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Farmers' perceptions of resource problems and adoption of conservation practices in a densely populated area

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Abstract

Population growth in Africa has had a significant effect on per capita food production over the past two decades. High population growth rates and the resulting increase in population density have also affected the environment. Pressure on farmland has led to deforestation, shortened fallow, decreased farm size and erosion. These trends are examined specifically for Rwanda and other selected nations. This paper presents findings from a series of Sondeo discussions in a high density area of Rwanda to illustrate how farmers view local soil and land fertility problems, in terms of their causes, solutions and adaptations. A second set of data collected from a survey of 448 farmers in the same area is used to examine their perceptions of erosion and soil fertility conditions on their farms, as well as their adoption of several recommended conservation practices.

The results from the Sondeo show that farmers' assessments of problems are in agreement with what outside observers have identified for the area. Farmers propose a wide rage of adaptations and solutions for addressing the problems. In the survey portion of the larger study a majority of farmers report soil erosion and reduced soil fertility problems on at least some of their fields, and a decrease in use of fallow. In terms of adopting certain recommended conservation practices farmers have adopted tall grasses and terraces on some plots, while other practices are not as widely adopted. The discussion of the findings focuses on several limiting factors which inhibit more extensive use of conservation practices. There is a final discussion of alternative adaptations farmers can make in a setting with high population growth and density.

1. Introduction

Population growth has had a pronounced effect on per capita food production in sub-Saharan Africa. In specific locations, growth between 3 % and 4 % has resulted in higher rural population density, smaller average farm size, deforestation, farming on steeper slopes, reduction in fallow, and higher levels of soil erosion and reduced soil fertility. Rwanda, which is among the fastest growing nations in the world, serves as a excellent illustration of these effects. The first part of this paper examines recent demographic and agricultural trends in Rwanda, in the context of other selected Africa countries, and discusses some of the causes and implications of higher population density. The second part of the paper draws on two sources of farm-level data (a 'Sondeo' and a formal survey) to examine how farmers view soil and soil fertility problems on their farms. It also documents farmers' adoption

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of several conservation practices being promoted in one area of Rwanda.

2. Background

Over the last three decades improvement in agricultural production has been a primary concern of both Africa governments and donors. This is still a major concern as per capita food production has worsened over the past decade. Food imports increased seven-fold between 1970 and 1985, and between 1980 and 1990 overall food production grew by 26 % but, on a per capita basis, declined by 5 % (FAO, 1991). Thus, the spectre of periodic hunger, mounting food deficits, and widespread rural poverty continues to dominate discussions of Africa development. More recently, these discussions are being framed within the context of a emerging agricultural paradigm emphasizing environmental issues and a 'sustainability' criterion. This paradigm is reflected in a emerging consensus on the inextricable links among agricultural production, environmental degradation, and demographic trends.

In areas of high population growth and high density environmental problems are becoming much more visible, as seen in soil erosion, farming on highly erosive land, loss of soil fertility, downstream pollution, and deforestation. These conditions describe large parts of Rwanda, Burundi, Malawi and the highlands of Kenya where there are dwindling supplies of cultivable land. Problems are less visible in areas where land is still plentiful and farmers are able to carry out traditional cropping practices, and where population density is still relatively low.

Africa exhibits considerable diversity on demographic and environmental indicators. This is illustrated in Table 1, which focuses on several high and low density Africa countries, as well as India, Pakistan and Nepal to serve as reference points. Rwanda, along with adjacent Burundi and Uganda, constitute three of the highest population density areas on the continent. Rwanda, the focus of this research, has a higher level of population density than India, Pakistan, and Nepal. It also displays the types of indicators alluded to earlier: high density, high population growth, expansion of cropland into forested areas, high level of rural population growth, small farm size, and a higher than average level of deforestation (Table 1). Even with the expansion of farmland into new areas, average farm size has decreased since 1982, from 1.19 ha to 1.0 ha (Balasubramanian and Egli, 1986; Lewis and Berry, 1988). In addition, farms have become more fragmented, averaging as much as 15 to 18 small, scattered plots per farm. The 'high' (> 1500 m) area of Rwanda, where the present research was conducted, contains half of the country's land and has a population density higher than India. Farmers are encroaching on both undrained swamps in the valleys and forested tops of mountains. Much of the land being farmed is on slopes exceeding 30° (Lewis and Berry, 1988), which is a major contributing factor to soil erosion.

2.1. Sources of pressure on land and resources

Rapid population growth and increased population density have potentially serious environmental and agricultural consequences, not to mention the political impacts as rural people cross national borders in search for farmland and off-farm work. Small farmers, under pressure of rapid population growth, modify their traditional fallow patterns and crop rotations. Shortened fallow prevents forest regrowth and fertility restoration, and causes higher erosion levels. Lower soil fertility and poorer soil quality, in turn, create a demand for more forest land and lead to encroachment on more marginal land and non-farm land. Eventually, a area becomes deforested and the long-term productivity of soils is diminished (Rudel, 1989).

The exploitation of fragile resources frequently leads to silting of streams, down-stream flooding and pollution, contamination of drinking water and, indirectly, the exacerbation of medical problems (Mellor, 1988). However, impacts may extend beyond those affecting the environment as farm size decreases, landholdings become fragmented, tenure conditions change, productivity decreases, and travel time

Table 1
Demographic and environmental indicators for selected African and Asian countries

	Population density (people 1000 ha^{-1}; 1989	Population (millions; 1989)	Average annual population change (%; 1980–1989)	% Change in cropland (1964/1966–1983–1985)	% Change: Ha in forests/ woodlands (1964/1966–1983–1985)	Population in rural areas (%) (1990)	Average annual growth of rural population (%) (1985–1990)	Cropland: Ha. per capita (1985)	Deforestation: percent per year (1980s)
High density[1]									
1. Rwanda	2781	6.9	3.2	54.3	−24.9	93.8	3.0	0.17	2.3
2. Burundi	2062	5.3	2.9	32.9	31.9	94.4	2.5	0.28	2.7
3. Nigeria	1201	113.8	3.4	5.7	−29.7	77.0	2.7	0.33	2.7
4. Ugunda	891	16.8	3.2	32.6	−7.4	90.5	3.2	0.43	0.8
5. Malawi	843	8.2	3.4	18.5	−12.8	85.0	2.7	0.34	3.5
Low density									
1. Mauritania	21	1.9	2.4	−28.6	−0.6	65.4	0.7	0.10	2.4
2. Botswana	23	1.2	3.4	32.4	0.4	82.8	2.6	1.23	0.1
3. Chad	44	5.5	2.4	8.7	4.3	73.0	0.6	0.63	0.6
4. C. African Rep.	46	3.0	2.7	7.8	3.0	57.6	0.9	0.77	0.2
Sub-Saharan Africa	211[2]	480.4	3.2	14.0	−8.6	70.3	2.2	0.33	0.5
Asia									
1. India	2736	832.5	2.2	3.8	10.7	72	1.0	0.22	0.3
2. Pakistan	1424	109.9	3.2	26.9	25.9	68	1.6	0.14	0.4
3. Nepal	1320	18.4	2.6	6.2	48.1	90	1.9	0.20	4.0

[1]Excludes island nations, World Resources 1988–1989 (1988).
[2]For Africa, World Development Report 1989. (1989).

for firewood collection increases. In general, the net effect of may of these changes in agricultural conditions will be a diminished opportunity for farmers to improve their farm income because of a worsened resource base, additional labor and time demands placed on farm households, or from farmers' inability to adequately manage dispersed parcels of land. The increased labor demands on farm households whose landholdings continue to fragment, and who are required to travel longer distances for wood and water, are scarcely known.

Population is not the only source of pressure on natural resources, although it is a major one. Other pressures emanate from the need for firewood and charcoal, lumber for construction, cash crops for export, and increased food production to feed rapidly growing urban populations. To illustrate, the cost of inanimate energy over the past 15 years has shifted demand from petroleum based products to wood for fuel as households have gone down the 'energy ladder' (French, 1986), and rapid urbanization has sharply increased demand for wood and lumber as a result of residential expansion, frequently onto adjacent farmlands. In the long-run, these urban-based pressures will surely exacerbate a already deteriorating natural resource base since African nations are generally not yet highly urbanized or industrialized compared with other low income nations in Latin America and Asia. Rwanda, currently about 6 % urban, has one of the lowest levels of urbanization on the continent, suggesting that the pressures on natural resources due to urbanization are yet to be felt.

2.2. *Local awareness of land pressure*

These problems are receiving increased attention, as seen in agroforestry projects, tree-planting campaigns, and farming systems projects emphasizing the introduction of new crops and crop combinations along with conservation practices. The government of Rwanda has banned burning in the country, encouraged and assisted in the planting of trees, and required the use of metal in roof construction, mulch on major cash crops, and trenches on steep slopes. To date, the adoption of recommended forestation and conservation practices across the farm population has been uneven, with at most, one third of the fields in Rwanda employing any type of conservation practice (Lewis et al., 1988).

The Buberuka Highlands, where the present research was conducted, include some of the more productive agricultural lands in the country. They are being subjected to intensive cultivation and forested areas are under increased pressure. Despite a general consensus among outside observers, and statements to the effect that farmers are aware of agricultural and environmental problems, there is virtually no systematically derived information on farmers' perceptions of these problems. Fragmentary research evidence suggests some awareness among farmers that agricultural conditions have worsened. In a recent survey on bean varieties grown under different treatments farmers explained low yields as being due to 'poor soil' (Ndiaye, 1989), which could be attributed to any number of soil and fertility factors. Observation of farmers' fields would also indicate a general awareness of erosion problems, as some have begun planting grass borders on the lower ends of sloping fields while others have constructed small terraces. A small proportion of farmers in the area (19 %) have started private woodlots to replace trees and provide for their wood needs, but these are generally found on larger farms of 2.50 ha or more (Ndiaye and Niang, 1992). Still, while there has been some response on the part of the farmers to the effects of land and population pressures, for most of them conservation is still an abstract concept. Farmers have been slow in adopting conservation practices related to prevention of soil erosion and fertility restoration.

Recommended conservation and soil fertility practices are available to farmers in the four Communes in the research area. Some of the practices have emerged out of government mandates to control erosion and plant trees, while other practices have been developed at area research stations. Undoubtedly, some farmers have become more serious about incorporating green manure and animal manure into their soil, planting woodlots, and constructing small terraces. In

addition, other practices are available for channelling excess rain water to reduce erosion, and Lal's (1989) research in West Africa has demonstrated the conservation benefits of reduced tillage and use of crop residue. At the present time, zero-till is not visible in the area, although a few farmers have reduced their tillage on some crops by turning the soil once rather the usual twice.

Researchers at ISAR (Institute des Sciences Agronomiques du Rwanda), the main government research station in the area of this research, have been conducting research on erosion control through utilization of leguminous shrubs, shrub harvesting for green manure and bean poles, alley-cropping using incorporated cover crops and green manure, as well as varietal improvement. Because of the slow process involved in developing a system that can be easily transferred to farmers, and the relatively weak extension system, few farmers have begun to use any of these practices. The delayed response to adoption of conservation practices is largely due to the fact that they are more demanding and complex agricultural innovations. They require more management and labor, take land away from crops, and are of questionable value in the eyes of many farmers. In the study area, for example, it was found that planting grass on the lower ends of fields and the building of terraces were not perceived as being effective by the majority of the non-adopters. Other constraints include the labor demands involved in the construction of terraces, and the loss of land area resulting from planting grass (Ndiaye, 1991). Loss of land is indicated as the major constraint to the introduction of *Pennisetum* in the area, by 79 % of farmers (Ndiaye and Niang, 1992).

3. Materials and methods

Two sources of information are used in this study. The first, comes from a modified 'Sondeo' technique, the objective of which is to gain insight into farmers' problems, perceptions, and strategies through informal discussions in small group sessions. The emphasis is on learning a lot in a short period, even though it may not be possible to generalize. The second source of information is a formal survey which incorporated many of the insights gleaned from the Sondeo. This survey covered a broader geographical area, including the area where the Sondeos were conducted. As the sampling was random, all farmers had an equal change of being included in the survey. There was no attempt to exclude the Sondeo participants.

3.1. Research site

Rwanda is divided into Prefectures, and below that into Sous-Prefectures, Communes, Sectors and Cellules. All of the information and data presented below were obtained from farmers in the Communes of Butaro, Cyeru, Nyamugali and Nyarotuvu, which are located in the Buberuka Highlands and the Central Plateau in Ruhengeri Prefecture in the northwest part of Rwanda. The four Communes cover an area of 603 km^2. In 1990, when the research was conducted, the area's population was estimated at 269 784, with a population density of 447 km^{-2}

The topography of the area is hilly, with steep slopes and deep valleys occasionally divided by rivers. Most soils in the area are oxisols, generally well drained and acidic, and prone to erosion due to the steep slopes. The altitude in the area ranges from nearly 1800 m to 2650 m. and temperatures range from 15.1 to 16.7 °C. Farmers in the area practice mainly small scale, semi-subsistence agriculture involving about 15 different crops. Farming is carried on at various elevations, ranging from the marshes in the valley bottoms to the tops of mountains (1900–2400 m). Rainfall averages 1100–1350 mm across two main growing seasons (September–March and March–July), during which a wide range of vegetables and grain crops are grown. Average farm size is estimated at 1 ha. However, there is considerable variation around this figure, with some estimates suggesting that as much as 40 % of the farms fall below 0.5 ha. Farmers have imprecise estimates of their land area in hectares, preferring instead to describe its size in terms of the number of 'fields' or 'parcels' they farm. There is

no easy conversion of number of fields into area farmed as they vary widely in size.

Many farmers have fields located at different elevations, which influences their choice of crops and agricultural practices. For example, Irish potatoes and sweet potatoes are generally grown in marshes, while bananas are planted on slopes and wheat on hilltops. Within the fields, there are numerous crop combinations. It is estimated that in any given season, associated crops occupy about 22 % of the land under cultivation (Ndiaye, 1991).

3.2. Farmer selection, 'Sondeo'

Sondeos, or informal popular discussions, were conducted among farmers in public gatherings which were announced in advance and conducted over the period of a month. At each site farmers were engaged in discussion about a variety of agricultural topics. Soil, land and conservation was but one of the several topics discussed.

The format for the discussions was to ask farmers what their main soil and land problems were, if any. They were then asked to identify reasons why they thought the problem existed (the cause), and how they were dealing (coping) with the problem(s). Finally, they were asked to offer what they thought were solutions to the problem(s).

Generally, when a farmer mentioned a particular problem, others were asked for their opinion or experience through a show of hands indicating 'yes/no' or 'agree/disagree' responses. This was done to eliminate idiosyncratic responses. Although no attempt was made to tally hands, all of the findings here are reported for more than a couple of farmers. What this procedure lacks in terms of specificity and quantitative detail, is compensated for, we believe, by providing insight into how farmers view problems in a rudimentary cause-effect framework. It also served as an a priori test of several questions that were to be included in the broader survey.

3.3. Farmer selection, formal survey

In 1990 an extensive formal farm survey was conducted among 448 farmers randomly selected in four communes of the Ruhengeri prefecture. The research site was determined by its inclusion in the area of a USAID-funded project at ISAR, Rwerere. This Institute is technically responsible for conducting research on cropping systems and conservation practices in the four selected communes.

The 448 farm households included in the survey represent approximately 1 % of the households in the four communes. The sample was designed to be proportional to the number of households, by commune. Thus, the appropriate level of generalization is at the commune level. While the survey was designed to be representative of the four communes, and perhaps of agriculture found in the northern and northeastern highland portions of the country, it is not representative of Rwandan agriculture.

To develop the sampling frame, lists of all farmers were compiled at the Sector level and aggregated to the Commune level. Farmers were randomly selected, along with replacements, for formal interviewing, which started in July, 1990. The questionnaire for the formal survey was translated into the local language, Kinyarwanda Interviews were conducted by 38 enumerators employed and trained by the senior author at ISAR. Interviewer training was conducted at the Institute, while farmers were interviewed at their place of residence. In all cases the farm head was the respondent. In 11 % of the cases a female farmer was the head of household. This is slightly below the estimated 16 % for the area.

It is likely that some of the original participants in the Sondeo discussion groups were also included in the formal survey. As it was not thought that their inclusion represented any systematic bias, they were not excluded. Approximately 3–5 % of the farmers were substituted for sampled farmers. The reasons for replacement were deaths which had not been reported to communal authorities, seasonal migrants who were away at the time of the survey, and those who were either infirm or mentally ill.

Random reliability checks were made by the senior author, mainly on the types of crops grown and the utilization of certain recommended conservation practices. He also was responsible for

overseeing and reviewing each completed questionnaire, and in every case where responses were either not recorded or appeared to be unusual they were confirmed by return visits to the farmers.

4. Results

4.1. Results from 'sondeo' discussions

The informal Sondeo results are revealing in terms of what farmers identify as soil conservation problems, the causes of the problems, their efforts at dealing with them, and what they believe are possible solutions. Farmers' responses to these discussion items are presented in Fig. 1, where the main soil and land problems farmers mentioned (problem) appear in the second column. The underlying causes (causes) they identified for the problems are shown in the first column. A distillation of farmers responses as to what they were doing to deal with particular problems is presented in the third column (coping strategy). Finally, responses to the question of how they thought the problems might ultimately be solved are shown in column four (preferred solutions).

The information contained in Fig. 1 suggests that farmers are aware of, and experience, soil and soil related problems. There is less clarity, however, on what they identify as causes of the problems, what farmers are doing to address the problems, and on what a solution would consist of. Without going into minute detail about each problem, several generalizations might be made about the information in Fig. 1. Farmers' assessments of problems are, for the most part, in agreement with what outside observers have identified as agricultural problems in the area: erosion, low fertility, plot fragmentation, population density. Also, in most cases farmers' attribution of causes are directly related to the problem. An interesting exception is erosion, which is seen by farmers as caused by climate, terrain, and tile roofs. The latter, they explained, channel the water and propel it onto the earth with great force, thus causing gullies. There is scant indication in the farmers' responses that they are doing anything to contribute to erosion, for example, removing crop residue, eliminating fal-

CAUSES →	PROBLEM →	COPING STRATEGY →	PREFERRED SOLUTION(S)
• Over-Population	LAND SCARCITY/ DISTANT FIELDS	• Anti-Erosion Techniques • Birth Control • Use of Marshes	• Land Reform • Facilitate Immigration • Birth Control Opportunities • Re-Groupment of Farmers
• Lack of Fallow • Lack of Manure • Erosion	LOW SOIL FERTILITY	• Use of Manure • Use of Chemical Fertilizer • Improved Seed Varieties • Food Gifts	• Credit for Cattle Purchases
• Natural Phenomenon • Steep Slopes • Light Soil • Rain • Tile Roofs	EROSION	• Dig Ditches • Grass on Contour • Use of Trees/Shrubs • Build Terraces	• Village Regroupment • Terrace Construction • Teaching Farmers Construction and Anti-Erosion Techniques
• No Limits on Births • High Birth Rate	TOO MANY	• Birth Control Practices	(No Answer)
• Not Enough Cattle • No Cash to Buy Manure	LACK OF MANURE	• Use of Compost • Use Available Manure	• Provide Chemical Fertilizer • Adapted Crop Varieties • Credit for Cattle Purchases

Fig. 1. Farmer's perceptions of problems related to land and soil.

low, or grazing animals on steeper and relatively bare slopes.

Farmers volunteered a fairly wide range of means for dealing with the identified soil and land problems, depending on what the problem was and what they thought the cause was. Their coping strategies ranged from birth control to use of conservation practices. When it came to offering longer-term solutions to the problems of land scarcity and 'distant fields' (land fragmentation), several suggestions arose which are not often heard in the area: 'land reform' (interpreted as opening up the government owned marshes for farming); 'regroupment of farmers into villages' to free up land; facilitating migration from the area into more land abundant areas. (Several of these solutions appeared also in discussions of other problems that were discussed pertaining to animals and specific crops.) There was also a heavy emphasis on the introduction of more modern forms of inputs: fertilizers, improved seed varieties, and credit. Credit to purchase cattle was specifically mentioned in order to provide farmers with more manure. However, at present many farmers do not do as well as they could in collecting and using available manure. In the long run, increasing the number of livestock would exacerbate some of the current problems farmers have identified for their animals, namely lack of pasture land and shortage of fodder.

The findings presented in Fig. 1 reveal a tendency on the part of farmers to view particular Problems in isolation. Throughout the Sondeo discussion, there was occasional mention of need for conservation practices, and need for instruction in the use of techniques to save and improve the soil. However, there was virtually no mention of reestablishing fallow to what it once was. Apparently, farmers believe they are beyond the point of returning to the more traditional fallow system.

The Sondeo discussions were revealing insofar as they indicated farmer awareness of the types of problems associated with population growth and increased density, which were mentioned, in one form or another, as the underlying causes of several agricultural problems. Finally, while farmers have offered some novel, even 'radical', solutions their emphases are mainly in the direction of more modern forms of agriculture and conservation. There is clearly an awareness among farmers that more modern inputs exist, although they are not widely available. This preference on the part of farmers for more extensive use of external farm inputs is consistent with many of the arguments that population pressures create a dynamic for agricultural modernization. Still, at the same time there has been a de-emphasis among policy-makers on higher-cost purchased inputs for agriculture. Rather, for African countries, including Rwanda, the emphasis is on low external input sustainable agriculture, known as LEISA.

4.2. Formal survey results

The following data comes from the formal survey of 448 farmers described above. In the first section we examine farmers' responses to several questions about environmental problems, and their modification of fallow practices, which are related to land shortages and soil infertility. In the second section we look specifically at farmers adoption of several conservation practices being promoted in the area of the research. And, third, we present some evidence on farmers' adaptations to increasing density and land scarcity.

4.2.1. Farmers' perceptions

An underlying motivation for alteration in farming practices is farmers' perceptions that conditions have indeed worsened. Earlier results from the Sondeo discussions suggested that farmers were experiencing soil and fertility problems. Table 2 presents more quantitative data on farmers' perceptions.

The first two questions, which were designed to get an estimate of how extensive farmers thought fertility and erosion problems were, show that very few farmers report 'no problem' with reduced soil fertility or soil erosion, 7.1 % and 20.1 %, respectively. More than 25 % (27.9) said soil fertility was a problem on 'all' of their fields, and almost 66 % said it was a problem on 'some'. A similar pattern holds for soil erosion, most are

Table 2
Farmer's perceptions of the extent of soil erosion and fertility problems, and reported changes in fallow practices

Question	Number	Percent
1. 'Is low soil fertility a problem on—of your fields?'		
A. None	32	7.1
B. Some	286	63.8
C. All	125	27.9
(Don/t Know or No Response/DK-NR)	5	1.1
	448	99.9
2. 'Is soil erosion a problem on—of your fields?'		
A. None	90	20.1
B. Some	305	68.1
C. All	52	11.6
(DK-NR)	1	0.2
	448	100
3. 'Has the land you put onto fallow decreased compared to 10 years ago?'		
A. Yes	264	58.9
B. No	177	39.5
(DK-NR)	7	1.6
	448	100
4. 'Has the number of seasons you leave a plot in fallow—since you started farming?'		
A. Increased	27	6.0
B. Remained the same	171	38.2
C. Decreased	236	52.7
(DK-NR)	14	3.1
	448	100
5. 'Are there some parts of your farmland that you never put in fallow?'		
A. Yes	268	58.9
B. No	178	39.7
(DK-NR)	2	0.5
	448	99.1
'Is your land producing—food since you started farming it?'		
A. More	62	13.8
B. Same Amount	38	8.5
C. Less	347	77.5
(DK-NR)	1	0.2
	448	100

experiencing soil erosion on 'some' plots (68.1 %).

Lower fertility may be a result of loss of top soil, reduction in fertilization, or a decrease in length of fallow. Questions three to five in Table 2 report responses to questions regarding fallow. Responses on all three reflect the same trend-less land is being put into fallow, and for reduced periods. Nearly 60 % of the farmers report that some parts of their farm are never fallowed. One consequence of these 'adaptations' to increased population pressure is likely to be lower production. An attempt to get farmers' perceptions of reduced food production resulted in question six, which asked a general question about their land's production capacity. The question was phrased in the context of the period since they started farming on their own, which was between 20 and 25 years ago. More than 75 % said their land was producing 'less'. How much less can't be determined from these types of questions. A small percentage (13.8 %) reported 'more', which was generally due to fertilizer use and recent acquisition of newly opened lands.

One possible adaptation to these types of problems is the adoption of any of a number of

conservation and fertilization practices being promoted in the area, by government through the extension service, donor-funded research conducted through research stations, or through governmental exhortation.

4.2.2. Adoption of soil conservation and fertility practices

A major portion of the survey conducted among farmers in the four Communes focuses specifically on their utilization of several recommended conservation and soil fertility practices. Table 3 shows the main coping strategies farmers have adopted to directly deal with erosion problems. Most farmers either 'build terraces' (82.8 %) on at least some of their fields, or else they 'plant tall grasses' (81.3 %) on the lower ends of fields to stop erosion. These practices are confirmed by observation of fields in the area. These are high percentages, although most of these practices are not performed on all 'fields' which are susceptible to erosion. Farmers in the study cultivate between nine and ten different fields, and most farmers have at least some fields on hillsides. Perhaps of more consequence is the farmers' perception of what constitutes a 'terrace'. Many of the so-called terraces have been washed away and barely serve a conservation function. A sizeable proportion of farmers (43.8 %) report leaving residue on the field to reduce runoff, but relatively few (9.8 %) keep animals from foraging on hillsides after harvest. About 25 % use ditches to channel runoff, and at the present time minimum tillage is a new concept. A few farmers report, however, that they have reduced tillage on some crops by turning the soil once rather than the usual twice.

Table 3
Adoption of recommended conservation and soil fertility practices

Practice	Number	Percent adoption
Soil conservation		
1. Construct terraces on steepest fields	371	82.8
2. Plant tall grasses to control erosion	364	81.3
3. Use crop residue for erosion control	196	43.8
4. Construct ditches to channel water	117	36.2
5. Prevent animals from consuming residue on steep hillsides	44	9.8
6. Use minimum tillage	24	5.4
Soil fertility		
1. Construction/use of compost pit	394	88.0
2. Corral large animals to increase available manure	120	26.8
3. Incorporate green manure into soil	8	1.8

Table 3 also displays three major practices whose adoption has been encouraged in order to cope with decreasing soil fertility. The construction and utilization of compost pits, as well as the application of animal manure, constitute the most widespread coping strategies among farmers in the area. Neither compost nor animal manure are thought to be very effective solutions by farmers, not because compost and manure are not available in sufficient quantity in the area but because they easily wash away under heavy rains on steep slopes. In addition, carrying compost and manure up steep slopes is viewed as a great burden by farmers, and so they are used more often on lower fields. Even though the use of green manure is not yet adopted by a significant number of farmers (1.8 %), it is widely believed to be a effective way of improving soil fertility. The effectiveness of green manure increases with proper timing (prior to the rainy season), of application. What is apparently holding many of the farmers back from the use of green manure is the work and management involved in planting shrubs, and the fact that use of shrubs whose leaves are incorporated into the soil can involve taking land out of production, even if they're well maintained.

What further complicates the adoption of several of the conservation practices is that as land becomes fragmented, more dispersed, and located higher on mountain sides, additional time demands are placed on farmers' schedules. There is also an additional risk of crop loss (from theft) on plots located farther from the main farm or family household, thus there is a reduced incentive for investing in conservation practices. Some conservation practices are also land-extensive, and may further reduce farm size. Finally, many of the conservation practices require better, or different, management skills than farmers have.

Consequently, there will have to be a heavy reliance on extension training and advice. In may countries, including Rwanda, this will be a major constraint to the spread of conservation practices.

4.3. Farmer adaptations

A series of questions on different sources of Income may provide information on one adaptive response to lower agricultural production and reduced farm income, and that is relying on farm work for wages and off-farm income and employment. Table 4 presents responses to a series of questions about sources of household income, other than crops and livestock. An attempt to get actual amounts of income on these items proved to be futile, and was therefore abandoned. Of the farmers 32.5 % reported that they regularly hired out to do casual farm work, mainly on nearby coffee and tea plantations. Of the farmers 45.5 % earn some income from a small 'side business' operated either by themselves or spouses. These consisted of brewing beer and operating a cabaret, selling crafts, tailoring, petty trade, selling food stuff, etc. Relatively few (5.8 %) reported any income from remittances sent back from family members living outside the area. This is undoubtedly influenced by the fact that Rwanda is not highly urbanized; less than 10 % of the population lives in urban areas. Several other minor sources of income are presented in Table 4. In other questions (not presented in tables) farmers were asked who contributed to household income; 30.4 % of the male household heads reported that 'women's work' brought in additional cash, and 15.6 % of all households reported that 'children's work' brought in outside income. In another general question (not presented) which asked farmers for their main source of income, 62 % reported that it was agriculture (crops and/or livestock). What the responses on types and sources of income show is that close to 40 % of the households in the survey do not consider agriculture to be their main source of income. This is apparently one way of adapting to lower agriculture production and income, but it is highly dependent on other sectors of the economy.

Table 4
Farmers' additional sources of household income

Source	Number	Percent
1. Small 'side business'	204	45.5
2. Employment in causal farm work	145	32.5
3. Construction work	45	10.0
4. Renting out housing/tools/land	28	6.3
5. Remittances from family	26	5.8
6. Treat illnesses/medical problems	13	2.9
7. Mechanical work/repairs	12	2.7
8. Sell construction material	11	2.5

It might be argued that the ultimate adaptive strategy for reducing population pressure on farmland is family planning. The average number of children in the sampled households is 6.3. A third of the farmers interviewed said that at one time or another they 'tried' birth control. Sixty-one percent of the males and 21 % of the female farmers reported not practising birth control at the time of the study. Most common reasons for not using birth control/family planning were: (1) 36 %, didn't know how; (2) 35 % said they had 'no means' to practice birth control; (3) 12 %, simply 'don't want to'; (4) 12 %, reported they liked a lot of children; (5) 3 %, thought it was risky/unhealthy; (6) 3 %, said they were not ready yet. In Rwanda the Office National de la Population (ONAPO) is the agency in charge of population control. The office advises on family planning methods and provides means of birth control. It reaches out to rural populations by means of leaflets and brochures through government offices, health centers and schools in rural areas.

5. Implications of population pressures for improvement of agriculture

Population pressures have been instrumental in altering agriculture and the rural landscape in Rwanda. Farms have become smaller and fields more dispersed. New lands have been settled, and trees have been removed. Soil fertility has gone down, and pressures have been placed on provi-

sion of food for livestock. All of these trends have serious implications for the viability of agriculture, and for its improvement.

There are several adaptive strategies available to farmers in such high density areas. Among them, classical theory identifies the extensive margin type of response in which farmers expand agriculture into new lands, and the intensive margin type of response which consists of intensifying cultivation on existing fields. In the case of farmers in the study area, they are adopting the latter. They recognize a need for the availability and introduction of new techniques and inputs to solve may of their soil and fertility problems. Yet, most farmers are short of cash (76.2 % of farmers average 15 000 Rwanda francs (1990, US$ 120) or less per year), are not heavily involved in a market economy, and many would have to receive training in use of any new inputs. This would clearly put additional pressure on extension, which is not particularly effective in establishing contact with farmers at the present time. The ratio of 'monagris' (extension agents) to farmers is 1–840. In addition, they lack transportation for the difficult terrain, farm households are spread out, and farm plots are dispersed. Perhaps the major constraint is the lack of experience among extension staff for teaching the conservation and soil fertility practices identified in this paper.

Outmigration of either selected members of the farm household, or even entire households, is another possible adaptation to a condition of high population pressure. Rwanda is almost entirely rural (94 %) and has had relatively little rural-to-urban migration. This may be due to the widespread perception of unemployment and underemployment in urban areas, and of the high cost of living in cities. Kigali, as most large East Africa cities, is already 'over-urbanized', in the sense that the number of jobseekers far outstrips the number of jobs being created annually. Were there to be job expansion in some of the larger towns this would quite possibly would stimulate off-farm migration. This would reduce some of the land pressures, and perhaps increase the transfer of resources from city to countryside through remittances. However, this rural-urban migration strategy is not likely to materialize in the near future, and it is not likely that there will be massive emigration into neighboring countries. This has been tried on the Tanzanian side, but the settlers are being returned.

It is possible also that there will be a greater shift of farmers and family members into rural off-farm employment in order to supplement low farm income. Survey results show that already off-farm employment and earnings are important for may households. However, opportunities in the area are limited to the making and sale of crafts, employment on agricultural estates, operating a small side business, and employment in local infrastructure projects. Barring any large scale construction projects, or location of new rural firms, rural employment is likely to remain limited.

A conservation strategy is being promoted, in combination with limited external inputs in the forms of new varieties, shrubs and bushes, and lime. There are considerable pressures on farmers to adopt any number of conservation practices, many of which have been discussed above. There are also considerable constraints to their adoption, ranging from the lack of a perceived comparative advantage of the practices, to their complexity, and land requirements. This is especially true with respect to terrace construction and afforestation. Information on new conservation techniques will also have to be communicated to farmers, and appropriate skills will have to be taught. There is little evidence that extension staff itself is receiving this training, or that they could adequately cover the farmers in the area.

What is likely to further complicate extension's work is the continual fragmentation and scatter of farmer plots. As farmers subdivide and acquire new lands, whenever and wherever they become available, extension's work with an individual farmer will require considerably more tailoring of advice to diverse climatic and topological conditions. And there will be more travel time involved in covering a particular 'farm'. Information from the present survey has provided some insight into farmers' perceptions of population and conservation issues, and their utiliza-

tion of several recommended practices. There is need for a better understanding of land issues, specifically of land use, fragmentation, and scatter, and how they affect adoption of conservation practices.

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