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# Use of the iterative diagnosis and design approach in the development of suitable agroforestry systems for a target area[1]

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**Key words:** farmer-participatory research, firewood/poles, fodder, semi-arid highlands, soil fertility/conservation, sustainable land use

**Abstract.** The process of iterative diagnosis and design with the active participation of farmers and extension agents was found effective in identifying appropriate agroforestry systems for farmers in the Bugesera and Gisaka-Migongo (BGM) regions of Rwanda. Periodic re-evaluation of research assumptions and technology designs was based on feedback from farmers and extensionists through regular visits to station trials, early initiation of on-farm testing, and interaction with farmer cooperators through informal discussions and formal surveys focused on specific agroforestry technologies. Statistical analysis is valuable for comparison between regions or periods. However, valid conclusions can be drawn without statistics, by employing several farmer-participatory approaches and pooling and properly interpreting the data obtained from them.

Farmers' preferred uses of tree biomass in the BGM regions and appropriate agroforestry systems are discussed. If researchers and development agents do not consider the farmers' real needs, circumstances, available resources and management capacity with regard to tree planting, they will fail in identifying and extending suitable agroforestry systems for any region.

## Background

### *Description of the project and study area*

The Rwanda Farming Systems Research (FSR) Project was an applied and adaptive research program of the Institute of Agronomic Sciences of Rwanda (ISAR), assisted technically by the International Institute of Tropical Agriculture (IITA) and financed by the International Development Agency (IDA) of the World Bank. The project period was 1983—88 and the area covered was about 2,600 km$^2$ with a population of 300,000 (about 50,000 farm families) [IITA, 1989].

The project area consisted of two regions, viz., Bugesera and Gisaka-Migongo, hereafter referred to as BGM, which are situated in the south-eastern part of the country (02°00′ to 02°26′S and 29°58′ to 30°53′E) (Fig. 1). The altitude is high (1300 to 2000 m) and the climate is semi-arid. An annual rainfall of 750 to more than 1000 mm is equally divided between two

[1] This study was a part of the ISAR/IITA/World Bank FSR Project, implemented in the BGM regions of Rwanda during 1983—1988.

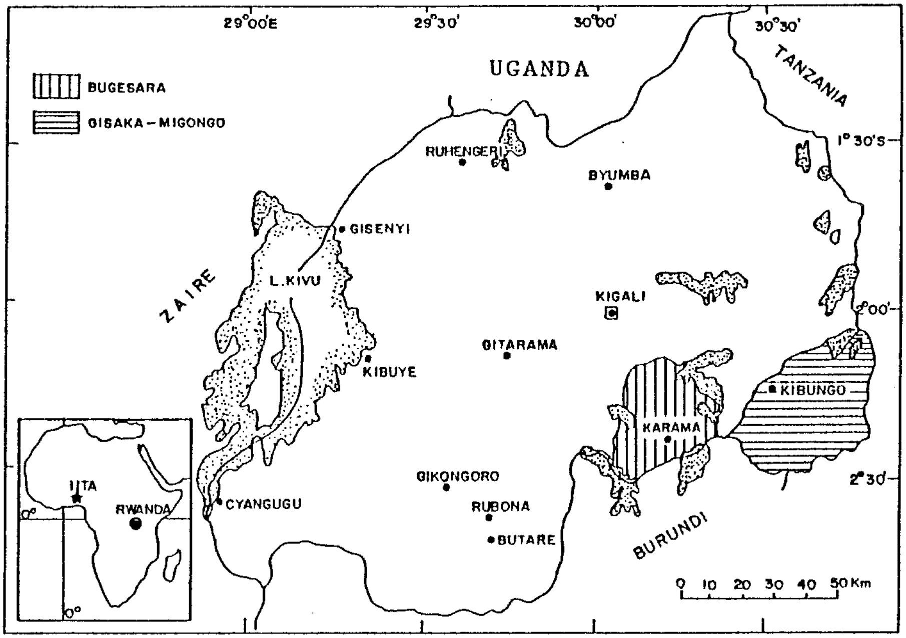


*Fig. 1.* The Bugesera and Gisaka-Migongo regions, Rwanda.

seasons: October–December and February–May, with a long dry season from June to September. The mean monthly values range from 20.6 to 22.1 °C for temperature, 59 to 82 percent for relative humidity, and 93.5 to 138.0 mm for potential evapo-transpiration. More than 60 percent of the project area is covered by the poor plateau soils (Ultisols, Oxisols and Inceptisols/ Entisols). The native vegetation consists of savanna woodlands containing tall grasses and scattered trees [Balasubramanian et al., 1988].

There are two ecological zones (Fig. 2) in the BGM regions: *Buju* with subhumid climate (rainfall about 1000 mm/yr), elevation higher than 1500 m, and relatively better soils and *Buges* with semi-arid climate (rainfall 700 to 900 mm per year), altitude less than 1500 meters, and poor soils.

Owing to increasing population pressure, these marginal areas (earlier reserved for cattle grazing) were settled with families from other parts of the country. The FSR Project was started to develop appropriate food production systems in these newly settled regions.

### *Present farming systems and land use*

In 1983, average farm size in the study area was 2.2 hectares for a family of

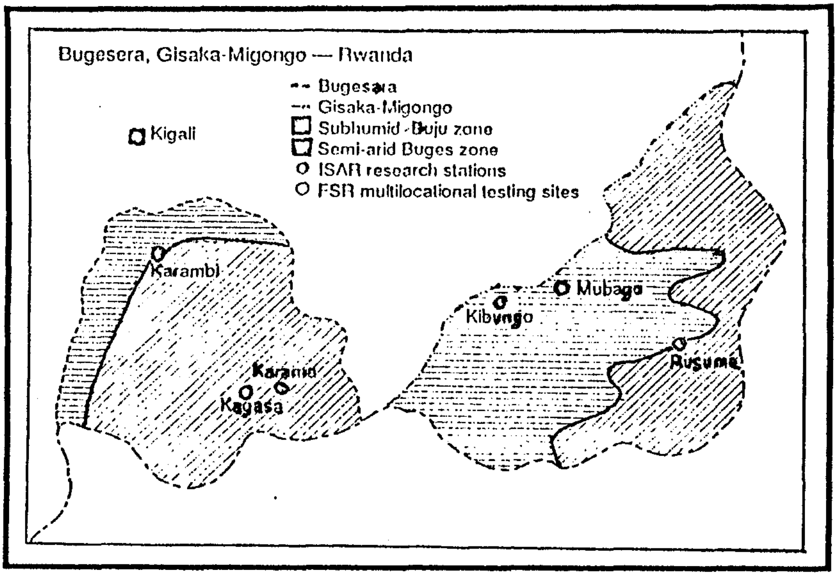


*Fig. 2.* Ecological zones and multllocational testing sites in the BGM regions.

6.2 members, somewhat higher than the national average of 1.2 hectares for a family of 4.5 members [Delepierre, 1985]. Important crops are banana (*Musa* spp.), sweet potato (*Ipomoea batatas* (L.) Lam.), cassava (*Manihot esculenta* Crantz), sorghum (*Sorghum bicolor* L.), maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), groundnut (*Arachis hypogaea* L.), pea (*Pisum sativum* L.) and coffee (*Coffea arabica* L.). On average, a family maintained one to two cattle, three to four goats, and five to six chickens [Balasubramanian and Egli, 1986]. The animal component contributes to farmers' cash income and provides milk, meat and manure. Crops grown in the two regions are similar, but area under coffee, banana and woodlot is higher in Buju than in Buges due to favorable climate and soils for these crops.

Land is owned by the farmers, who have all rights to utilize crops and trees on their farms. Land is divided equally among sons upon death of the family head and this leads to smaller and smaller farms with each generation. Men clear the land and prepare the fields for planting, while women are involved in planting, weeding and harvesting. Children also share in farm operations.

Figure 3 depicts the interactions between components of the farming systems in the project area. In 1983, about 30% of the land area was uncleared in the BGM regions; these are infertile lands located on steep slopes or hill tops that are normally used for the communal grazing of domestic animals. The natural vegetation is usually poor and these lands are

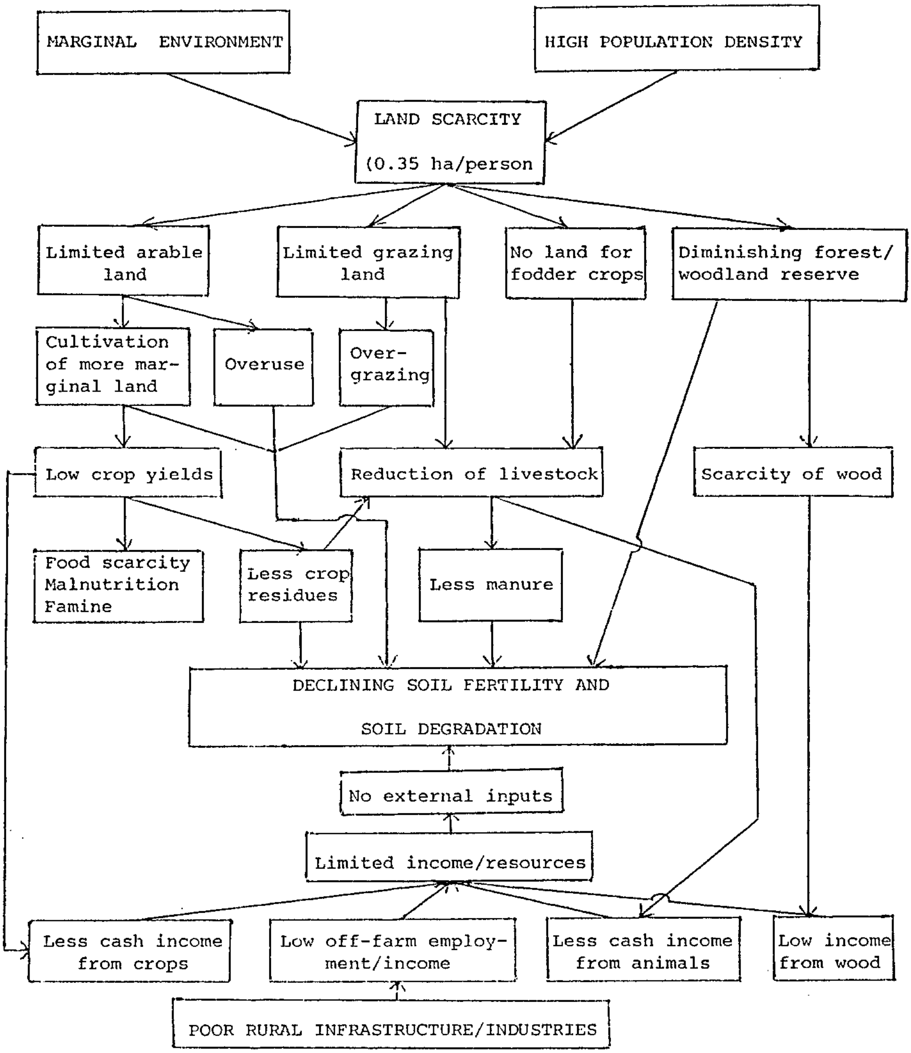


*Fig. 3.* Flow diagram of interactions between components of the farming systems in the project area.

overgrazed. Another source of (temporary) grazing land for farm animals is the land under short term fallow which covered about 9 to 12% of the farm area. Thus, the shortage of pasture and feeds constitutes a major constraint to livestock production in small farms.

Farmers in the BGM regions practice an intensive form of organic agriculture with several features favoring sustainability built into the system: absence of burning in land preparation, recycling of organic residues, inclusion of legumes in cropping systems (beans, groundnut, pea), use of mixtures of varieties (beans, banana) and/or crops, mulching of certain crops (coffee, banana), use of overlapping mounds for root and tuber crops, burying fallow vegetation, etc.

Both intensive compound farming and extensive cultivation of outlying fields are prevalent [Balasubramanian and Egli, 1986]. Farmers use compost and cattle manure but not fertilizers to maintain soil fertility. Nevertheless, the quantity of animal manure produced is not sufficient to replenish the nutrients exported in the harvests of economic produce and lost through other sources. As such, these systems cannot satisfy the demands of rapidly growing population (3.5% per year) for food and other products. Heavy demographic pressure has led to the over-exploitation of croplands and pasture and extension of cultivation to marginal areas. The consequences of land pressure are: fragmented small farms, reduced fallow period, falling yield, and soil degradation [Balasubramanian et al., 1988; Lewis et al., 1988].

In short, farmers in the BGM area face the following production problems [Balasubramanian and Price, 1985; Price et al., 1984]:

i. Low and poorly distributed rainfall;
ii. Lack of arable and pasture land;
iii. Serious soil degradation due to
   - inadequate use of nutrients with continuous and intensive cultivation,
   - extension of cultivation to fragile land,
   - high erosion hazard on exposed slopes;
iv. Increased scarcity of wood and fodder, in addition to food.

The above constraints are relatively more severe in the semi-arid Buges zone than in the subhumid Buju zone.

### *Research approach*

The research approach used in this project tried to combine the local knowledge base with suitable modern agricultural practices in developing appropriate technologies for the project area. A rich body of local technical knowledge on organic farming exists in Rwanda. Through field visits and discussion with farmers, extension agents and other agriculture development staff in the area, traditional knowledge and practices were documented and carefully analyzed for their usefulness under the changing circumstances of intensive cultivation. Based on this analysis, a list of researchable topics was established to alleviate the constraints mentioned above and to identify the most appropriate changes needed for intensifying food crop production in existing areas.

The research agenda included the validation and refinement of certain local practices as well as development of new technologies [Balasubramanian and Price, 1985; Balasubramanian and Sekayange, 1986]. Soybean (*Glycine* *max* L. Merr.) and pigeonpea (*Cajanus cajan* L. Millsp.) as new crops, and better varieties of cassava, sweet potato, beans, groundnut, sorghum and maize were evaluated on the crop improvement side. New soil improvement and production technologies chosen for study included alley cropping/farming, planted fallow, tree hedges on contour, woodlots, manure/compost with different levels of fertilizer, *Rhizobium* inoculation, and intercropping systems [IITA, 1989]. In 1983–86, available crop varieties were directly tested on farmers' fields, whereas new crops and soil improvement technologies were experimented with at the research site at Kagasa, before testing them on-farm.

Extension agents and farmers actively participated in a baseline survey, constraints identification, informal discussion, participant observation, group discussions, periodic visits to the station trials to see and comment on technologies under development, and on-farm testing. Regular re-evaluation of concepts and assumptions as well as redesigning of research activities based on extension agent and farmer feedback was an integral part of the research methodology. This method resembles the "iterative diagnosis and design" approach of ICRAF [Raintree, 1987]. The only stage in which the farmers did not actively participate was the initial selection of technologies for testing on-station.

### *Alley cropping research*

Since alley-cropping was a completely new technology in the country, it was first tested on-station. Alley-cropping systems using different tree species were evaluated to determine contributions to soil fertility restoration and maintenance, the most important constraint limiting crop production in the area. The five tree species were selected based on observations of growth of tree species planted by the Forest Department and other organizations working on trees in the BGM regions. On-farm observation plots of alley farming were also established with the commonly used *Leucaena leucocephala* as hedgerow species and the locally important fodder grass, *Tripsacum laxum*, as alley species. In addition, data was collected from farmer-established *Cassia spectabilis* boundary hedges.

By 1987, an effective alley-cropping technology had been successfully developed at the research station. It was shown to improve soil fertility and crop (beans, sorghum and maize) yields slowly, but steadily, with time. The best treatment (using *C. spectabilis*) produced 33, 95 and 108% more yield than the control without trees in 1984, 1985 and 1986, respectively [IITA, 1989]. Therefore, it was decided to test this technology on-farm and fifty (50) farmer collaborators were selected from the list of farmers who visited the trial at Kagasa and volunteered to try it in their own farms. The trials were established in 1987–88 to assess the performance of the technology on farmers' fields, using the best three tree species selected from the station trial.

They were designed by researchers and implemented jointly by researchers/ extension agents and farmers.

Informal discussions with farmers, and observations on the level of their involvement in the care of tree seedlings during the hedgerow establishment period, indicated problems with farmer interest in implementing alley cropping. The reasons deduced from farmer opinions were (a) the slow growth of trees, particularly on poor soils, and hence the long waiting period for the realization of benefits on soil fertility and crop yields; (b) the loss of land to tree hedges; (c) the requirement of additional labor at critical times for hedgerow establishment and pruning; and (d) their suspicion about tree/crop competition in such a close association as alley cropping. A farmer survey was conducted during 1988 to verify why they were not interested in the alley cropping technique, and to find out what modifications of the technique or what other agroforestry system(s) would best serve their needs. The findings of this survey and related informal data collection and observation are discussed below.

## Survey activities

### *Objectives of the survey*

The objectives of the survey were to:

(a) find out why the farmers in the study area were disinterested in the alley cropping technique, and what modifications of the technique or what other agroforestry system(s) would best serve their needs;
(b) obtain more information on the relative importance of tree products such as fruits, fodder, firewood, construction poles and stakes to farmers in the project zone;
(c) describe existing methods of soil fertility management and conservation, and the possible role of trees in them.

### *Selection and interview of farmers, and analysis of data*

This survey was conducted by farmer interview, using a structured questionnaire guide (Annex 1). The majority (87%) of the farmers included in the survey had worked with the FSR project in on-farm trials and observation plots. Others were selected from the farmers who visited on-station trials and showed interest in trees. They were the progressive farmers chosen by the BGM extension service for testing new technologies. These farmers were somewhat better off than others, and better able to hire labour if necessary, but were still considered representative. Selected for enthusiasm and leadership qualities, they served as a link between the researcher/extension agent and the region's farmers at large. Five of the 46 farmers were women. The names of the six communes and the number of farmers interviewed in each commune are given in Table 1.

Farmers and other household members were encouraged to frankly discuss the topics, to ensure two-way flow of information. Each interview took about an hour. Technicians speaking the local language assisted in the interview. Area under different crops was measured using metric tapes, in collaboration with farmers, and different types of trees and animals were counted. Families provided estimates on distance travelled for collection of fuelwood, which was verified on 40% of farms.

Two baseline surveys had been conducted in the same area in 1983, using farmer interviews and actual field measurements. Topics included houshold composition, farm area, crop/cropping systems, farm animals, marketing, income, expenditures, savings, education, rural infrastructure, constraints and opportunities. The survey did not distinguish between the Buges and Buju regions. Using the administrative units (sectors) as a base and the size of the sector to decide the number of sample farmers, two to four farmers had been randomly selected in each sector with the help of extension agents. The sample size was 56 in the first survey [Price et al., 1984] and 96 in the second [Balasubramanian and Price, 1985]. Selected data from these surveys were compared with the data of the present survey to show changes from 1983 to 1988. The data on changes should be viewed merely as indicators of direction rather than absolute values, due to differences in survey samples and the absence of statistical validation.

*Table 1.* Names of communes and number of farmers interviewed in the Bugesera and Gisaka-Migongo regions of Rwanda, 1988.

| Zone | Commune | No. of farmers |
|---|---|---|
| Buju | Kanzenze | 9 |
| | Ngenda | 2 |
| | Birenga | 9 |
| Subtotal | — | 20 |
| Buges | Gashora | 9 |
| | Ngenda | 9 |
| | Rusumo/Rukira | 8 |
| Subtotal | — | 26 |
| Buju + Buges | — | 46 |

*Research results and their use*

*Land use characteristics.* Mean farm size of the farmers interviewed in 1988 was 2.2 hectares, little different from that in the 1983 survey (Table 2). Percentage area devoted to annual crops, fodder and wood was larger for the 1988 sample, but percentage land left under pasture and fallow was smaller. Percentage area under coffee, banana, fodder grass, pasture, fallow and trees was higher in the subhumid Buju than in the semiarid Buges zone. Less than two-thirds of the farm area in Buges was utilized for annual food crop production. This could be, in addition to other factors, due to the food crop fields being located in the low fertility soils with drought risks and fewer farm animals (Table 3) contributing insufficient manure to improve soil fertility. Food production cannot be intensified in these marginal areas without the use of supplementary fertilizers.

*Importance of trees in farms.* Prior to the project, farmers planted some *Cassia spectabilis*, *Grevillea robusta*, *Eucalyptus* spp., and avocado. After the project, new species were introduced (*Leucaena leucocephala* and *Calliandra calothyrsus*), and farmers increased their planting of *C. spectabilis* and various fruit trees.

Fruit trees are now commonly found on small farms (Table 4); the average number of trees per farm increased from nine in 1983 [Balasubramanian and Egli, 1986] to 19 in 1988. The increase in the number of trees per farm could be due to effective farmer education on tree planting and the distribution of tree seedlings by the BGM Project, as well as a good market for fruits and increased demand for firewood in the region.

The periodic visit by farmers to the Kagasa research site and on-farm

*Table 2.* Mean family size, mean farm size and land use in the Bugesera and Gisaka-Migongo regions, Rwanda, 1983* and 1988.

| Zone | No. of persons/ family | Farm area, ha | % of farm area under | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Annual crops | Banana | Coffee | Fodder crops | Pasture** | Fallow | Wood lot |
| Buju | 8.6 | 2.25 | 36.2 | 25.4 | 3.7 | 5.8 | 7.2 | 9.3 | 12.4 |
| Buges | 7.4 | 2.21 | 62.7 | 21.0 | 1.6 | 1.9 | 4.2 | 5.9 | 2.7 |
| Mean-88 | 8.0 | 2.23 | 49.4 | 23.2 | 2.6 | 3.9 | 5.7 | 7.6 | 7.5 |
| Mean-83 | 6.2 | 2.25 | 37.0 | 26.8 | 3.2 | 0.3 | 22.0 | 10.4 | 0.3 |

* Balasubramanian and Price (1985) and Price et al. (1984).
** Areas not cleared and used as pastures within farms (Reduction in communal pasture land was not determined in this survey).

*Table 3.* Mean number of animals maintained per farm in the Bugesera and Gisaka-Migongo regions, Rwanda, 1983* and 1988.

| Zone | Cattle | Goats | Sheep | Pigs | Rabbits | Poultry | Total, CU** |
|---|---|---|---|---|---|---|---|
| Buju | 2.2 | 3.1 | 0.0 | 0.1 | 0.6 | 7.8 | 2.7 |
| Buges | 0.7 | 2.6 | 0.5 | 0.1 | 0.0 | 4.3 | 1.2 |
| Mean-88 | 1.4 | 2.9 | 0.2 | 0.1 | 0.3 | 6.0 | 1.9 |
| Mean-83 | 1.4 | 3.5 | 0.4 | 0.1 | ND | 5.7 | 2.1 |

* Balasubramanian and Egli (1986).
** CU = Cattle unit = No. of cattle + 1/6 (goats + sheep + pigs); ND = Not determined.

*Table 4.* Mean number of fruit trees of different types per farm in the Bugesera and Gisaka-Migongo regions, Rwanda, 1983* and 1988.

| Zone | Avocado | Papaya | Guava | Mango | Passion | Citrus | Other | Total |
|---|---|---|---|---|---|---|---|---|
| Buju | 10.9 | 4.5 | 2.4 | 1.4 | 1.1 | 0.2 | 0.7 | 21 |
| Buges | 8.2 | 4.8 | 0.9 | 0.6 | 0.2 | 0.8 | 0.5 | 16 |
| Mean-88 | 9.6 | 4.6 | 1.7 | 1.0 | 0.6 | 0.5 | 0.6 | 19 |
| Mean-83 | | | | | | | | 9 |

* Balasubramanian and Price (1985) and Price et al. (1984).

observation plots could have also enhanced their knowledge about efficient ways of incorporating trees into food crop fields. They were probably motivated to plant trees by seeing practical examples. Frequently encountered fruit trees are avocado (*Persea americana* Mill.), papaya (*Carica papaya* L.), guava (*Psidium guajava* L.) and mango (*Mangifera indica* L.). All the farmers realize the need to plant trees for purposes other than fruits in their farms (e.g., the production of wood and/or fodder). The preferred species are *Eucalyptus* spp., *L. leucocephala*, *C. spectabilis*, and *Grevillea robusta* A. Cunn. Farmers in the Buges zone planted more *C. spectabilis* because it resists termite attack which is common in the drier areas. Farmers also reported that *C. spectabilis* stems cut in the morning and dried just for one day burn well as firewood. Many farmers complained that Community nurseries were not able to meet their seedling needs indicating a need for development of on-farm mini-nurseries.

*Fodder production.* As mentioned earlier, the animal component provides cash in times of need (insurance against bad times), in addition to milk, meat, eggs and manure. About 63% of farmers interviewed had fodder scarcity problems, particularly during the dry season. Because the pasture land within-farms is increasingly being brought into cultivation (Table 2), it is becoming more difficult to find enough fodder. Although not measured in this survey, the extent of communal grazing land is also diminishing due to clearing and development of new farms. Thus, the farmers have to find alternative fodder/feed production methods, e.g., using fallow plots for grazing, planting fodder grasses in marginal areas or on anti-erosion bunds, planting browse trees on contour bunds or on property borders (Table 5), using crop residues and household wastes, etc. For animals kept in stalls, a cut and carry system of fodder production and use is being extended. Species of preference for planting, particularly on anti-erosion bunds, are *Tripsacum laxum*, followed by *Setaria* spp. and *Pennisetum purpureum* Schumach. They like to plant browse trees or shrubs (*Ficus* spp., *L. leucocephala*, *Vernonia amygdalina* Del.) on contour bunds or on property borders to get dry season fodder. Balasubramanian and Sekayange [1989] report that when tree legumes were planted on contour bunds in 11 farms and left for the farmers to manage, all of them used the trees as a reserve for dry season fodder and/or a source of firewood.

*Wood production.* The area under trees, especially in woodlots, was reported to be several times higher in 1988 than in 1983 (Table 2). The scarcity of firewood was more severe in the semi-arid Buges than in the subhumid Buju zone, mainly because of the lack of farm woodlots (Table 6). People (mostly children) in the Buges zone spent more time and walked longer distance in search of firewood as compared to their counterparts in the Buju zone. Faced with this serious firewood shortage, they often utilize crop residues as a source of firewood and this increases the depletion of soil fertility in food crop fields. Farmers in both zones use the large poles of *C. spectabilis*, *Eucalyptus* spp., *Ricinus communis* L., *Markhamia* sp., etc., as stakes for banana or for the construction of huts. Fourteen of the sample farmers who have *C. spectabilis* in their farms have planted them on boundaries of their

*Table 5.* Fodder sources and % farms with fodder shortage in the Bugesera and Gisaka-Migongo regions, Rwanda, 1988.

| Zone | Mean area or length per farm | | | Farms with fodder shortage, % |
|---|---|---|---|---|
| | Fallow + pasture (ha) | Fodder crop field (ha) | Grass strip on contour (m) | |
| Buju | 0.37 | 0.13 | 979 | 63 |
| Buges | 0.27 | 0.03 | 556 | 63 |

property (50%) or fields (20%); other planting sites of *C. spectabilis* include banana fields, anti-erosion bunds and woodlot.

*Soil fertility maintenance.* About 58% of farmers in Buju and 89% in Buges complained about falling crop yields due to declining soil fertility (Table 7). This is due to continuous nutrient export in harvested produce and lack of domestic animals to produce enough manure to bring about a meaningful improvement in soil fertility. The quality of manure produced is also highly variable. Farmers without animals resort to composting of crop residues and/or weed biomass for use in maintaining soil fertility in their fields. If adequate cattle manure cannot be produced, some amount of chemical fertilizers has to be brought into the system to maintain soil fertility and crop yields. Judicious use of mineral fertilizers in combination with animal manure or compost has been shown to give encouraging results in these soils [IITA, 1989].

Soils are protected against erosion through contour grass strips plus trenches, mulching (coffee, banana, pineapple), and ridging across slope for root and tuber crops. The survey showed that 85% of farmers used contour grass strips on at least part of their farm. Mean length of grass strip per farm was 979 m (planted over about 50% of farm area) in Buju and 556 m (planted over about 25% of farm area) in Buges. Overall, they occupied about 17% of arable land in Buju and 10% in Buges. About 40% of farmers

*Table 6.* Firewood problems in the Bugesera and Gisaka-Migongo regions, Rwanda, 1988.

| Zone | Woodlot area, ha | Farms with firewood problems (%) | Farms buying firewood (%) | Farms searching firewood (%) | Search of wood | |
|---|---|---|---|---|---|---|
| | | | | | Time, hr/wk | Dist. km/trip |
| Buju | 0.124 | 54 | 21 | 21 | 8.9 | 1.2 |
| Buges | 0.027 | 90 | 7 | 28 | 10.6 | 3.1 |

*Table 7.* Factors related to manure production and soil fertility status in the Bugesera and Gisaka-Migongo regions, Rwanda, 1988.

| Zone | Cattle units* | Farms with cattle sheds (%) | Farms with compost pits (%) | Farms with declining yield (%) |
|---|---|---|---|---|
| Buju | 2.7 | 26 | 96 | 58 |
| Buges | 1.2 | 36 | 96 | 89 |

* Cattle unit = No. of cattle + 1/6 (goats + sheep + pigs).

were interested in planting trees on contour bunds, mainly for fodder, mulch and/or fuelwood, but they were aware of and interested in their anti-erosive value. About 95% of farmers mulched their coffee, as this practice is required by law. Ridging or mounding of root crops was done by over 85% of farmers surveyed.

## Critical analysis of findings and methods

### *Findings for the BGM region*

Specific conclusions can be drawn for the BGM regions from the data collected through several farmer-participatory approaches: informal discussions, authors' observations in the field, farmer feedback and surveys. These conclusions are as follows:

(a) Although alley cropping was introduced with a view to improve and maintain soil fertility through the utilization of tree foliage as green manure/mulch, farmers in the BGM regions prefer multipurpose trees for the production of fodder, poles/stakes, and/or firewood. This could be because the farmers would more easily see the visible growth of their animals fed with tree foliage or the use/sale of tree products, than they can perceive the slow improvement in soil fertility and crop yields through mulch/green manure use.
(b) The authors observe that soil fertility improvement will be indirect through increased production of manure from animals and/or compost. The farmers perceive that they are better off by feeding the tree foliage to their livestock for improved animal production and cash income, and using the animal manure to fertilize their fields.
(c) In farms without an animal component, trees can be planted for the production of green manure/mulch for direct soil fertility improvement. However, farmers do not favor the close association of trees and crops as in alley cropping for fear of interspecies competition and loss of land to trees. Other tree arrangements such as contour/boundary hedges, tree lots, etc. need to be tried.
(d) For fodder production, farmers in BGM prefer *L. leucocephala*, *C. calothyrsus* and *Ficus* spp. Other suitable browse trees, if available, may be added to this list.
(e) Farmers in the study area prize *Eucalyptus* spp. and *C. spectabilis* for wood production. More such species for the BGM regions are needed.
(f) Production and supply of tree seedlings need further attention. The possibility of developing mini on-farm nurseries to satisfy the seedling needs of individual farmers should be explored.

*Participatory methods for technology development*

The FSR project demonstrated that farmer surveys, focused on specific technologies actually being tried on their farms, are useful in assessing farmers' expectations from an introduced technology. The survey also served as a training tool for young scientists. It should be pointed out that the information collected from this survey merely confirmed that obtained from informal discussion with farmers during field visits, although the former provided quantitative frequency data useful as a baseline to measure change with time and to judge the severity of fuelwood scarcity, and land allocation to different crops. Differences in sampling procedure between surveys did not permit the use of statistics to compare results from the two periods. Nevertheless, it should be noted that drawing valid conclusions from survey data depends more on the experience and judgement of field practioners and farmers than on formal statistical analysis [Rocheleau et al., 1988].

Periodic evaluation of research concepts and assumptions as well as redesigning of research activities and technologies based on farmer feedback ("iterative diagnosis and design") are important steps in the implementation of the research programme. Early farmer participation in technology design (which we did not use fully in the present project), development and testing is vital to keep the research focused on practical problems faced by farmers. Regular farmer visits to station trials enhance early feedback on technologies under testing.

Skillful utilization of traditional knowledge and modern agricultural practices is the key to successful development of useful and practical technologies for small farmers. In short, researchers and development agents need to consider the farmers' real needs, circumstances, available resources and management capacity with regard to tree planting, or are likely to fail in identifying and extending suitable agroforestry systems for any region.

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## Annex: Questionnaire

*I. Introduction*

1. General:

Date: ....  Name of Farmer: .............
Commune: .......  Sector: ........  Cellule: ......

2. Household: How many people are there in your family? ..........

   Farmer: .... Wife (ves): .... Children: M .... F ....
   Others: M .... F .... Total ....

3. Land area: What is the total area of your farm? ...... ha

   | | | |
   |---|---|---|
   | Area under: | Banana | : ....ha |
   | | Coffee | : ....ha |
   | | Woodlot/trees | : .... |
   | | Fodder crops | : .... |
   | | Pasture | : .... |
   | | Fallow | : .... |
   | | Annual crops | : .... |
   | | House/compound | : .... |
   | | Others | : .... |
   | | Total | : .... |

4. Number of trees:

   Fruit trees: Avocado: .... Papaya: .... Guava: .... Mango: ....

   Passion fruit: .... Citrus: .... Others: .... Total: ....

   Firewood trees (excluding those in woodlot): Names & No.

   1. ........ 2. ........ 3. ........ 4. ........

   Fodder trees: Names & No. 1. ........ 2. ........

   What other fodder trees do you know? ........

   Do you wish to plant more trees? Yes .... No ....
   If yes, what types? ........
   If no, why not? ........

5. Methods of soil conservation: What methods of soil conservation do you practice?

   Anti-erosion trenches? Yes .... No .... If yes, No. of trenches ..... Total length of trenches ....... m

   Contour grass strips? Yes .... No .... If yes, what species? 1. ......... 2. ........ 3. ........ 4. ........

   Ridges across slopes? Yes .... No .... If yes, for what crops?
   1. ........ 2. ........ 3. ........ 4. ........

   Mulching? Yes .... No .... If yes, for what crops? 1. ........
   2. ........ 3. ........ 4. ........ 5. ........

   Burying of organic materials? Yes .... No .... If yes, what materials? Weeds .... Compost .... Manure .... Manure + compost .... Crop residues .... Others .... (specify)

*II. Firewood*

1. What type of energy do you use for cooking?

   Firewood .... Charcoal .... Gas .... Others (specify) ....

2. What are the sources of firewood?

   Farm woodlot .... Community forestry .... Crop residues .... (what crop?) Buying .... (quantity per week ....) Collecting from outside the farm ....

3. Firewood collection

   Who collects the firewood? Children .... Women .... Men .... others ....

   How much time do you spend in search of firewood? .... h .... mt/wk

4. Do you have difficulty in getting enough firewood? Yes ... No.

   If yes, how do you plan to tackle this problem?

   Plant trees on (a) anti-erosion bunds ...... (b) Farm woodlot ...... (c) community forestry ...... (d) property borders ...... (e) Field boundaries ...... (f) around the compound ...... (g) others ......

   Buy firewood from outside ........

   Search from outside the farm ........

   No visible solution ........

   Others, e.g. Alley cropping ........

5. What type of firewood trees do you like to plant in your farm?

   1. ........ 2. ........ 3. ........ 4. ........

*III. Fodder/forage production*

1. Number of domestic animals

| *Type* | *No.* | *Local* | *Improved* | *Stallfed* | *Free range* |
|---|---|---|---|---|---|
| Cattle | ... | ...... | ........ | ........ | .......... |
| Goats | ... | ...... | ........ | ........ | .......... |
| Sheep | ... | ...... | ........ | ........ | .......... |
| Pigs | ... | ...... | ........ | ........ | .......... |
| Rabbits | ... | ...... | ........ | ........ | .......... |
| Poultry | ... | ...... | ........ | ........ | .......... |
| Others | ... | ...... | ........ | ........ | .......... |

2. How do you utilize the cattle manure?

   (a) Composting in manure pit .... For what crops? .............................
   (b) Direct spreading in field ....... For what crops? .............................
   (c) Burying in the field ............ For what crops? .............................
   (d) Any other method ............. For what crops? .............................

3. Fodder sources

   (a) Pasture Yes .... No .... What animals ................................
   (b) Cut fodder Yes .... No. .... What animals ................................

(c) Crop residues Yes .... No .... What animals ................................
(d) Others (specify) Yes .... No .... What animals ................................

4. What type of crop residues do you use as fodder?

1. ........ 2. ........ 3. ........ 4. ........ 5. ........

5. What species do you use for cut fodder?

1. ........ 2. ........ 3. ........ 4. ........ 5. ........

6. Do you use browse trees for feeding animals? Yes .... No ....

If yes, what species? 1. ........ 2. ........ 3. ........ 4. ........

7. What other fodder/forage trees do you have in your farm?

1. ........ 2. ........ 3. ........ 4. ........ 5. ........

8. What type of problems do you face in getting enough fodder?

1. No land to plant fodder crops .... 2. Lack of pasture .... 3. Lack of feed concentrates ....4. Others ....

9. During what period do you face serious fodder problems?

1. Dry season .... 2. Rainy season .... 3. Throughout ....

10. How do you plan to solve the fodder scarcity problem?

1. Plant trees on contour bunds .... 2. Fodder crop cultivation .... 3. Community pasture .... 4. Plant fodder trees in farm .... 5. Buy fodder/feed concentrates .... 6. Others ....

*IV. Stakes and construction poles*

1. Do you use stakes? Yes .... No ....

If yes, for what crops? 1. Banana .... 2. Yam .... 3. climbing beans .... 4. Melon .... 5. Others ....

2. Do you face problems finding enough stakes for your crops?
Yes .... No ....

3. Do you know the cassia tree used for producing stakes?
Yes .... No ....

If yes, how many trees do you have in your farm ....

How did you plant them? (a) Direct seeding .... (b) Seedling .... (c) Stem cutting .... (d) Other ....

Where did you plant them? (a) On contour bunds ....
(b) Around compounds .... (c) Around fields ....

(d) In banana fields ....   (e) In woodlot .....
(f) Others .....

After how long, do you cut them for the first time? .... months or years

How often do you cut them? .... times per year

How many stakes per tree per cutting do you obtain? ....

What are the length and basal diameter of cassia stakes?
Mean length .... m Basal diameter .... cm

What do you do with the cassia foliage? (a) Dump in compost pits .... (b) Use as mulch .... (c) Bury it in the ground .... (d) Burn it .... (e) Throw away ....

Do you wish to plant more cassia? Yes .... No ....

If yes, how will you obtain the planting material? ....

*V. Soil fertility maintenance*

1. Do crop yields decrease with time in your farm? Yes .... No ....

   If yes, why? .....

2. What steps do you take to maintain soil fertility?

| *Method* | *Crops* |
|---|---|
| Manure | ................. |
| Compost | ................. |
| Natural fallow | ................. |
| Planted fallow | ................. |
| Burying fallow vegetation/weeds | ................. |
| Rhizobium inoculation | ................. |
| Fertilizers | ................. |
| Others | ................. |

3. Do you know about improved fallow? Yes . . . No . . .

   If yes, what species do you like for improved fallow?
   Mucuna .... Sunn hemp .... Other crotalaria .... Desmodium .... Others ....

4. Do you know about shrubs/trees that produce green manure/mulch? Yes .... No ....

   If yes, what species? ...................
   Do you have any of them in your farm? Yes .... No ....
   If yes, what species? ...................

5. Are you interested in producing green manure? Yes .... No ....

   If yes, what method of green manure production do you prefer? (a) Alley cropping .... (b) Trees in groups on less fertile soils .... (c) Trees on contour bunds .... (d) Trees on field boundaries .... (e) Around compound .... (f) Planted fallow .... (g) Other ....

6. What type of soil do you choose for planting trees?

Fertile .... Moderately fertile .... Poor .... V. poor ....

7. If you have enough money, which of the following will you choose to improve fertility of soils in your farm?

   (a) Buy seed, seedling or cutting of trees for planting ............................................
   What species? ....................................................................................
   (b) Buy animals to produce more manure ......................................................
   What types? .......................................................................................
   (c) Buy manure directly .....
   (d) Buy compost .....
   (e) Buy fertilizers .....
   (f) Others (specify) .....

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