The Contribution of Banana Farming Systems to Sustainable Land Use in Burundi

Th. Risirimuhirwa & E. Roose

Summary

Two field surveys were conducted in the Kirimiro region in the centre of Burundi. The goal was to study the banana-based cropping systems in the area especially traditional practices of soil fertility management. The region is densely populated and average farm size is 0.88 ha. The number of cattle is declining due to fodder shortage resulting in a decline of manure production. Soil fertility and consequently production is low.

Farmers use all sources of organic manure in order to maintain soil fertility such as farmyard manure, compost and crop residues. The limiting factor for manure and compost production is the availability of organic matter. Mulching is used for banana groves and coffee plantations. Under these crops there is hardly any soil erosion.

Soil fertility is declining with distance from the homestead. The study revealed four distinct rings of soil fertility status which are again managed in different ways. The area around the homestead is the most fertile, receiving the highest amount of organic manure. The next ring receives already much lower rates while distant fields are not fertilised at all, except for some incorporated crop residues or weed. The fourth ring is constituted by pasture and forest, which are sources of organic matter. There is thus a net transfer of fertility from distant fields towards the homestead. Crops are chosen according to the fertility status, i.e. the most demanding crops and especially banana are grown close to the homestead. The authors propose ways of increasing productivity, such as agroforestry, mineral fertilisers, more efficient organic matter recycling and erosion control.

Keywords: Traditional farming systems, tropical highlands, banana, soil fertility management, organic manure

1 Introduction

Most parts of Burundi are densely populated and land is permanently cultivated. The average population density is 232 people/km² and the average farm size 0.88 ha (in 1995). Burundi belongs to the tropical highlands of central Africa. Large areas of Burundi have a high erosion hazard. Erosion and leaching of nutrients reduce soil fertility and productivity of the land.

Facing these limitations, how do the farmers perform in controlling their negative effects? What are their skills and know-how in land husbandry for sustainable food production? To try to answer these questions, traditional agricultural practices have been studied with a particular emphasis on land fertility restoration techniques.

This paper presents the results of these studies. It gives the main characteristics of the Burundian Central Plateau farming systems, in which banana is the basic component, and their impact on
sustainable land use. In addition, the efficiency of the residues of this crop in soil conservation and in soil properties improvement, as pointed out by previous studies, are highlighted.

2 Materials and methods

The study was conducted in Kirimiro, one of the main ecological districts of the Burundi Central Plateau.

This plateau is characterised by a tropical climate modified by altitude (1600 - 2000 m above sea level). According to Rishirumuhirwa et al. (1989), the mean annual temperature is 18.7°C and mean annual rainfall is 1157 mm. The rains are bimodal with the maxima in November and in April, respectively. There is a dry season from June to August. More than 80% of the soils are acid and leached with pH < 5.0 and C.E.C. < 5 meq/100 g. They belong to the Hygro-xero-ferralitic soils and to Ultic Haplustox according to the INEAC (Institut National pour l'Etude Agronomique du Congo) soil classification system and to the Soil Taxonomy, respectively. Slopes are gentle (less than 8%) to moderate (8 - 20%).

Two fields surveys were carried out. The first was designed to characterise and to assess farm size, family composition, labour availability, cropping systems and livestock (kind, number, management). Forty farms, with household heads, grouped according to years in charge (0 - 5 years; 6 - 10 years; 11 - 20 years and more than 20 years), were selected for this survey.

The second survey was conducted in 16 farms selected out of the 40 farms (4 farms per age group). This survey allowed us to study traditional agricultural practices including recycling of organic matter, production and use of ashes, manure and mineral fertilisers and their flow within the farm.

For the two surveys, field and farm surfaces were determined with a tape-measure of 20 m +/- 0.01 long. The ash production was observed for one month, the ash was collected and weighed once per week. The annual production was computed on the basis of these data. The manure production was calculated by its weight determined from the stall and the compost pit when emptied (twice per year, October and February). Crop residues used as fodder and litter contribute to manure production. Some of these residues are also used as raw material for compost production or as mulch primary on coffee plantation. The quantities of residues removed from the farm and used as mulch were weighed. The residues remaining in the fields were not taken into account.

3 Results and discussion

3.1 Farm characteristics

3.1.1 Size

The agricultural extension services classify the farm land in the following categories (AFRENA, 1987): (1) total area, physical area of the farm; (2) cropped area; (3) the annual exploited area, the total area exploited during the two seasons. Table 1 presents the characteristics of the farms in Burundi, in the Kirimiro region and Kiremera site.

The average farm size in Burundi and Kiremera, in particular, is very small due to the high population density. Land is intensively cropped with a land intensification rate varying from 147 to 159%. The farms have been grouped into 4 classes according to their sizes. The results are presented in Table 2.
Banana farming systems and sustainable land use, Burundi

<table>
<thead>
<tr>
<th>Total area (TA)</th>
<th>Burundi (1)</th>
<th>Kirimiro (1)</th>
<th>Kiremera (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropped area (CA)</td>
<td>1.74</td>
<td>1.35</td>
<td>0.88</td>
</tr>
<tr>
<td>Annual exploited area (AEA)</td>
<td>0.88</td>
<td>0.61</td>
<td>0.66</td>
</tr>
<tr>
<td>Land use rate (CA/TA) in %</td>
<td>1.29</td>
<td>0.97</td>
<td>1.01</td>
</tr>
<tr>
<td>Land intensification rate (AEA/CA) in %</td>
<td>51</td>
<td>45</td>
<td>75</td>
</tr>
<tr>
<td>Total population per farm</td>
<td>147</td>
<td>159</td>
<td>153</td>
</tr>
<tr>
<td>Active population per farm</td>
<td>4.6</td>
<td>4.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Source: (1): République du Burundi (1981) and (2) survey data.</td>
<td></td>
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</tr>
</tbody>
</table>

Table 1: Farm size and land use in Burundi, Kirimiro - Kiremera (ha).

<table>
<thead>
<tr>
<th>Farm group limits (ha)</th>
<th>Total farms per group</th>
<th>% per group</th>
<th>Mean farm size per group</th>
<th>Total farm size per group</th>
<th>% per group</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.5</td>
<td>11</td>
<td>28</td>
<td>0.30</td>
<td>3.33</td>
<td>9</td>
</tr>
<tr>
<td>0.5 - 1</td>
<td>14</td>
<td>35</td>
<td>0.73</td>
<td>10.26</td>
<td>29</td>
</tr>
<tr>
<td>1.0 - 1.5</td>
<td>8</td>
<td>20</td>
<td>1.21</td>
<td>9.70</td>
<td>28</td>
</tr>
<tr>
<td>&gt; 2</td>
<td>7</td>
<td>17</td>
<td>1.72</td>
<td>12.01</td>
<td>34</td>
</tr>
</tbody>
</table>

The farm size recorded at Kiremera ranges between 0.18 to 2.57 ha with an average of 0.88 ha per farm. The smallest (less than 1 ha) represent 63% but cover only 39% of the investigated areas. The biggest (more than 1.5 ha) represent 17% of all the farms and 34% of the total area.

3.1.2. Livestock husbandry

The livestock density in Kiremera and Kirimiro as compared to Burundi is presented with the cattle situation in Burundi (Table 3).

<table>
<thead>
<tr>
<th>Burundi (1)</th>
<th>Kirimiro (1)</th>
<th>Kiremera (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle density/ha</td>
<td>0.23</td>
<td>0.29</td>
</tr>
<tr>
<td>Cattle density/habitant</td>
<td>0.14</td>
<td>0.11</td>
</tr>
<tr>
<td>Small ruminants density/ha</td>
<td>0.48</td>
<td>0.80</td>
</tr>
<tr>
<td>Small ruminants density/habitant</td>
<td>0.36</td>
<td>0.30</td>
</tr>
</tbody>
</table>


Table 3: Cattle and small ruminants density in Burundi, Kirimiro and Kiremera.

According to PNUD (1986), average cattle density decreases while small ruminants density increases as the farm size declines due to the increasing population. At Kiremera this reduction is confirmed since 30% of the investigated farms do not dispose of cattle. Small ruminants are prominent in farms smaller than 0.80 ha. In this case, cattle husbandry is possible only with intensification practices including permanent stalling and fodder production. The declining number of cattle and the shift to small ruminants cause a reduction of the production of farmyard manure with negative impact on soil fertility maintenance.

Blume, Eger, Fleischhauer, Hebel, Reij & Steiner (Editors): Towards Sustainable Land Use
3.1.3 Land use and cropping systems

When studying the land use and cropping systems, 6 sub-units or rings could be identified. The first ring, around homestead, is highly fertilised by manure, ashes, plant residues and domestic wastes provided by the other sub-units and by communal lands. It is cropped with densely planted bananas sometimes associated with taro or cassava. The second ring is characterised by a multi-cropping system, comprising banana, beans, maize, cassava, sorghum. This ring receives manure but much less as the first one. The third ring is not fertilised at all and soils are unfertile. It is planted with less demanding crops such as cassava and sweet potato. Intercropping is no longer practised here. The forth ring is occupied by pasture, fallow and wood and the fifth comprises valley bottoms. Coffee plots constitute a separate unit, which is always mulched. Table 4 describes ring size and cropping systems within Kiremera farms.

<table>
<thead>
<tr>
<th>Ring</th>
<th>Ring size in ha</th>
<th>Main crops</th>
<th>Associated crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana grove</td>
<td>0.03 0.11 0.25</td>
<td>Banana</td>
<td>taro, beans, cassava</td>
</tr>
<tr>
<td>Multi-cropping system</td>
<td>0.07 0.34 1.11</td>
<td>Banana</td>
<td>bean, maize, cassava, groundnuts</td>
</tr>
<tr>
<td>Cassava/sweet potato</td>
<td>0.00 0.15 0.42</td>
<td>Cassava/sweet potato</td>
<td>pasture, fallow and wood</td>
</tr>
<tr>
<td>Pasture and wood-lands</td>
<td>0.00 0.22 1.15</td>
<td>Bean</td>
<td></td>
</tr>
<tr>
<td>Valley bottom</td>
<td>0.00 0.07 0.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Land use systems of farms in Kiremera (1st season 1995).

The first 3 rings are present in all farms, while the others may be absent. The relative size of each ring depends on the total farm area, the presence of cattle, the soil fertility and the investment capabilities of the farmer.

The associated crops vary with the season. In Kiremera and Kirimiro, maize is the prominent component of crop associations during the first season while bean predominates during the second season.

3.2 Farms operations and fertility transfers

The ring farming is closely related to organic matter recycling and to fertilising practices, which again is related to the choice of crops. The following methods have been identified within the survey areas.

a) Farmyard manure production: organic matter is used as fodder or litter. The litter, the dung and the cattle urine are mixed and decompose together for at least six months. This manure can be of good quality if the shed is deep enough or associated with the compost method.

b) Compost production: organic matter is dumped into pits. Three pits are recommended by extension services. Organic residues are put in the first pit to decompose and are removed from one pit to another every 2 months. They must be covered to avoid nitrogen losses by ammoniacal evaporation and sprinkled during dry season to enhance biological processes. Compost production is labour demanding and farmers rarely meet its requirements. In average, one compost-pit was recorded for 2 farms in the survey area. Fifty five % of the farms, particularly the smallest, did not have any pit. The compost was never sprinkled and rarely covered. Thus, compost production is rather limited and its quality is low.

c) Restitution of crop residues: crops residues, particularly banana leaves and pseudo-stems, maize, sorghum, cassava and sweet potatoes stalks are left in the field after harvest.
d) Incorporation of weeds and crop residues: this is a particular case of the previous method and consists in incorporating weeds and crop residues when ploughing. According to Simonart (1992), this method contributes to neutralise aluminium in the soil and to increase phosphorus availability.

e) Burning: dry weeds and crop residues are gathered and burnt before harrowing for planting.

All these methods generally are applied simultaneously in the same farm with manuring being the most productive one. Quantities applied could not be exactly determined during the survey. Production of manure, compost, mulch and ashes at Kiremera is presented below (Table 5) and correlated with farm size and livestock.

<table>
<thead>
<tr>
<th>Farm size (ha)</th>
<th>Cattle in UBT(1)</th>
<th>Manure (kg)</th>
<th>Compost (kg)</th>
<th>Mulch (kg)</th>
<th>Total O.M. (kg)</th>
<th>Ashes (kg)</th>
<th>NPK fertilisers (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.5</td>
<td>0.5</td>
<td>33</td>
<td>154</td>
<td>362</td>
<td>549</td>
<td>294</td>
<td>35</td>
</tr>
<tr>
<td>0.5 - 1</td>
<td>0.8</td>
<td>204</td>
<td>423</td>
<td>290</td>
<td>917</td>
<td>257</td>
<td>24</td>
</tr>
<tr>
<td>1 - 1.5</td>
<td>1.3</td>
<td>343</td>
<td>157</td>
<td>274</td>
<td>774</td>
<td>261</td>
<td>42</td>
</tr>
<tr>
<td>&gt; 2</td>
<td>1.8</td>
<td>415</td>
<td>381</td>
<td>440</td>
<td>1236</td>
<td>286</td>
<td>56</td>
</tr>
</tbody>
</table>

(1) UBT = Unité de bétail tropical (tropical cattle unit, 250 kg)
(2) O.M. = organic matter

Table 5: Relation between farm size, number of cattle and manure, compost, and ashes production at Kiremera (kg of dry matter/farm/year).

There is a clear correlation between farm size and number of cattle. As stated by several authors, manure production varies with husbandry practices. In the traditional system it is estimated at 500-600 kg/cattle/year (Rooste, 1994; Popy, 1989) while it is 5-8 tons/cattle/year and 8-12 tons/cattle/year in semi-intensive and intensive systems, respectively (Simonart, 1992). In Kiremera manure production is low since traditional system still prevails even though semi-intensive and intensive systems are already applied at a small scale.

No effect of farm size and number of cattle have been noted on compost production and on use of crop residues in Kiremera. These practices seem to be related to the farmer's skills. Ash production does not vary between farms. Organic matter used for manure or compost production is provided by the different units (rings) of the farm. It is transported to the homestead where stall and compost pits are located. The mulch is primarily provided by bananas of ring 1 and 2, but also by ring 4 (pasture and woodlands) as well as the communal areas. It is generally applied to coffee plantations.

Ashes can be considered as a traditional mineral fertiliser. They are provided by wood combustion for cooking purposes from ring 4 or from communal areas. Their production comes up to 275 kg/year/family. It seems to depend neither on farm size nor on cattle numbers but on the number of meals per day and the kind of food to cook. The homestead is the main manure and ash production area. According to traditional agricultural practices, these products, as well as the domestic wastes, are used as fertilisers on bananas in the first ring and, at a lesser scale, on banana and associated crops of ring 2. Manure is generally placed around the banana stems or spread in the seed-bed when planting. In the other rings, the recycling of organic matter by burning or by incorporating grasses and residues prevails.

Traditional practices thus create a gradient of soil fertility by transfer of organic matter from the other rings to the most fertile area situated around homestead (ring 1). Communal lands can contribute to this transfer. Crops are located in this gradient according to their requirements. The functioning of the system is presented in figure 1.

Mineral NPK fertilisers are used in Kiremera on maize and bean in very limited quantities (< 50 kg/farm/year) only.
3.3 Role

Banana is an important cash crop at high altitude. It is grown on 14,000 ha in the country.

There are about 10,000 ha of banana groves in the country. The bananas are sold to the market and receive a good price. The main source of income is from bananas.

Exportation

4 Conclusions

The production of bananas is an important source of income. Bananas are grown in the highlands, where the climate is suitable for their growth. The production of bananas is increasing due to the demand in the international market. The banana groves are managed to ensure a good yield.

Rings and crop distribution within the farm

Fig. 1: Farming system in the densely populated areas of Burundi.
3.3 Role of banana in farming systems

Banana is the main crop in the traditional farming systems of Burundi in all areas below 1900 m altitude. It plays a key role from an economic and ecological point of view. According to Nkurunziza (1991), it occupies 17% of agricultural land and represents about 40% of the total food production in the country.

There are three main types of banana grown in Burundi: cooking bananas (+/- 15%), beer bananas (more than 50%), and dessert bananas (less than 5%). As a consequence of its prominent position in the farming systems, banana is given particular care. It is planted around the homestead and receives important quantities of manure and other fertilisers. These practices lead to a high production of fruits and crop residues. These residues (leaves and pseudo-stems) are used as mulch for coffee, to cover roofs, as fodder or litter for cattle and for some handicraft. Banana is then the main provider of organic matter in the farm and plays a key role in land fertility restoration. Banana residues used as mulch control runoff and erosion and improve soil chemical and physical properties (Rishirumuhirwa, 1993a). Banana plants protect the soil when densely spaced and mulched with banana leaves, the erosion crop index (C index as defined by Wischmeier and Smith, 1978) ranges from 0.3-0.6 with row spacing of 2 to 5 m. Soil losses increase with a wider spacing, while run-off is little affected. The efficiency of mulch is significantly increased when disposed in rows across the slope. Annual mean runoff is reduced to +/- 2% and banana erosion C index from 0.2-0.6 to 0.03-0.06 (Rishirumuhirwa, 1994).

4 Conclusions

The productivity of the traditional system is very limited. The quantity of dry matter residues produced in Kiremira does not exceed 1.5 tons/ha/year even with cattle and in the largest farms. Substantial improvements can be achieved by several practices among which the following are recommended:

a) Agroforestry: This technique consists in introducing trees in the farming systems. Trees can be planted at the borders between farms or associated with crop production. They can provide fodder, litter, mulch, firewood and for other purposes. Roos et al. (1993), have recorded a production of 1 to 4 tons/ha/year of leaves with an average of 200 trees per farm and 3 to 9 tons/ha/year with Calliandra and Leucaena hedges (4 m spacing). In addition some leguminous trees used in agroforestry can provide over 160 kg of N/ha/year by biological fixation (Kang et al., 1984).

b) Mineral fertilisers: The use of mineral fertilisers is very limited in Burundi and in Kiremira even though FAO trials and demonstration tests (FAO, 1982) have pointed out its efficiency. Banana never receives mineral fertilisers, even though fruit and biomass (crop residues) production can be significantly increased by fertiliser application, from 1-2.7 tons/ha/year residues (Rishirumuhirwa, 1993b) to 17 tons/ha/16 months (Martin-Prevel et al., 1968).

c) Efficient organic matter recycling: Cattle keeping increases organic matter recycling, the manure production depending on the intensity of the production system. Declining farm size in Kiremira are linked with a shift to stall keeping. In this system, cattle remains permanently in stall and can be kept with 0.32 ha of forage plants. Farms without cattle (30% recorded at Kiremira) can produce compost in pits.

d) Erosion and runoff control: In intensive production systems biomass yields of about 17 tons of dry matter/ha/year can be obtained by combining agroforestry and mineral fertilisers. This is sufficient for fodder and mulching, with a soil cover rate of more than 25%. According to Rishirumuhirwa (1993b) this soil cover rate is achieved with 2.7 tons of mulch 7 cm thick. When mulch is disposed in rows across the slope the annual runoff is reduced to 2% and soil loss +/- 30 times.
The adoption of these methods could significantly improve the sustainability of traditional farming systems which are affected by the increasing population and the declining number of cattle, both leading to a decline of soil fertility and yields.

References

Addresses of authors:
Théodore Rishirumuhirwa
EPFL-DGR
IAFE-Pédologie, Ecublens
CH-1015 Lausanne, Switzerland
Eric Roose
Réseau Erosion
Centre ORSTOM
BP 5045
34032 Montpellier, France

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Summary
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