODUCTION

Soil conservation has been and still is an emphasized theme in Rwandan agriculture. Given the total surface area (lakes included) of about 26,000 km$^2$ inhabited by approximately 6 million people, competition for space, be it for farming, construction or recreation, is bound to be severe. The problem is exacerbated by the population growth rate now standing at 3.5%. This seems to rule out the possibility of Rwandan farmers expanding their cultivable land in the foreseeable future. Thus, intensive land use has become the most logical means of satisfying the food needs of the people. However, intensive land use, if not accompanied by the required soil amendments and conservation measures, leads to declining crop yields over time.

This report first examines the land-use practices in the Buberuka and Central Plateau agro-ecological regions of Rwanda in the context of soil conservation. Second, it borrows from the practical lessons and research experiences of areas in Kenya analogous to the highland region of Rwanda. Third, it makes suggestions for improving the situation in Rwanda.

## BIO-PHYSICAL CHARACTERISTICS OF THE HIGHLAND REGION IN RWANDA

Tables 1 and 2 give a summary of the environmental and some land-use characteristics of the target regions in Rwanda. This represents the zone of operation of the Farming Systems Research Program (FSRP). Entries of these tables highlight all the conditions that promote accelerated soil erosion on agricultural lands. Key among them are the steep slopes, high and regular rainfall, non-use of manure and mulch cover, absence of fallow and lack of adequate erosion control measures.

Rainfall occurrence is illustrated with data for the past 6 years recorded at the Institut des Sciences Agronomiques du Rwanda (ISAR) high altitude experimental station (Fig. 1). The bimodal pattern of rainfall allows two cropping seasons from mid-March to the end of May and from mid-September to

December. The rainfall data are calculated on a 10-day basis to reveal regularity. The probability of rain falling in a 10-day period is shown at the lower section of Fig. 1. During the cropping period (i.e mid-March to end of May and mid-September to December), there is a 60 to >80% chance of rainfall occurring per day. Serious erosion problems are experienced at the early stages of the cropping seasons about the time when crops have just been planted and there is no soil cover. Traditional land preparation with a long-handled hoe akin to conventional tillage with agricultural machinery leaves no residues on the surface to protect the soil. Worse still, environmental temperatures are low with a minimum value of less than 13 C and a maximum of slightly above 17 C (based on 11 years' data at ISAR). This in itself retards germination, nutrient uptake and subsequent growth of crops. The result is that complete soil coverage is delayed.

Terraces meant to stop erosion are not functioning well and in some cases have even collapsed because they are not properly and constantly maintained. Grass planted along contours is discontinuous as a result of uncontrolled grazing and harvesting for other uses; therefore, it is ineffective in controlling erosion. In short, no standardized or systematic erosion-control measure is widely adopted by the farming community. A common sight in the area is the cultivation of fields as continuous strips from the top to the bottom of hills. Erosion in such cases is phenomenal. The amount of soil loss is conservatively put at about 12 t/ha/year (SESA, 1984). Afforestation, a potential tool for environmental protection, is practiced on an ad hoc basis with the principal aim of producing wood for fuel and construction and not for erosion control. Common trees used for this purpose are Eucalyptus and cypress either planted as woodlots close to houses or along the sides of roads. Eucalyptus in particular is seldom found on food crop fields. Grevellia has become a popular tree in recent times with the advent of the USAID funded communal tree-planting project. Sesbania and Leucaena are retained shrubs around homes but are not connected with any form of intensive land use. Erythrina is a common wild species used mainly for fencing. It is viewed as a taboo tree; hence, its utilization for soil conservation is limited. A detailed treatment of the general wood and afforestation status in the region is given by Robins (1985) and RRAM (1987). Both reports concluded that wood is a scarce commodity and advocated an extensive afforestation program alongside other corrective measures to conserve and upgrade the most valuable natural resource base - the soil in this region.

## KENYAN EXPERIENCE

Various forms of soil conservation techniques (i.e. erosion control and/or fertility improvement) were observed at

- the International Council for Research in Agroforestry (ICRAF) field station at Machakos.
- the Kenya Renewable Energy Development Project (KREDP) agroforestry/Energy Centre at Jamhuri. KREDP is implemented with technical assistance from Energy/Development International (E/DI).
- parts of Kenya coffee and tea belts in the Muranga district.

### ICRAF's Field Station at Machakos

The ICRAF field station is in a relatively dry area with an average annual rainfall of about 700 mm. Altitude is around 1500 m above sea level. For detailed information about this station, refer to ICRAF field station status report (1987). Of special interest in the activities of the station are the agroforestry technologies that have been developed to combat soil erosion and at the same time increase soil fertility to permit sustained cropping. The research/demonstration plots include, among others

- planting of continuous bands of grasses along contours
- planting of thick rows of leguminous shrubs (e.g. Leucaena, Cassia and Sesbania) along contours
- a mixture of grasses and shrubs
- fanya juu system of erosion control. With the fanya juu, ditches of about 0.5 m wide and 0.5 m deep are dug along the contours. Soil from the ditches are thrown up-slope and grasses are planted to stabilize the heap. In the ditches, fruit trees such as avocados, guavas and citrus are planted to take advantage of the stored moisture during dry spells.
- bench terraces with grasses planted along the edges.

## KREDP Agroforestry/Energy Centre at Jamhuri.

Details of the activities of the centre are reported in KREDP, 1985. Of relevance to this report is the methodology for screening and management of a wide range of agroforestry species. The screening exercise began with about 28 woody species out of which a few have been selected for intensive land use in alley cropping systems. The chosen species were Calliandra, Leucaena, Sesbania and Eucalyptus. The other species that perhaps are not very suitable for the above land-use systems are still intercropped with food crops but managed differently with the primary aim of harvesting wood or other products. For instance, Casuarina was found to be doing well at a site where even weeds could not thrive. In this case, proceeds from the sale of Casuarina wood could be used to purchase maize or beans not able to tolerate the bad land. The KREDP is a firm believer in the use of agroforestry techniques as a means of improving the land-use efficiency of traditional low-input agricultural systems and not as a substitute for these systems. Thus, in all KREDP's field trials and demonstration plots, the recommended agricultural practices, e.g. fertilizer and insecticide applications, are duly respected. The use of the above external inputs, of course, is de-emphasized with time.

## Soil Conservation Practices on Farmers' Fields in Muranga District

The bio-physical features in the region closely resemble those described for Rwanda. Local rules guiding the use of farmlands require that all lands intended for farming be terraced or at least carry an equally effective erosion control device before planting of any crop. Violators of the regulation are reprimanded or fined by local administrative heads and, in fact, can become unpopular among rural folks.

By combining erosion-control measures with the use of external inputs (fertilizer, manure, insecticides, etc), readily obtainable at the district service centers, Kenyan farmers have maintained yields at reasonable levels. Whereas bench terraces are used on all coffee farms, Fanya juu is mostly observed on food-crop fields. The construction of both structures is preceded by the digging of infiltration ditches or cut-off drains to reduce the volume of run-off water coming from the upper lands. The comparatively deep soils here accommodate these structures. Consequently, landslides are uncommon as compared to the highland areas of Rwanda. Any excess water is discharged via natural or artificial waterways into nearby rivers or streams. To prevent siltation and possible flooding of rivers, all farming activities are expected by law to halt approximately 5 m from river beds. In highly erosion-prone watersheds, grazing by livestock is prohibited to protect rivers. As in mountain ecosystems elsewhere, land on slopes greater than 60% is considered non-arable in the district and put under permanent grass or tree cover. Adherence to such a rule in the highland areas of Rwanda would throw many farmers out of business since the majority of farms fall in this slope range (Table 1).

The success of erosion control in this part of Kenya can be attributed partly to the total community appreciation and commitment to the program and partly to the trained field extension staff and organized network. The extension agents make use of progressive farmers (known as paraprofessionals in FSRP documents) to reach many farmers. This applies not only to soil conservation but also to other agricultural innovations. Fields of the progressive farmers are used as model sites for proven technologies. Through field days, other farmers come to learn of new practices from the model sites. The progressive farmers receive counsel from the extension agents fortnightly. Technologies that qualify for extension or farm-level testing are transmitted to the district agricultural extension staff during scheduled monthly meetings with researchers from Kenya Agricultural Research Institutes (KARI). The KARI staff take home researchable problems that emanate from the field extension personnel and work on them. The use of progressive farmers as paraprofessionals is particularly suited to an area in which lack of transportation facilities and other logistics prevent the few trained extension staff from reaching the thousands of farmers they are charged to serve. Technical information bulletins issued periodically by the Soil Conservation branch of the Ministry of Agriculture to field extension staff contribute to the quality and accurateness of the messages that are disseminated. Where farmers are literate, the bulletins speed up the technology diffusion process.

## DISCUSSION AND SUGGESTIONS

The erosion-control measures currently practiced in Kenya are not unknown in Rwandan agricultural circles. Rather, it is the way they are organized and implemented at the farm level that needs to be learned and pursued in Rwanda.

The current view among observers worldwide is that it is more rational to use persuasion instead of force to get farmers to adopt new technologies. Mass education through radio, news bulletins, role plays on market days, etc. can make farmers aware of the dangers of soil erosion and the merits of its control. The aim is to gain farmers' appreciation of the problem and to solicit their collective effort for solving it. The employment of progressive farmers or paraprofessionals fits well under the conditions in Rwanda, especially given the inadequacy of trained extension manpower, lack of transportation facilities, dispersed farm families and the cooperative attitude of the farmers.

Even though the use of bench terraces has achieved some amount of success in Kenyan agricultural systems, it is quite doubtful if the same technology can gain widespread acceptance in the highland regions of Rwanda. There are many technical and socio-economic points that go against its promotion. Typical among them are

- the high cost of construction and maintenance (estimated at $800/ha)
- loss of scarce arable land, which could be more than 50% on slopes greater than 60%.
- lack of trained personnel to supervise implementation at farm level.
- predominantly shallow soils underlain by schists and quartz. The soils are classified as lithosols (ISAR, 1985), and depths <30 cm are not infrequent.
- accumulation of water on the ungraded terraces, causing landslides.
- difficulty in getting rid of excess water via artificial waterways due to scarcity and fragmentation of farmlands.
- initial reduction in fertility status of the soil, which calls for application of relatively large quantities of manure and fertilizer also not readily available in the system (Table 2).

The other, simpler methods--namely, Fanya juu, shrubs, shrub/grass mixture or integration of Fanya juu, grasses and shrubs--are more likely to be welcomed by farmers. The above structures develop into natural terraces over time and are strategies that have been followed successfully by some farmers on food crop fields in Kenya. Apart from low establishment and maintenance costs, the trees help to enrich the soil with fixed and recycled nutrients. In addition, the trees via transpiration pump out excess water from the subsoil to reduce lateral flow and consequent occurrence of land slides. Another argument in favor of the use of shrub/grass mixture is the continuous supply of in-situ mulch for soil coverage. A recent review on soil erosion control by Young (1986) in which he cited the work of Rose et al. (1983), among others, indicated that soil coverage is the most significant factor in checking erosion. Land-use experts (Lundgren and Nair, 1985; Lal, 1981; Bensalem, 1977; Onstad, pers comm.) have expressed similar views for erosion in regions of the third world analogous to the conditions in Rwanda. Lastly, instead of putting the very steep areas under constant grass or tree cover, one can adopt the strip clearing (mosaic cultivation) proposed by Jordan (1982) for the Amazon forest. With this practice, cultivated parcels are alternated with fallow patches. The fallow strips serve as buffer zones to minimize erosion as well as take up and conserve nutrient elements washed down from the upslope soils. Inclusion of fast-growing leguminous species such as Sesbania, Calliandra, Tephrosia, Mucuna and Vetch in the fallow would certainly upgrade its productivity. In fact some of the above propositions are currently underway as part of the FSRP/RRAM research agenda. The experiences so far accumulated could be used as a basis for action now to avoid catastrophic consequences for the future generation.

## ACKNOWLEDGMENTS

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**Table 1. Dominant environmental features of the FSRP zone.**

| Characteristics | Burberuka | Central Plateau |
|---|---|---|
| Altitude range (m) | 1900-2400 | <1500-1900 |
| Rainfall range (mm) | 1100-1350 | 1300-1600 |
| Common slopes on farmlands (%) | <60-70 | <40-60 |
| Temperature range (°C) | 13-17 | <17-22 |
| Soil pH range | 4.6-6.7 | 4.3-5.2 |
| Soil clay content (%) | 33.0-65.8 | 30.6-37.2 |
| Soil organic carbon (%) | 1.27-3.8 | 0.99-1.51 |
| Surface area (excluding lakes) $km^2$ | 492 | 372 |

Sources: RRAM, 1987, and FSRP, unpublished.

Table 2. Some landuse characteristics of the FSRP zone.

| Characteristics | Buberuka | Central Plateau |
|---|---|---|
| Population | 492,738 | 1,299,371 |
| Average farm size (ha) | 1.0 | 1.1 |
| Fallow land (%) | 15.5 | 10.4 |
| Use of manure and mulch (%) | 4.6 | 5.4 |
| Lack of manure and mulch (%) | 69.6 | 57.4 |
| Erosion control, terracing, etc. (%) | 39.5 | 43.3 |
| No erosion control measure (%) | 55.2 | 54.9 |

Source: SESA, 1984.

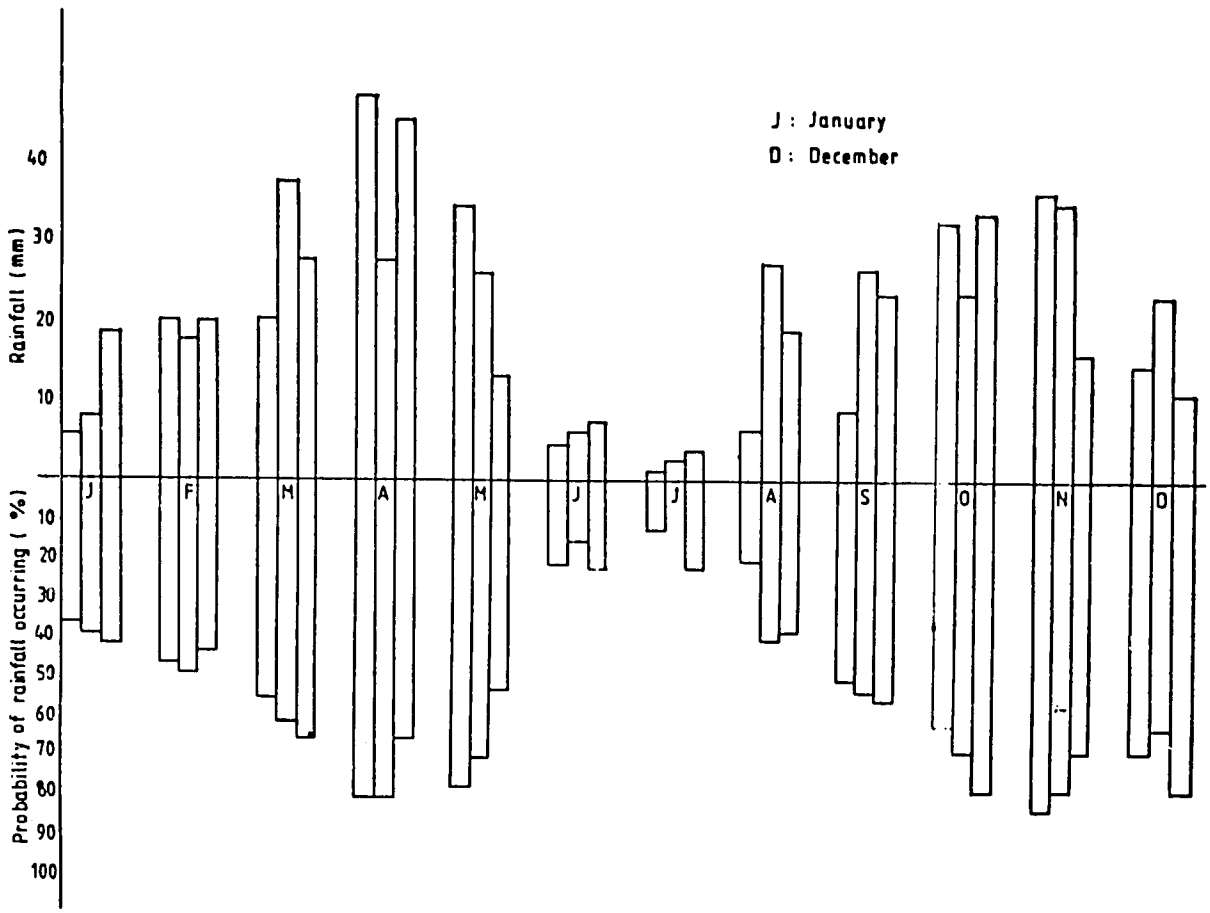


Fig. 1. Rainfall distribution in the Buberuka highland region.