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**Soil Conservation and Sustainable Development
in the Sahel:
A Study of Two Senegalese Villages**

by

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Preface

The objective of this paper is to examine the environmental and socio-economic impacts of a range of soil conservation policies in the setting of two villages in Senegal's Peanut Basin. The methodology employed relies on the technique of Social Accounting, permitting policy experiments by simulation. It is hoped that the findings of this paper hold validity for the wider region of the Sahel and that they may contribute, therefore, to efforts to contain the serious problems of desertification affecting the region. The Social Accounting Matrix constructed for each of the two villages provides detailed and quantified information on income, employment and land-use patterns. Accordingly, employment and distributional consequences of environmental conservation policies can be traced with a measure of numerical accuracy.

Seven policy options for land conservation are analyzed. They are taxes and subsidy cuts to reduce peanut cultivation, migration and diversification, subsidies and usufruct reform to encourage reforestation, and land-tenure reform. It is shown that because of the lack of viable agricultural alternatives, a tax on peanut production or a cut in peanut supply would probably serve as catalysts to the process of diversification. The environmental impact of reduced cultivation, whether pushed via taxes on agriculture, or pulled via government schemes to absorb agricultural labour, need not be positive unless it is accompanied by agro-forestry innovations or other conservation programmes. Reductions in the agricultural labour force could actually reduce the possibility for labour intensive soil conservation (weeding, land preparation, contouring, walling, intercropping, etc.), increase the possibility for millet mono-cropping, and increase land-tenure insecurity due to current usufruct laws. Without complementary conservation programmes, a tax on peanut production and a reduction in the peanut seed subsidy could have minimal environmental benefit, but significant social impact. Without extra-agricultural opportunities, the result of the tax and seed cut could be further impoverishment of the rural poor and a shift in intra-compound income distribution. With migration and diversification opportunities, the fall in rural income caused by reduced peanut cultivation may be compensated for, but if migration is pursued, the cost to the family structure could be high.

It is also demonstrated that efforts to establish complementary conservation practices and foster active participation of the rural community are complicated by the complexity of the compound farming system. Because of the diversity of the field managers in the compound and the possible splintering of incentive structures, subsidies on conservation projects such as tree planting, walling, contouring, etc., could be dampened by as much as 45 per cent. All subsidies, fines and taxes must be tailored to the incentives of the individual field managers for maximum success. As an alternative to such a complicated subsidy scheme, the possibility of encouraging tree cultivation (or other conservation practices) through changes in the current usufruct laws could prove effective.

The final policy to be examined is individualisation of tenure. Evidence drawn from this study and elsewhere suggests that the benefits accredited to private registered land ownership, in contrast to traditional ownership, have yet to manifest themselves. It

appears that other constraints to efficient land management (environmental, infrastructure, market, etc.) are currently more binding than any possible constraints that traditional tenure might pose. In addition, due to the complexity of the compound system, caution must be exercised in devising any land or resource privatisation scheme.

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Soil Conservation and Sustainable Development in the Sahel: A Study of Two Senegalese Villages - Elise H. Golan¹

I Introduction

The West African Sahel and Sahelo-Sudan zones are experiencing widespread soil degradation and desertification. As the vast majority of the population of these regions depends on agriculture for its livelihood, the need for governments in the area to provide policy to address the problem of environmental degradation is critical. The welfare of the rural population in the Sahel depends on the ability of Sahelian governments to provide policy that will create incentives for soil-preserving land management practices. If this is not possible, the welfare of these peoples depends on the ability of Sahelian governments to provide policy which will create employment opportunities outside of the farming sector.

The objective of this paper is to examine some of the policy options available to Sahelian governments and to evaluate, primarily through simulation experiments conducted with a Social Accounting Model (SAM), the socioeconomic impact of such policy on two sample villages in Senegal's Peanut Basin. The two village SAMs were constructed so as to provide information on income, employment and land use patterns for large, medium and small compounds, and on income, employment and land-use patterns for the individual classes of compound members. Because of the attention paid to the complexity of land management and land ownership in the sample villages, the two SAMs presented here are equipped to examine the employment and distributional effects of various conservation options.

In order to situate and focus the policy discussion it is necessary to examine those factors which have combined to accelerate and entrench the desertification process in the West African Sahel and Sahelo-Sudan zones. This is briefly done below.

First, a principal contributing factor of desertification in the Sahelo-Sudan zones is the fact that soils in this area are structurally fragile with low humus content and low water retention capacity. They are particularly vulnerable to hydromorphy, hard clay pan, laterisation, and wind and water erosion. In addition, the low fertility and fragility of the soil acts as a constraint on plant productivity thereby reducing the potential of plant cover in protecting the soil from erosion [Gorse (1987)].

Second, there has been a continuous and at times rapid destruction of tree varieties in the area due to domestic and international trade in charcoal and gum arabic. The devastating effects of deforestation is well documented in the literature [Gitzner (1988) gives a good overview].

¹ I would like to thank Irma Adelman of the University of California and Ko Doeleman of the International Labour Office in Geneva, for helpful comments and suggestions.

Third, the rapid expansion of and continued dependence on peanut cultivation has been doubly detrimental to the environment. The introduction of peanut cultivation resulted in a reduction in fallow land and a shift in livestock grazing patterns. For food security reasons, peanut crop production did not displace staple crop cultivation, but instead took place on the fallow areas around and between villages. Because peanut crop residue offers only about one third the dry matter fodder of traditional subsistence crops, the expansion of peanut production not only eroded traditional buffer zones, but also forced Nomads and other herders north, onto the fragile desert fringe [Franke and Chasin (1981)]. Both effects have served to reinforce the desertification process.

Fourth, population pressures in the heartland of the Sahelian and Sudanian zones of West Africa, as opposed to the desert fringe, make these areas particularly vulnerable to desertification. In particular, the Senegalese Peanut Basin, the location of this study, has been identified as an area where actual rural population (1980 data) already greatly exceeds the carrying capacity of the land, both in terms of agricultural and livestock production, and fuel wood consumption.

Fifth, to date, the results of research into alternative, soil-friendly agricultural techniques for the Sahelo-Sudan zones have been disappointing, and it has been argued that without a technological breakthrough, significant change in carrying capacity in the Sahelo-Sudan zones heartland is not possible [Gorse (1987), Perrings (1991)]. Because rapid population growth and increased agricultural production have not been accompanied by technological innovation, stress on the environment has not been matched by technologically induced changes in carrying capacity. Overcultivation, overgrazing and deforestation, the major contributors to desertification, have been the result.

Sixth, since 1968 a period of drought has affected the Sahel region of West Africa. In spite of expectations to the contrary, this drought has not abated to date. The history of the drought has been long, painful and even horrific. In its first stages, from 1968 to 1972, the Club du Sahel estimated that between 50,000 to 100,000 people died in the region as a result of the drought. The FAO estimated that 3.5 million head of cattle (25 per cent of the total) died in the Sahel in 1972-3 alone. Rainfall improved between 1973-1975 but has since remained below the average for this century. Average rainfall between 1977 and 1981 was no higher than that for the period from 1968 to 1973, and 1983 and 1984 were even drier than 1972. Drought continued during the second half of the 1980s, and despite heavy rainfall and excellent crop yields in 1988, there is still no evidence that the drought has subsided. The continuation of the drought has led to speculation that the region is experiencing a long-term warming trend. Possible explanations for this trend include the albedo effect (a result of overcultivation, overgrazing and deforestation in the region), El Nino, and the Greenhouse effect. [Grainger (1990) gives an excellent overview of the history and possible explanations for the drought in the Sahel.]

Even though the drought itself might be a result of the desertification process, it is also serving as a catalyst to the process. With the continuation of the drought, streams dry up, water tables drop, salination occurs, and in many cases, irreversible damage is done not only to the environment but to human and animal populations as well. In addition, the possibility of long-term climatic change in the area raises the issue of climatic

variability. It has been argued that even a small rise in climatic mean could result (and maybe already *has* resulted) in large increases in climatic extremes, and that the shock of more extreme climatic events may lead to the destruction of the resiliency and sustainability of an ecosystem [Parry (1990), Perrings (1991)].

The six factors listed above have combined to accelerate the process of soil degradation and desertification in the Sahel and Sahelo-Sudan zones. Conservation policy designed for the region must be considered against the background of these issues.

Following the above introduction, the next section of this paper describes Senegal's Peanut Basin, the location of the study. In the third section, the sample area and the data collection procedure is discussed. In the fourth section, the economies of the two villages are described. Technical details relating to Social Accounting and to the SAM for each village have been relegated to Appendices. In the subsequent section of the paper, seven policy options for land conservation are analyzed. They are taxes and subsidy cuts to reduce peanut cultivation, migration and diversification, reforestation through subsidies and usufruct reform, and land-tenure reform. The final section presents the conclusions.

II The Peanut Basin

The bulk of Senegal's population lives and farms in the Peanut Basin. This region extends southward from Louga to Kaolack and eastward from Thies to Tiaf and broadly follows the historical and current distribution of peanut production in Senegal. Like all of Senegal, the Peanut Basin has a late summer rainy season (about 4 months) and an extended dry season (about 8 months). Rain levels in the Basin range from approximately 800 mm in the south to approximately 475 mm in the north, with rains becoming more variable as one moves north. The most widely distributed soil types in the Basin are desaturated ferruginous tropical soils, and the natural vegetation ranges from wooded savannah in the south to sparsely wooded, shrubby steppe in the north. Giant Baobab trees are prevalent throughout the area.

In the Basin, the Wolof and then Serer ethnic groups predominate, with Peul, Lebou, Malinke, Toucouleur, Nouminda, and Bambara scattered throughout the region. As of 1980, population densities in the Basin ranged from 30 to 40 people per square kilometre in the north and east, to approximately 100 people per square kilometre in the south-centre districts. These numbers represent high population densities for a desert region like the Sahel.

The Farming System and Land Tenure

Historically, land in the Basin was claimed by the first settlers by right of having cleared it by fire. These men became known as the "masters of fire" or the "borom daye" (Wolof). They usually claimed vast areas of land with up to six days of burning.

Being unable to cultivate the totality of their holdings themselves, these men accorded use rights or "rights of hatchet" to men who could cultivate the land. Once given use rights, the "master of hatchet" or "borom n'gadio" (Wolof) had incontestable, irrevocable rights to that land as long as he paid a yearly homage to the master of fire. Usually, this annual payment was symbolic (an ear of millet for example), but in different areas and at different times in the Basin's history, the homage payment became a substantial portion of the year's harvest.

Rights of fire and hatchet were (and still are) passed from father to son. In the area of the Basin where this study was conducted, farmers reported that the right of fire had died out during the period of French rule and that at present only the right of hatchet remains.

Farm production is organised at the compound level. The compound is composed of any number of households. The nucleus of the compound is typically composed of one male, who has right of hatchet, and his household (wives, children, older parents, aunt, sisters, unmarried male relatives, etc.). The male with rights of hatchet is not only the head of his household, but also the head of the compound. Other households in the compound are typically headed by male relatives of the compound head (brothers, sons or cousins). These secondary households are either independent or dependent households, where the primary distinction is that independent households prepare their own meals and are responsible for meeting their own millet needs. The position of head of the compound, along with the right of hatchet, is passed from father to oldest son. If the oldest son is unable or unwilling to assume control, responsibility is passed to the most appropriate male (or occasionally female) relative.

In the Basin, peanuts and millet are the primary cash crop and primary staple crop respectively. The compound head is responsible for distributing compound land between millet and peanut crops. He oversees the compound's millet fields and has the ultimate responsibility for assuring the food needs of the compound. If there is an independent household in the compound, the head of this household will also oversee a millet field in order to supply his household's grain needs. The millet flow between the compound and independent member households seems to be fluid and varies, with transfers taking place in both directions.

After allocating enough land to millet production, the compound head distributes the remaining land among the various compound members for cultivation. Occasionally, land is set aside for manioc, vegetables, and condiments. Wives, unmarried compound members (called *sourga*), older male children, heads of households, brothers, cousins, aunts, uncles, etc. can all be allocated land to cultivate for their personal benefit. Peanuts is usually the crop of choice. Peanut and millet fields are customarily rotated on a yearly basis so that from one year to the next many compound members do not know which fields they will be allocated for their personal peanut crops. The compound head also cultivates a peanut field for his own cash needs. All compound members donate labour to the compound's millet fields, but assuring enough labour for the peanut fields is usually the responsibility of each field manager and labour swaps are arranged on an individual basis.

Two types of hired labour are common in the Peanut Basin. One type is the "firdou". The firdou travel throughout the area supplying supplemental labour as needed. They are usually paid in cash and are given food and lodging during the duration of the labour contract. "Navetanes" are the second common type of hired labour. These men hire out their labour in return for the loan of peanut seeds and a parcel of land. Traditionally, navetanes work on the compound fields in the mornings and on their personal peanut field in the afternoon. At the end of the season, they repay the peanut seed loan with interest. Navetanes live and eat with their host compounds during the growing season and then return home during the dry season. Navetanes usually have ongoing relationships with a compound, returning year after year to the same place.

Inputs such as seeds, pesticides and fertilizer are acquired by the compound in a number of ways. Up to and including 1986, the year of this study, farmers had access to government-provided peanut seed (which included pesticide) that was distributed on credit through the farmers cooperative. With this system, farmers received the peanut seed and pesticide at the beginning of the season, and after harvest they were responsible for reimbursement with interest. As heads of compounds and sometimes independent heads of households are usually the only compound members with access to peanut seed credit, it is their responsibility to determine the allocation of this peanut seed and pesticide among the other compound members who wished to plant peanut fields. Peanut seed was, and is, also available for sale on the open market and, of course, some farmers reserve seed from year to year (though this practice cannot be continued over a long period of time due to the eventual deterioration of seed quality). Pesticide and fertilizer are both sold on the open market though fertilizer is extremely expensive and relatively difficult to obtain.

Tool use in the Basin is primarily restricted to horse or donkey-pulled ploughs and small hand-held implements. The "iler", a metal arrow shaped piece attached to a long stick, appears to be the most popular tool in the area. It is principally used for weeding but has many other uses from field preparation, to seeding and harvesting.

The legal land tenure system in Senegal is complex. A Law of National Domain was passed in 1964, which granted the state ownership rights to previously unregistered land. As a result, approximately 98 per cent of all Senegalese land became part of the National Domain and subject to state control. However, due to incomplete and uneven application of the Law of National Domain, usufruct or ownership rights over most agricultural land is still determined through traditional practice.

III Data Collection

Every region in Senegal is broken into administrative units called village sections, each of which is governed by a democratically elected rural council. Depending on the population density of an area, these sections are composed of one or more villages. At the village section level, land disputes and inheritance are decided by the rural council.

Two village sections in the Peanut Basin, Keur Marie and Keur Magaye,² were chosen for the study sample. They were chosen primarily on the basis of logistical criteria. Each section is less than an hour's drive from the huge daily market at the regional capital of Kaolack, and each section is within walking distance of a large weekly market. The sections were chosen so that a number of marketing opportunities would be readily available to the farmers. The sample sections were also chosen so as to reflect the variation in population density in the Peanut Basin. Keur Marie is located to the west of Kaolack where population densities are highest, while Keur Magaye lies to the east where population densities are at their lowest.

A list of compound heads for each section was acquired from the sections' extension agents. Compounds were then chosen randomly from the list with approximately one third of each sections' compounds chosen for the study. In Keur Marie, twenty-two compounds were interviewed and in Keur Magaye, twenty-six compounds were interviewed. Interviewing was conducted from January 1987 to May 1987. The interview period corresponds to a part of the year of low agricultural activity in the Peanut Basin. Data was collected as soon after harvest as was feasible given the time constraints of the compound and the availability of the enumerators. The figures thus obtained rely primarily on the 1986 agricultural season.

The compilation of data formed part of a study on African tenure and land management that was conducted by The United States Agency for International Development, The World Bank and The Land Tenure Centre at the University of Wisconsin [Hardy (1989), Golan (1990)]. Findings have permitted the construction of a SAM for each of the two villages. These SAMs provide a methodological framework for the analysis of land management, land tenure and incentives, which, in turn, provide a key to the policy issues addressed in the present study.

The Questionnaire

The questionnaire used to survey the villages of Keur Marie and Key Magaye has a design that pays careful attention to the structure of the farming system in the Basin and, as a result, the structure of the questionnaire incorporated two issues that are often neglected in the literature.

First, the organisation of the compound was carefully investigated, and second, the tenure rights of the compound as a whole and the rights of each individual member of the compound were detailed. The importance of each of these steps is described below.

To begin, faulty or incomplete characterisation of the African farming unit has led economists astray in many land management studies. Economists and other development planners must be careful to go beyond the compound head (who happens to be the easiest to interview), and define the role of each member of the compound. The majority of

² Three compounds from the adjoining section of Keur Ismaila are included with the compounds of Keur Magaye.

economic or development studies exhibit a particular stubbornness in continually reducing the African farming unit to "the farmer". When this step is taken in ignorance, references to "the farmer" allude to an owner-operator. On the other hand, when the simplification occurs after much apology to the compound household literature, "the farmer" refers to an amorphous entity and the compound takes on the quality of a black box in that it reacts through an unspecified mechanism to economic, environmental or social stimuli. With or without qualification, in practice the notion of "farmer" remains misinterpreted as a decision maker accorded owner-operator status and comparable to the compound head. This is a costly reduction. In the African setting, compound heads, wives, children, cousins, uncles, nephews, etc., could all be responsible for cultivating compound land. Each one of them is "the farmer". Each one of them is subject to a different set of constraints and a different set of motivations. In persisting to model rural Africa using just the constraints and motivations of the compound head and excluding those of the other farmers in the compound, economists cannot hope to develop successful agricultural programmes. In this study, therefore, each compound member who was responsible for the cultivation of a field of land was interviewed and the constraints and incentives of each field manager were evaluated.

Further, it is extremely important to correctly detail the tenure rights held by the compound as a whole, and by each member of the compound individually. Failure to take this step has resulted in difficulties for many Western scholars when trying to model African tenure and land-management systems. Economics must overcome its propensity to apply labels such as individual, communal, indigenous or traditional to various tenure systems and to then deliver sweeping comparisons of these systems. There are many rights associated with land ownership, and these rights must be detailed individually to accurately describe a system of tenure and to provide a basis of comparison with other systems. In the words of R. Simpson (1976):

The collection of rights pertaining to any one land parcel may be likened to a bundle of sticks. From time to time the sticks may vary in number (representing the number of rights), in thickness (representing the size or "quantum" of each right), and in length (representing the duration of each right). Sometimes the whole bundle may be held by one person or it may be held by a group of persons such as a company or a family or clan or tribe, but very often separate sticks are held by different people. Sticks out of the bundle can be acquired in many different ways and held for different periods, but, the ownership of the land is not itself one of the sticks; it must be regarded as a vessel or container for the bundle, the owner being the person (individual or corporate) who has the "right of disposal" as it can be called.

The sticks in the bundle can be determined in any number of ways. They could be determined according to ecological use, which might specify seasonal rights to fish, hunt, gather, or graze over a virtually unbounded area of land, or they could be determined according to market or production specifications, which might delineate rights over trees and plants, minerals, water, as well as alienability, mortgageability, etc.

For Western economists and development planners, the idea of land rights being likened to a bundle of sticks is an appealing one, and R. Simpson is quoted or referred to

in a number of tenure studies. Many scholars understand that the bundle of rights the African farmer possesses might contain different sorts of rights from those possessed by American or European farmers. What most studies fail to do is to untie the bundle of rights: they get stuck at the level of "the farmer", or in other words, the compound head. This is wrong. Even though the compound head is usually allocated the lion's share of land rights, other compound members also possess solid rights over compound land. These rights are recognised by the whole community and often limit those possessed by the compound head.

In the data set used here, a considerable amount of effort was spent determining not only the rights of the compound as a whole over land, but also the individual compound members' rights to land, i.e., the individual bundles of sticks. In this way, the tenure security and incentive structure operating on every field manager within the compound as well as the compound as a whole was reconstructed.

The desire to provide a complete characterisation of the farming organisation and a detailed description of the tenure system necessitated lengthy interviews with each land manager in the compound. In the Peanut Basin sample, 136 different field managers were identified. These 136 managers supervised 262 fields, meaning that one manager could supervise numerous fields. In order to gauge the tenurial rights of the field managers, a series of questions was asked of the manager of each field. These questions are listed below.

- (1) How did you obtain this field? or, Who gave you this field to work?
- (2) How many years have you been the manager of this field?
- (3) Who could take this field away from you?
- (4) Will you manage this field next year?
- (5) Will your children operate this field?
- (6) Who determines who the heirs to this field will be?
- (7) Can you give this field away?
- (8) Who determines the crop planted on this field?
- (9) Who determines the quantity of seeds planted?
- (10) Who determines the amount of pesticide used?

According to the managers' responses to these questions, the 262 fields owned by the various compounds were classified according to the bundle of tenurial rights possessed by their field managers. For use in the village SAM, the fields were grouped into three classes, those managed by managers possessing secure tenure rights, those managed by managers possessing moderately secure rights, and those managed by managers with insecure tenure rights.

Managers with the most secure rights over a field were those who stated that no one could take the field from them, that they would work the field next year and that their children would operate the field. These managers determined what crops they planted, the amount of seeds planted, and the amount of pesticide used. There are 126 fields in the sample managed by managers with secure rights. Of these 126 fields, 31 managers had the added rights of determining who would inherit the field and stated that they had the unconditional power to give the field away, though most expressed the sentiment that

even if they could give the field away, they never would. All of the secure managers stated that their children would operate the field in question.

The fields in the moderately secure fields classification include managers who stated that no one could take the field from them but at the same time they either did not determine crop, seed or pesticide, or they did not know if they would be working the field next year or if their children would operate the field. Only 30 fields fall into this category.

In the insecure classification are the 75 fields managed by individuals who felt that someone had the right to take the land away from them. Sixty of these field managers said that the compound head could take the field from them, eight said the village chief, one said the rural council, one said another relative, and three said someone else. Also included in this classification are the two fields whose managers did not know if someone could take the land from them.

A category for borrowed fields can be added to the three above. The inclusion of the borrowed fields brings the total number of fields to 262: 126 with secure tenure, 30 with managers possessing moderately secure rights, 75 with managers possessing insecure tenure rights and 41 borrowed fields. The field portfolios of the managers could be diverse, with some managers managing one field and others managing several. For example, a single manager could be responsible for three fields: one over which he/she had secure tenure rights, another over which he/she had insecure rights, and another that was borrowed. And of course, the tenurial security of every field manager is conditioned by the tenure rights and security of the compound as a whole.

After determining who the field managers were, and the degree of responsibility accorded to each one, information on production, consumption, input allocation and use, capital holding, etc., was collected from the compound head and from the various field managers. A complete outline of the questionnaire is provided in Appendix 2.

IV Village Surveys

Although Keur Marie is situated in a densely populated area and Keur Magaye is not, the basic economic structure of the two villages selected for this study, is similar. Both villages have single cash crop and single staple crop economies that revolve around peanuts and millet. The flow pattern is uncomplicated. The majority of purchased inputs and consumption items is imported from outside the village, and the majority of cash crops is exported to outside the village. There is relatively little interaction between compounds within each village and neither village has a store or market.

Examination of the flows in and out of the villages makes clear the cash crop staple crop dichotomy which exists in the two villages. Peanut seeds are primarily purchased from the government cooperative as is pesticide. The peanut crop is then sold to the cooperative. Millet seeds are almost exclusively retained from previous harvests, and

most millet production is consumed by the compound. Tables 1 and 2 illustrate the flow pattern between the village and the rest of Senegal. Table 1 gives the percentage breakdowns of the amount of seed that village compounds retained for cultivation in 1986.

Table 1
Retained Seeds - Percentage of Total Seeds Planted in 1986

	Keur Marie	Keur Magaye
Peanut Seeds Retained	34	31
Millet Seeds Retained	93	89
Other Crop Seeds Retained	39	29

As shown, almost all of the compounds' millet seed needs are met by retained stocks in both villages. The small amount of peanut seed retained by the compounds from one year to the next can be explained by three facts. First, peanut seed is supplied by the government cooperative on credit, an important consideration for an area with a "hungry season". Second, peanut seed storage can prove quite costly. Whereas on average, it requires only 3 to 4 kilos of seed to plant a hectare of millet, it requires about 90 to 95 kilos of peanut seed to plant a corresponding area. Third, peanut seed quality deteriorates from one year to the next, and farmers must periodically supplement retained stocks with higher quality seeds.

Table 1 also shows that in both villages, the largest portion of other crop "seed" is purchased, either from village neighbours, the weekly market, or, from elsewhere in Senegal. This reflects the fact that in Keur Magaye manioc is a booming crop, with farmers currently planting first time plantations, and in Keur Marie the vegetable and melon market is organised by Lebanese merchants from Dakar who supply seeds fertilizer and pesticide on credit.

It is interesting to note that in both villages the amount of peanut seed retained for cultivation in 1987 exceeds that in 1986. In Keur Marie, 50 per cent more seeds were saved for use in 1987, and in Keur Magaye, 14 per cent more. The large increase in retained seeds in Keur Marie probably reflects the unease that Keur Marie farmers are experiencing over the expected change in the government's peanut seed distribution policy. The relatively small increase in Keur Magaye probably reflects the confidence that the farmers in Keur Magaye have in the ability of their cooperative president to assure them of a continued supply of government peanut seed.

Neither village substantially increased its retained millet seed: 0 per cent for Keur Marie and 7 per cent for Keur Magaye. The increase in Keur Magaye is too small to state with confidence that farmers in this section anticipated expanding millet production in 1987. But the increase in retained other crop seeds in Keur Magaye reflects a definite trend; farmers are allocating more and more land to manioc production. From 1986 to 1987, 511 per cent more seeds were retained for this purpose. Indeed, through

conversations with farmers, it becomes clear that a manioc craze is sweeping this village section. No similar craze has hit the vegetable and melon farmers in Keur Marie and manioc is not popular in this area.

Turning now to consumption, Table 2 shows the percentage of harvest retained for compound consumption.

Table 2
Percentage of Harvest Retained for Compound Consumption

	Keur Marie	Keur Magaye
Peanuts	7	2
Millet	99	98
Other Crops	51	50

Again, the distinction between the cash crop and the staple is clearly drawn; very few peanuts are kept for compound consumption and very little millet is sold. In both villages, the other crop, primarily melons and vegetables in Keur Marie and manioc in Keur Magaye is almost equally sold and consumed by the compounds. It should be noted that not one farmer in either village listed a neighbour as the purchaser of peanuts, millet or other crops and that conversely, in the consumption questionnaire, not one farmer stated that he/she had purchased any of these crops from a neighbour for consumption. This implies that a village market for consumption crops does not exist and that the consumption of these goods by village compounds represents a compound's own consumption exclusively.

In both villages, the primary village-produced consumption good is each compound's own millet. The vast majority of all other consumption goods is imported. They consist primarily of clothes, foodstuffs (sugar, tea, coffee, condiments, fish, etc.), and small manufactured goods (matches, pots, utensils, etc.).

The amount and type of village-produced goods and services exported outside the village also reflects the millet-peanut dichotomy: peanuts are sold outside the village and millet is for own consumption. The organisation of the peanut market shows some difference in the two villages (see Appendix 3). Keur Marie farmers sold their peanuts exclusively to the government-sponsored cooperative while the farmers in Keur Magaye sold 27 per cent of their marketed surplus to peanut merchants from the rest of Senegal. As for millet, the farmers in Keur Marie did not sell any of their harvest to the outside world (or to anyone), while in Keur Magaye, a paltry 1 per cent was sold at the weekly market or to merchants from the rest of Senegal. In Keur Magaye, the manioc crop was sold at the weekly market and to other points in Senegal while in Keur Marie, all of the vegetables and melons were sold to the Lebanese merchants from Dakar who were responsible for initiating these crops in Keur Marie. In neither village section were any services sold to the rest of Senegal, but more than 75 per cent of the commerce activities

(76 per cent in Keur Marie and 87 per cent in Keur Magaye) were completed in locations other than the village.

The main economic interaction within the villages takes place on the input side: there is fairly extensive borrowing and lending of fields among compounds, and compounds use not only household and compound labour but also labour from other compounds ("village labour") and labour from other villages ("imported labour"). In fact, the complexity of these SAMs is generated by detailing intra-compound interactions and stratifying village land owners. The importance of inter-village and inter- and intra-compound interaction is illustrated in the factor value-added calculations. Here the percentage of farm income due to labour and land transactions is clearly shown. Table 3 presents the percentage of farm income derived from the different factors.

Table 3
Factor Value-Added as a Percentage of Farm Income

	Large Compounds	Medium Compounds	Small Compounds
Keur Marie:			
Manager Labour	6	7	15.4
Household Labour	15	10	22
Compound Labour	2	6	0.2
Village Labour	2	2	5
Secure Fields	44	46	26
Moderately Sec. Fields	8	2	0
Insecure Fields	5	14	0
Borrowed Fields	11	4	20
Animals	7	9	11
Keur Magaye:			
Manager Labour	3.4	5	13
Household Labour	6	6	15
Compound Labour	3	2	1
Village Labour	0.6	0.2	1
Secure Fields	38	53.5	9
Moderately Sec. Fields	19	0.3	12
Insecure Fields	17	23	11
Borrowed Fields	9	6	32
Animals	4	4	6

Table 3 shows that labour value-added percentages across labour types and compound types are comparable, with all compounds deriving most labour value-added from household, manager, and compound labour in descending order. There is comparatively little labour interaction between compounds in the same village, and little imported labour from outside the village. The distribution across labour types in both villages is similar, with small compounds deriving almost twice the value-added from

labour than medium or large compounds. This means that relative to the income gained, small compounds expended about twice the labour time on agriculture as large and medium compounds did. Animal use across compounds, across villages is not strikingly different. Secure fields account for most of the land value-added, though in Keur Magaye the smaller compounds relied most heavily on borrowed land.

Though the farming system and tenure patterns in the two villages are similar, the size of land holdings is quite different. This observation is not surprising given the fact that Keur Marie is located in a more densely populated area. The 26 compounds in Keur Magaye controlled almost three times the amount of land controlled by the 22 compounds in Keur Marie. They also had twice the amount of land in fallow as the Keur Marie sample. The statistics on size and number of parcels are presented in Table 4.

Table 4
Parcels and Hectares by Village - Keur Marie Keur Magaye

	# of Parcels		Hectares		% of Hectares	
	Marie	Magaye	Marie	Magaye	Marie	Magaye
Total	138	213	190.6	546.2	100	100
Owned and Operated	98	150	152.0	412.1	80	76
Borrowed	25	24	25.2	40.6	13	7
Lent	15	39	13.4	90.8	7	17
Borrowed and Lent	0	1	0	.1		
Fallow	34	74	35.2	209.0	18	39
Fallow:						
Owned and Operated	30	71	31.4	203.6		
Borrowed	3	3	3.2	5.4		
Lent	1	0	.6	0		

Owned land area per compound in Keur Magaye ranged from .1 hectares to 59.7 hectares, while that in Keur Marie ranged from 0 to 18.1. The average owned land area per compound in Keur Marie was 7.5 hectares (st=5.0), as compared to an average owned land area of 19.3 hectares (st = 15.8) in Keur Magaye. The average amount of land each compound had access to the previous year [i.e., owned (including fallow) + borrowed - lent] was 8.1 hectares for Keur Marie (st = 5.1) and 17.4 hectares for Keur Magaye (st = 13.0). The average amount of operated land per compound (i.e., owned land + borrowed - lent - fallow) was 9.4 hectares for Keur Magaye and 6.5 hectares for Keur Marie. The gap in the ratios of land per compound in the two villages narrows once reallocation due to borrowing and lending is considered, and narrows further once fallow (particularly the huge tracts of fallow in Keur Magaye) is removed from the calculations.

The average distance between a compound and one of its parcels was approximately one kilometre (st = 1312 meters). Compound members usually walk this distance, though for the longer treks, which range up to six kilometres, horse or donkey carts are sometimes employed. For those most distant parcels, small huts are built in the parcel for over-night stays by compound members. Table 5 shows the average distances between parcel and compound for each village and for each type of parcel.

Table 5
Average Distance Between Compound and Parcel (Meters)

	Keur Marie	Keur Magaye
All Parcels	441	1632
Owned and Operated	489	1465
Lent	272	2163
Borrowed	356	1879
Fallow	584	1679

Given the size of the holdings in Keur Magaye, it is not surprising to find that on average they lay almost four times farther from the compound than those in Keur Marie.

V Policy Analysis

Seven policy options for land conservation will be analyzed, either through experimentation with the SAM model, or through examination of the SAMs themselves. The policy options are taxes and subsidy cuts to reduce peanut cultivation, migration and diversification, reforestation through subsidies and usufruct reform, and land-tenure reform.

Financial Incentives to Reduce Peanut Production

Three assumptions lie behind the argument supporting the use of taxes and subsidies in the control of desertification. First is the assumption that the social cost of land use is higher than the private cost; the farmer or herder over-utilises land resources because he or she does not consider the true cost to society today or in the future. Taxation on marginal land use or tree harvesting or grazing represents an effort to internalise a negative externality. By levying a tax on the producer, private and social costs can be reconciled (and a high discount rate compensated for). With the tax, the individual producer will factor the true cost of expanded cultivation, grazing or wood gathering into his/her utility-maximising calculus. Likewise, a subsidy on environmental conservation will help tip utility-maximising calculations in favour of conservation practices.

The second assumption necessary to validate the use of financial incentives in controlling desertification is the existence of an alternative environment-friendly agricultural technology or an alternative extra-agricultural income-generating option. The objective of taxes and subsidies is to change the cost-benefit calculations of the producer in such a way that a soil-saving technology or conservation scheme or income option that was once unprofitable, or at least not the most profitable, becomes the profit-maximising choice.

The third condition or assumption necessary for the successful use of financial incentives is that the appropriate decision maker can be identified and influenced. Any effort to use financial incentives to influence the profit maximising calculus of the producer crucially depends on determining who the producer is and tailoring policy to his or her incentive structure. Close attention must be paid to the complexity of the compound farming system if the compound is taxed or subsidised in order to enhance conservation practices in the region.

The financial incentives to curtail peanut production will be examined in light of these three considerations as will the financial incentives examined later in the paper.

Tax on Peanut Production

In the first SAM experiment, a simple tax to curtail peanut cultivation is imposed. Because expanded peanut production has been identified as a driving force in overcultivation, overgrazing and deforestation in the Sahel (Franke and Chasin, 1981), this is a logical tax to consider. For the purpose of the experiment, it will be assumed that the tax is collected as a value-added tax by the government cooperative at the time of sale of the peanut crop (it is assumed that the private market peanut price will fall to meet the government "price"). The purpose of the tax is to simply reduce the amount of land currently under peanut production. A value-added tax has four advantages. First, it is easily collected and monitored. Second, villagers retain control of land management decisions. Third, a value-added tax should not disrupt informal tenure arrangement in the villages. If a marginal land-use tax were imposed instead, large landholders might just repossess, and then leave fallow, land that had been previously lent to land-poor compounds. If this were the case, the land-poor compounds would bear the entire burden of increased land conservation. A value-added tax is also regressive due to the fact that large producers and small producers face the same percentage charge, but this could be avoided by devising a tax schedule dependant on total production. Fourth, this tax would be applicable to every land manager in the compound, not just the compound head.

In this experiment, a tax of 20 per cent is applied to peanut production. The price elasticity of hectareage of peanut production in the Basin is calculated at approximately .4 (Behgin 1987). This means that the hectareage response to a 1 per cent change in producer price is calculated at approximately .4 per cent. A tax of 20 per cent would lead to a change in hectareage of 8 per cent. Calculated at this elasticity, peanut production in Keur Marie would fall by 2.24 hectares to a new total of 28 hectares, and in Keur Magaye,

8.44 hectares would be taken out of peanut production for a new total of 105.5 hectares.³ Average peanut production in Keur Marie is calculated at approximately 870 kilos per hectare so that post-tax production amounts would equal 22,183 kilos. Multiplying by 80 CFA⁴ (price per kilo inclusive of the tax) gives a new exogenous peanut revenue of 1,774,640 CFA for Keur Marie, a net difference of -638,573 CFA. In Keur Magaye, average peanut production is calculated at approximately 1,100 kilos per hectare, meaning that post-tax production would equal 106,880 kilos. Multiplying by 80 CFA gives a new exogenous peanut revenue of 8,550,400 CFA for Keur Magaye, a net difference of -3,066,096 CFA.

The impact that these changes in peanut revenue will have on the village economies can be calculated with the relevant multiplier derived from the SAM of each village. For changes in exogenous peanut revenue, the overall multiplier for compound income is 1.5 for Keur Marie and 1.2 for Keur Magaye.

The multiplier for the whole economy is 5.0 for Keur Marie and 3.9 for Keur Magaye. Percentage and absolute changes in compound income due to this decrease are shown in row 1 of Table 6. Row 2 and 3 relate to findings of policies to be discussed below.

Reduce Government Peanut Seed Allocation Programme

Another way to restrict peanut production, at least in the medium run would be to reduce the government credit programme for peanut seed. At the time of the study, there was very little private supply of peanut seed in Senegal implying that the government effectively had the ability (at least in the short run) to regulate peanut production through regulation of peanut seed supply. This hypothesis is supported by the observation that farmers in the two sample villages stated that the primary constraint to expanded production was the lack of peanut seed. Not only are private traders failing to fill the gap left by the government programme, but they are also unable to offer the low credit terms inherent in the programme. The government programme distributes seed at the beginning of the season and seeks reimbursement at harvest time. The subsidy represented by this programme is reinforced by the fact that peanut seed debt has often been written off by the government. In the following experiment it is assumed that if peanut seed supply were constrained, peanut production in both villages would decrease.

³ For the relatively poor farmers in the sample villages, the hectareage elasticity could be much lower due to a lack of alternatives to peanut cultivation. It is conceivable that the hectareage response could approach zero and that the only impact of the tax would be a reduction in rural income.

⁴ At the time of the study, 1,000 CFA were equal to over 3 US dollars. CFA is the abbreviation of *Communauté Financière Africaine*.

Table 6
Income Effects of (a) a Tax on Peanut Production, (b) a Cut in Seed Subsidy, (c) Migration

	Keur Marie			Keur Magaye		
	Large	Medium	Small	Large	Medium	Small
Number of Compounds	6	9	7	8	9	9
Ave. People per Compound	17	11	7	14	10	9
Base Income ¹ per Compound	2,342	955	406	2,889	1,650	1,062
Base Income per Capita	138	87	58	206	165	118
1. Tax on Peanut Production						
Income Change	-196	-140	-65	-656	-388	-252
Percentage Change	-8%	-15%	-16%	-23%	-23%	-24%
2. Cut Peanut Seed Subsidy						
Income Change	-588	-421	-195	-612	-362	-235
Percentage Change	-25%	-44%	-48%	-21%	-22%	-22%
3. Migration Experiments						
Income Change	+140	+126	+108	+116	+111	+104
Percentage Change	+6%	+13%	+26%	+4%	+7%	+10%

¹ In 1987 dollars, converted from CFA at a rate of 333 CFA per dollar.

For this experiment, peanut seed supply to each village is cut by enough to theoretically reduce each compound's peanut cultivation by one hectare. In Keur Marie, the 22 compounds would contract peanut production by 22 hectares and experience a decrease in peanut income of 1,914,000 CFA. The 26 compounds in Keur Magaye would contract peanut production by 26 hectares and suffer a decrease in peanut income of 2,860,000 CFA. The absolute and percentage effects on compound income for both villages is shown in row 2 in Table 6.

Social and Environmental Impacts

In the two experiments conducted above, it was assumed that farmers in the Basin are over-utilising the environment through the production of peanuts. The question is, if additional pressure is applied via the peanut production tax or the peanut seed cut (in addition to the pressure already imposed by an increasingly hostile environment), what type of modification in the farming system will transpire. The tax and subsidy cut should succeed in removing land from peanut cultivation, but will they also result in the adoption of an environmentally sustainable agriculture? In order to address this question, the probable response of the rural community to the tax and seed programme reduction must be analyzed.

Given the fact that to date there are no viable technological alternatives for the region, the response of the rural community to the tax and seed cut described above will most likely be diversification and migration. The added pressure placed on the system via the tax and seed cut are not likely to persuade farmers to consider new technologies or crops, because few alternatives exist at present. Nor, due to the lack of markets, would farmers expand millet production. The probable result of these policy changes would instead be a shift away from agricultural production. In addition there would probably be a shift in cultivation patterns and income distribution within individual compounds.

In fact, diversification and redistribution are what has been observed from the Peanut Basin data. In the village of Keur Marie, a number of factors have combined to put additional stress on the agricultural system. First, the higher population density and longer cultivation of the Keur Marie area seem to have resulted in greater soil degradation than in Keur Magaye. This hypothesis is supported by the fact that the land value-added calculations for Keur Marie are lower than those for Keur Magaye.

Second, due to both greater population pressure, and greater application of the Law of National Domain, the farmers in Keur Marie are less secure in their land holdings than those in Keur Magaye [Golan, 1990]. Third, because of the structure of the government cooperative in Keur Marie, farmers in that village section are less secure in their continued access to government supplied peanut seeds [Golan, 1990].

Contrary to predictions [Boserup (1965), Pingali et al.(1987)], the technological response to these stresses has been none. It had been hypothesised that in response to population growth coupled with land degradation, compounds might adopt technological changes like the introduction of manuring, better seed or chemical pesticide; or, compounds might respond with institutional changes such as consolidating tenure rights, reducing hired labour, and increasing migration from the village [Adelman et al. (1990)].

Of these hypothesised responses though, it appears that only the institutional changes are beginning to take place in the Peanut Basin sample.

Examination of the farming practices in the two villages reveals that there are no differences in capital improvements in the land, agricultural innovation, or fallow and rotation schedules. Neither village has undertaken aggressive measures to prevent soil degradation. Very few improvements have been made to land in either village (no bunding, contour planting, etc.), and fallow land is not being managed. For the most part, rotation schedules are adhered to but, as we will see, a few cases of disregard for this simple, inexpensive soil-saving technology have been observed. Tables 7-9 below give details on land stewardship.

Table 7
Land Improvements

	Keur Marie	Keur Magaye
No Improvements	75	133
Trees	66	70
Fences	8	14
Pasturage	2	1
Manure	0	1
Wells	8	0
No Response	0	3
Total number of parcels	138	213

Note: No borrowed parcels are included.

The most common type of improvement made in both villages is tree planting. Yet, the real investment in land maintenance found in this respect is probably inflated as scrubby bushes were often defined as trees. The fences in both villages were primarily found around the small fields of vegetables, melon and manioc. The wells in Keur Marie provide water for the vegetable and melon fields. No wells were found in Keur Magaye because the water table is too low. The information presented in Table 3 (page 12) corresponds to 80 fields with one or more improvements in Keur Magaye and 63 fields with one or more improvements in Keur Marie. This translates to 38 per cent of Keur Magaye's 213 parcels and 46 per cent of Keur Marie's 138 parcels. The quality and quantity of land improvements in both villages is disappointing.

Fallow land is also not being actively managed for soil conservation. What emerges from the Peanut Basin study is almost invariably that compounds had more land in fallow than they would have preferred and aside from deciding which parcels to leave fallow, very little strategy went into determining the amount of fallow; i.e., compounds simply left land in fallow due to one or more resource constraints. Out of the 108 parcels that

were left fallow in the two village sections, 76 were fallow due to lack of seeds or labour, 6 because they were too far from the compound or were of exceptionally low quality (insect holes or perpetually harassed by animals) and 2 had no response given. Only 24 of the 108 were left fallow "in order to give the land a rest". The percentage of land left fallow for productive reasons is almost exactly the same for the two villages, 23 per cent for Keur Marie and 22 per cent for Keur Magaye. The table of responses by village is presented below in Table 8.

Table 8
Reasons for Leaving Parcel Fallow

	Keur Marie	%	Keur Magaye	%
Lack of Peanut Seed	22	65	49	52
Lack of Seeds Other Than Peanut	0	0	2	2
Lack of Labour	1	3	2	2
Give Land a Rest	8	23	16	17
Too Far From Compound	0	0	1	1
Poor Quality Land (Insect Holes etc.)	1	3	23	24
No Response	2	6	2	2
Total Number of parcels	34		74	

What becomes evident through the responses regarding fallow land is that overriding any other constraint to efficient land management - such as tenure insecurity or labour shortages or other input shortages - is the inability of farmers in the Basin to acquire enough peanut seed. Because the quality of peanut seed stock cannot be maintained with a farmer's own reserves, farmers are dependant on the government or traders for their supply of peanut seed. Prior to and including the 1985-86 season, the amount of government supplied peanut seed was being curtailed, and private traders had not yet taken up the slack. As seen from the responses above, the ability of a farmer to acquire this scarce input was the primary factor in determining how much land was left fallow.

Tables 9a and 9b present statistics on rotation schedules. For the most part, an every-other-year rotation schedule between peanuts and millet is closely maintained throughout the sample area. Farmers recognise the benefits to soil quality and hence to productivity. As most compounds within the sample do have enough parcels to rotate them between millet and peanuts, the decision not to rotate is surprising. Table 9a shows the number of fields that were left in peanuts or millet for three years in a row, and Table 9b, those fields that were planted in peanuts or millet for two years. Data were collected for the three year period from 1984 through 1986. The sample size is 103 fields for Keur Marie and 151 fields for Keur Magaye.

Table 9a
No Rotation for Three Years

	Keur Marie	% of Fields	Keur Magaye	% of Fields
Peanuts	1	1	0	0
Millet	2	2	11	7

Table 9b
No Rotation for Two Years

	Keur Marie	% of Fields	Keur Magaye	% of Fields
Peanuts	2	2	2	1
Millet	12	12	8	5

It does appear that on average, farmers in Keur Marie are not as meticulous about following rotation schedules as those in Keur Magaye. In particular, they are more likely to designate a field as the compound's millet field and cultivate millet there for sequential years.

Contrary to the lack of evidence concerning technical responses to population pressure and soil degradation, there is evidence to support the hypothesis that compounds in Keur Marie are making institutional changes. In response to population pressure and related stress on the environment and the tenure system, the villagers in the more populated village of Keur Marie have begun to express strong reservations about lending land outside of the compound, and labour-use patterns in the two villages seem to be diverging. Particularly important is that remittance, salary and extra-agricultural income play a much more important role in Keur Marie than in Keur Magaye. The 22 compounds in Keur Marie earned 2,669,520 CFA (31 per cent of income) from remittances or salaries originating in "Other Senegal" while the 26 compounds in Keur Magaye earned only 539,300 (3 per cent of income) from the same sources. These numbers are not quite as significant as they appear because a large portion, 1,800,000 CFA, of the amount earned by Keur Marie households was in fact earned by one compound head who worked as a trained bookkeeper in Kaolack. Nonetheless, even if his salary is excluded from the total, remittance and salary income in Keur Marie was still 869,520 CFA, or 10 per cent of total income as compared to 3 per cent in Keur Magaye. As for village based extra-agricultural activities, in Keur Marie 818,000 CFA of compound income (or 10 per cent) was gained through service or commerce activities while in Keur Magaye this number is 817,725 CFA (5 per cent of total income). Income diversification is one possible reaction to a diminished resource base and dwindling agricultural income, and it appears this reaction is taken up by the farmers in Keur Marie.

Intra-compound redistributive responses to the added pressure in Keur Marie also seems to be occurring. The amount of land allocated to insecure managers (who possess

merely the right of access to land) is much lower in Keur Marie (10 per cent of village land) than in Keur Magaye (32 per cent of village land). It appears that these insecure managers must also contend themselves with the smallest tenurial bundles. In difficult times, for example when compound land becomes scarce or peanut seed becomes difficult to acquire, insecure managers, the majority of which are women, are usually the first to lose their access to land and seeds. If the compound is poor, women are usually the poorest members; if the compound is rich, women are usually allowed access to money making projects, notably the growing of peanuts.

It is hypothesised that the probable response of the village communities to the additional pressure of a tax on peanut production or a cut in peanut seed supply, will be similar to that observed in the sample data. Because farmers in the Peanut Basin would be constrained in their reactions to the tax or subsidy cut by the lack of technological options, their reaction will probably be to diversify and reduce the agricultural work force. If opportunities are created in the urban centres or in the rural areas themselves, the results of the forced migration and diversification, as spurred by the tax and peanut seed cut, need not be impoverishment of the rural populations. But, with no alternative income-generating options, the cost of conservation will be a substantial reductions in compound employment and income. For Keur Marie, a 16 per cent decrease in income is forecast as a result of the value-added tax. This would bring their per capita income down to \$49 a year. Likewise, in the absence of replacement employment and income, a 48 per cent drop in income (to \$30) is predicted for the small farmers in Keur Magaye as a result of the cut in peanut seed supply.

An over-all reduction in employment and income is expected to involve a redistribution of intra-compound income; women and other insecure managers being the first to lose access to agricultural income opportunities. Wives and lesser compound members' access to sustenance, shelter, clothing, and income is always difficult to specify and safeguard. Nevertheless, it should not be overlooked that with the two policies examined above, particularly with the reduction in peanut seed allocation, the economic well-being of insecure managers could be doubly threatened.

The environmental improvement purchased by the tax and subsidy cut would probably be small in the short to medium term. Particularly any change in the albedo effect will be slow to materialise. In addition, though the tax results in a maximum reduction in peanut production of 2.24 hectares in Keur Marie and 8.44 hectares in Keur Magaye, and the seed cut in a reduction of 22 hectares in Keur Marie and 26 hectares in Keur Magaye, the environmental benefits might only be partially realised due to the fact that migration and diversification will be the probable response of the rural community. Stress on the environment will be reduced through curtailing peanut production, but this reduction will not be accompanied by ecology minded up-keep of the land. There is evidence that the regeneration process in the Sahel will not occur without active human assistance [Gitzner (1988)]. It will not be enough to abandon the land to natural forces. In this case, any policy which leads to rural out-migration would not necessarily lead to a slowing of the desertification process. A reduction in cultivation would need to be reinforced by conservation measures in order to be environmentally beneficial.

Even where difficulties of irreversibility and causation are overcome, and measurements linking farming intensity and soil degradation are pursued, these measurements are nevertheless of questionable value when analyzing a reduction in agricultural activity. For the Peanut Basin, the differences in population densities and cultivated number of hectares per person in the two sample villages suggest that the farming intensity in the two villages might be different [Pingali 1987]. Calculation of input use per hectare, output per hectare, and the value of land services further suggest that this intensification has resulted in soil degradation. Input and output calculations for peanuts and millet are given in Table 10a and Table 10b. The value of land services per hectare is given in Table 11 where the figures are disaggregated by field type.

Table 10a
Input-Output Calculations for Peanut Cultivation

	Keur Marie	Keur Magaye
Hectares	33.7704	106.9873
Output per Hectare (kilos)	871	1,183
Seed use per Hectare (CFA)	167	193
Pesticide use per Hectare (CFA)	209	297
Fertilizer use per Hectare (CFA)	88	448
Animal use per Hectare (CFA)	6,470	3,505
Labour Days per Hectare	36	26
Output per Labour Day (kilos)	24	45

Table 10b
Input-Output Calculations for Millet Cultivation

	Keur Marie	Keur Magaye
Hectares	83.1033	92.3788
Output per Hectare (kilos)	343	348
Seed use per Hectare (CFA)	3.2	3.6
Pesticide use per Hectare (CFA)	1.5	41.4
Fertilizer use per Hectare (CFA)	0	454
Animal use per Hectare (CFA)	2,623	2,024
Labour Days per Hectare	26	21
Output per Labour Day (kilos)*	13	16

* The millet output in both villages, but particularly Keur Magaye, was inordinately low due to locust.

Table 11
Value of Land Services per Hectare (Residual Calculations)

	Secure Fields	Mod. Sec.	Insecure	Borrowed	All Field Ave
Keur Marie	25,880	33,558	70,85	22,719	27,913
Keur Magaye	54,598	65,401	56,023	56,743	56,404

The tables above map out a process of intensification similar to the one hypothesised by Boserup (1965). Intensification in the highly populated area of Keur Marie has resulted in greater labour use per hectare and a lower productivity of labour. But, contrary to predictions [Boserup (1965), Berry and Cline (1979), Pingali et al. (1987)], this has not translated into higher productivity per hectare. It can be argued that the process of degradation is at such a stage that even high levels of land preparation, weeding, etc. cannot compensate for the loss in soil quality. Before making this claim though, the figures on fertilizer, pesticide, and seed use must be examined. At first glance it appears that the much greater use of fertilizer in Keur Magaye could account for the difference in productivity. But, examination of the primary data reveals that the large fertilizer numbers for Keur Magaye were generated by a "gift" of fertilizer made to the village chief. The bulk of the 90,000 CFA worth of fertilizer used in Keur Magaye was expended on three fields (two peanut, one millet), and probably could not have skewed productivity results to the extent exhibited above. Pesticide use in Keur Magaye was also higher than that in Keur Marie. This result is explained by two observations. First, the insect problem is greater in Keur Magaye than in Keur Marie. This means that for the same amount of protection more pesticide would have to be used in Keur Magaye. Second, the government cooperative responsible for pesticide distribution is weaker in Keur Marie than in Keur Magaye. It could be that the managers of the Keur Marie cooperative were unable to secure enough pesticide for their members. The weakness and inability of the government cooperative to secure enough peanut seed could also help explain the lower seed ratio in Keur Marie. Again though, the difference in pesticide and seed use in the two villages is probably not significant enough to translate into such a marked difference in productivity. The difference of 88 CFA in pesticide use corresponds to a difference of 35 grams per hectare, and the difference in seed use of 26 CFA corresponds to about 100 grams of shelled peanuts per hectare.

If, given the evidence, the case can be made that intensification in Keur Marie has resulted in soil degradation, the usefulness of such a statement is still nebulous. It has been suggested in the literature that the elasticity of farming intensity on soil degradation is approximately .38 [Adelman et al. (1990)]. Rough calculations using the peanut cultivation data collected from the two sample villages (millet harvest amounts are not useful due to locust) suggests that in the Peanut Basin this number could be as high as .49. But, even if the data is stretched to this conclusion, the applicability of such a calculation is questionable. In giving up 19 per cent of their income, farmers will not be repaid with a 49 per cent increase in productivity. Nor will the country. Eventually, considering questions of irreversibility, environmental forces in the area might regenerate themselves to the extent that a 49 per cent increase in productivity could be achieved, but the

condition for such an increase is that the land is left uncultivated. Without an alternative agricultural technique which could capture the increased productivity of the soil, the benefits of environmental regeneration would need to be measured in terms of existence value, option value, or discounted possible future use.

The need for diversification out of agriculture is evidenced by the social and economic cost that intensification of the farming system and soil degradation is imposing on the farmers of the Sahel. In addition to reducing peanut cultivation, the probable result of a tax on agriculture will be to speed up the process of diversification out of agriculture. If the government has established the infrastructure to absorb agricultural labour then the result of taxation need not be a reduction in the rural population's income. Without diversification opportunities though, the result of taxation will be further impoverishment of the rural poor and a shift in intra-compound income.

Migration

In the next set of experiments, it is assumed that opportunities are available for rural labour outside of agriculture. This assumption permits an investigation of the effects of increased migration on the village economies. Many experts on desertification in the Sahel recommend regional diversification and migration (both national and international) as a necessary step in combatting soil degradation and income erosion (Perrings, 1991).

Migration of Two Compound Members

As a first step in the migration experiment, it is assumed that two people from each compound migrate to Dakar. This number was chosen because on average there are two single or childless adults attached to each compound. With 300 work days calculated at the agricultural salary of 500 CFA per day, these migrants would each make 150,000 CFA a year. If they remit 10 per cent (remember that they are marginal compound members), the increase in remittance income to each compound would be 30,000 CFA or \$90.00. Reading from the SAM model, the overall multipliers for increased exogenous income to each compound group are presented in the Table 12 below.

Table 12
Overall Multipliers for an Injection of Exogenous Income

	Keur Marie	Keur Magaye
Large Compounds	2.8	2.0
Medium Compounds	3.6	2.7
Small Compounds	5.2	2.2

Reading the first entry, the boost to the village economy of an increase in exogenous large compound income in Keur Marie is 2.8 times greater than the original injection. In

Keur Marie, an exogenous transfer to small compounds has 53 per cent more impact on the village economy than a comparable transfer to large compounds, while in Keur Magaye, medium-sized compounds have the largest overall multiplier. As is shown in Table 13 below, the same ranking holds for the multipliers for compound income.

Table 13
Compound Income Multipliers for Injections of Exogenous Income

	Keur Marie	Keur Magaye
Large Compounds	1.6	1.3
Medium Compounds	1.8	1.5
Small Compounds	2.3	1.3

In both villages and for every compound size, village production (and hence consumption in these villages) of millet has the largest multipliers. As millet is currently the largest village-produced consumption good, it is not surprising that the SAM model predicts that increased income will translate into higher consumption and production of this good. This problem arises because the SAM imposes unitary income elasticity. As millet is not exported by either village in substantial amounts, it is not reasonable to expect that as compounds in the village get richer, a ceiling on millet production and consumption would not be reached. Compounds would not be interested in growing and consuming ever-increasing amounts of millet. In order to correct for this difficulty, marginal millet consumption values (estimated), as opposed to average consumption values were inserted in the normalised SAMs and new multiplier matrices were calculated. In calculating the new multipliers, it was assumed that larger percentages of new compound income were used for purchases at the weekly market or in Kaolack. The new compound income multipliers for injections of exogenous income are shown in Table 14.

Table 14
New Compound Income Multipliers for Injections of Exogenous Income

	Keur Marie	Keur Magaye
Large Compounds	1.2	1.2
Medium Compounds	1.3	1.3
Small Compounds	1.5	1.2

The lower numbers in Table 14, when compared to Table 13, reflect the fact that in the recalculated model, as income grows and millet consumption needs are met, increasing amounts of income are channelled into consumables which are purchased outside of the village. The net effect of the increase in remittance income on compound income is shown in row 3 in Table 6 (page 17).

In the first step of the migration experiment, it is assumed that neither millet nor peanut hectareage is reduced. Compounds typically strive to supply migrants with the staple crop (if at all possible), meaning that millet production would not fall. In addition, because labour is not a constraint to peanut production (see discussion of fallow land), it is assumed that, with no change in the supply of peanut seed, peanut production would not fall in response to the migration of two compound members. Instead, the compounds would just increase or reallocate compound labour (or village or imported labour) to any peanut fields that the migrants might have vacated. With this scenario, the net impact of migration would be a reduction in the number of labourers per hectare, thereby further reducing the possibility of labour being expended on intensive agricultural procedures like weeding, manuring, bunding, etc. Environmentally speaking, the net result of the first step of the migration experiment would probably not be positive.

Further Migration and Reduction of Peanut Cultivation

In the next step of the migration experiment, two more adults migrate from the compound to the capital city of Dakar. This time, each migrant remits 43 per cent of his income to the compound. This means that each compound experiences an increase of 130,000 CFA in remittance income. By now though, it must be assumed that some kind of labour constraint is being reached and that compounds must begin decreasing peanut production. For this stage of the experiment, each compound reduces peanut production by one hectare.⁵ The net impact of this reduction plus the increase in remittance income is exactly the same as the first stage of the migration experiment as shown in row 3 in Table 6. In this case, each compound was forced to reduce peanut production by one hectare. This is unlike the case where total village peanut revenue was restricted and individual compound response was determined by the model. For this reason, the peanut revenue reduction was forced through on a per compound basis. The slight adjustments in inter-compound labour and animal exchanges, which would be expected in response to decreased peanut cultivation, are lost in this process.

Even though land is taken out of peanut production, the net effect of further migration on the environment might still be negative. Not only are there fewer labourers per hectare, but the production system is gravitating towards a mono-crop system. Millet is becoming the single major crop, thus reducing the possibilities for crop rotation. Successful rotation between millet and fallow is extremely labour-intensive, requiring the clearing of overgrown fallow fields on a regular basis. In addition, in areas like the Peanut Basin, where usufruct rights are established only if land has been *mise en valeur*, extensive fallow periods could lead to compound land being repossessed and reallocated by the regional council. Repossession is particularly worrying if compound population is decreasing as in the migration experiments. A logical consequence of this fact would be extensively but sparsely planted millet fields. Land would be *mise en valeur* as evidenced by the millet crop, and hence tenure rights would be secured. Accordingly, the net effects of migration and tenure insecurity could prove harmful to the environment.

⁵ Per hectare peanut production has been averaged at 1,000 kilos for this experiment.

Moreover, the social cost of the continued migration could prove very high. If two more adults leave each compound, single parent households (probably headed by women) would be the result. This is a scenario which has been played out in many regions of Africa. The men migrate to job opportunities sometimes hundreds of miles from home, and the women and children remain behind. The increased income generated by the men is vital to the household, and the homestead cannot be abandoned, nor can the staple crop that it produces.

Note that the experiments conducted above have tacitly assumed a zero or very small rate of population growth. With a high population growth rate, the rate of out-migration would have to be even higher to result in reduced cultivation levels.

Regional Development

Regional development which leads to the employment of compound members at a nearby regional centre, such as Kaolack in the Peanut Basin, would lead to the same results as detailed in the migration experiment except that the social costs would not be as high. Nuclear families would not be broken if compound members could commute to regional jobs. In addition, the "weekend" hours of commuters could be expended in land maintenance projects such as weeding, bunding, manuring, etc., thereby supplying the possibility that regional development, as opposed to migration, could be made environment-friendly.

Reforestation

The establishment or reestablishment of tree stands, shelter belts and forest cover throughout the Sahel is essential for retardation of the desertification process [Gitzner (1988), Stiles (1988)]. As of 1985, 15 of the 20 anti-desertification programmes operating in Senegal involved reforestation or were related to agro-forestry. Meanwhile, there continues to be a serious lack of fuel wood and building materials in the Peanut Basin and other densely populated areas [UNEP (1985)]. The results of plantation schemes have often proved disappointing and further examination of the policy tools used to encourage tree cultivation is warranted.

Subsidies on Tree Planting

The complexity of the compound farming system suggests that the targeting of subsidies could prove a difficult task. The compound incentive structure is often splintered and rarely obvious. Inattention to the incentives of individual classes of land managers could serve to dampen the usefulness of subsidies for conservation. For example, suppose that tree planting is found not only to reduce wind erosion and runoff, but also to increase yields within ten years of construction. Further, suppose that the government grants a subsidy on seedlings to all compounds in the Peanut Basin. Even then there is reason to suspect that the incentive structure of the compound is such that tree planting may not be adopted on many compound fields.

The rationale for adopting the planting of trees is that the costs of planting and maintenance are outweighed by the benefits. But if the distribution of costs and benefits is splintered, so that decision makers share unequally, efficient investment might not be made. In the Peanut Basin, where land is habitually rotated between millet and peanuts, many land managers cultivate different fields each year and are often unsure as to which fields they will cultivate from year to year. Those field managers with insecure or moderately secure tenure rights, who tend to work a different field every year, could have little incentive other than to get the most peanuts out of the land during the year that they manage it. This could particularly be the case of a peanut field that is passed from one wife to the next in successive years. Even where a strict rotation between millet and peanuts is maintained, the incentives of the compound head as millet overseer to make improvements in the land could be diminished by knowing that, in the off-years, a nephew or wife will be using the field for personal peanut cultivation.⁶

It seems, land managers disregard not only the cost of inefficient land management to society in general, but they also disregard the cost of inefficient land use on their fellow compound members. If this is the case then even a full subsidy on seedlings might be insufficient to convince an insecure field manager to adopt the technology since labour requirements alone might dissuade him or her from planting trees [Monimart (1989) also raises this point].

We estimated that 71 per cent of village land in Keur Marie and 55 per cent of village land in Keur Magaye was managed by secure field managers. This essentially means that management practices on at least 29 per cent of the land in Keur Marie and 45 per cent of the land in Keur Magaye is unsusceptible to change via subsidies, whether they be subsidies on seedling, walling material, contouring equipment, etc. The same could be said for taxes if there is any dichotomy between the payer of the tax (usually the compound head), and the actual land manager and if taxes were not, or not easily, passed on. It could be that due to the complexity of the compound system, a large percentage of land managers in the Sahel are impervious to many fiscal policy instruments.

Usufruct Reform

With the 1964 Law of National Domain, close to 98 per cent of all the agricultural land in Senegal became national property. Farmers retain usufruct rights to land as long as they actively cultivate it, i.e., if the land is *mise en valeur*. If, as a policy to encourage tree cultivation, the status of *mise en valeur* were explicitly changed to include the cultivation of specific soil-saving tree species, farmers seeking to solidify their tenure rights would have every incentive to plant trees in fallow fields or even interspersed in

⁶ A more idealistic scenario could be envisioned in which compound members identify strongly with one another and with the compound so that the costs and benefits of land are essentially distributed equally throughout the group. In this case, even the most insecure managers would have incentive to maintain the soil quality of the land and make improvements in the land where possible. Even if they did not directly reap all of the benefits of such care to the land, they would know that someone whose well-being they valued would benefit. However, this scenario does not appear to be borne out by the facts on land improvement.

cultivated fields. In many traditions, tree planting is a symbol of ownership [(Bruce and Fortmann (1985)]. Recognition of this fact by the legal system, though not a difficult or costly policy change, could well result in extensive tree planting.

As evidenced through discussions with the farmers in Keur Marie (the more populated of the two sample villages), the introduction of the Law of National Domain has added an element of insecurity to the traditional tenure system. Farmers in this village are nervous about lending land outside of the compound for fear of permanent reallocation through the Law of National Domain. These farmers are looking for opportunities to consolidate their rights over land. In areas with laws similar to Senegal's Law of National Domain, where land registration is not an option, tree planting represents one concrete method of establishing ownership, or at least usufruct rights. If trees such as *Acacia Senegal*, *Acacia mellifera*, *Commiphora myrrha*, and others, were planted, tenure security could be accomplished plus additional income gained from gum or oil extraction, or fruit, nut or bark collection.

By encouraging tree cultivation via land-tenure laws, difficulties anticipated with other policies due to the splintered incentive structure of the compound might be avoided. In order to retain control of compound land, the compound head would have strong incentive to see that trees were planted on compound land. Other compound members would likewise have an incentive to help retain compound lands. Furthermore, if root rights could be established (along similar lines as found in some coffee producing areas), then the benefits of harvest (gums, nuts, fruits, barks, leaves) could be consolidated in the actual planter of the tree. This would also encourage the cultivation of trees.

Land Tenure Reform

Much of the literature on desertification in the Sahel pays attention to the issue of property rights and efficient land or resource use. Three reasons are given to support the argument that if resource rights could be firmly established and then registered, resource use would become more efficient. First, it is hypothesised that individualised, registered rights have the property of securely internalising in a single user the costs and benefits of resource use. Efficient resource management is the result.

Second, individualised resource ownership can transform a resource into a commodity, and where resources have been commoditised, allocative efficiency will result. The bidder willing to pay the highest price is assumed to put the land to its highest valued use.

Third, private ownership of land (or possibly any resource) could entail mortgage rights, thus permitting farmers to acquire credit, which otherwise might be impossible to secure. Theory states that when land can be mortgaged, credit will result in productive improvements in the land and greater use of purchased inputs, the net result being higher long-run yields.

For these reasons, many theorists advocate the privatisation of resource rights. Nonetheless, the evidence examined suggests caution in advocating and justifying the expense of any land or resource registration scheme. To date, land-tenure studies conducted in Africa [IBRID (1989)], including the study from the Peanut Basin [Golan (1990)], suggest that the benefits accredited to private registered land ownership as contrasted to traditional ownership have yet to manifest themselves. It appears that other constraints to efficient land management (environmental, infrastructure, markets, etc.) are currently more binding than possible constraints that traditional tenure might pose.

In addition, due to the complexity of the compound system, caution must be exercised in devising a land or resource privatisation scheme. Just as land tenure rights can be depicted as sticks in a bundle, so can rights over any resource. And though the compound head is usually accorded the majority of rights, his rights are nevertheless conditioned and constrained by the rights possessed by other compound members. The mere existence of all of the land managers in a compound is an important factor when contemplating any change in resource rights.

To use land tenure as an example, if an individualised tenure system is contemplated, the question immediately arises: under whose name should the compound land be registered? The most obvious choice is the compound head; his is the name that appears on all administrative lists, from village to cooperative. But, if all compound land is registered in the compound head's name, the primary logic for registration breaks down. The compound head becomes more secure in his control over compound land, but the other field managers are dispossessed of their tenurial rights. The hypothesised link between tenure security and efficient resource management is broken. The compound head would be vested with the legal authority to sell, rent or mortgage land, and the tenurial status of the other compound members would become very insecure. For example, in Senegal, in 5 of the 11 cases of registered land, the land was repossessed or is in court because of failure to reimburse mortgage loans. In these cases, registration clearly presents a threat to the tenure rights of wives, brothers, sons, etc. Managers who once had secure rights of access to particular fields would lose that security. Even those managers with the general right of access to land would lose their small bundle of tenurial rights. This corresponds to 85 fields that would be less efficiently managed as a result of registration in the name of the compound head.

Another registration option would be to register land in the name of the manager with the most secure rights to that particular piece of land. This would amount to compound heads, and dependent and independent household heads having their traditional rights of access to a field legally recognised. Again, wives and younger compound members would not be legally insured continued right of access to land and their incentive structure would thus be weakened. In addition, this detailed registration strategy would pose a number of difficulties. Three of them are listed here.

First, the bureaucratic machinery needed to handle the complicated registration of not just compound heads but other compound members as well, may prove difficult to maintain. The Senegalese bureaucracy is still processing registration claims that were filed in the two-year grace period granted by the 1964 National Domain Law. The number of

requests for registration was staggering, almost 13,000, but many of these had already had cadastral surveys, and twenty-four years is a long time.

Second, within the compound, the distinction of where one member's tenurial bundle stops and another's begins, is often vague. The legal and social battles that could result from a registration effort could be overwhelming. Registration schemes offer a potential of triggering violent boundary disputes between neighbours and a major source of friction within and between compounds.

Third, to date, Senegal has not experienced land fragmentation problems like those experienced in some countries of East Africa. In Senegal, land that remains within the compound can be aggregately managed. Fields can be joined together to support overlapping crops, or fields can be redistributed among field managers to achieve proper crop rotation. Though tenure bundles are individualised within the compound, land use strategies can be organised at the compound level. Private registration could weaken the compound structure and result in a greater degree of land fragmentation.

VI Conclusions

The paucity of technical packages that would allow for the continuation of agriculture in the Sahel while at the same time reversing or at least arresting the desertification process, has led many experts to conclude that migration and regional diversification are necessary steps to combat soil degradation and income erosion in the Sahel. Even policy which provides incentives for agricultural change would probably result in migration and diversification out of agriculture. Due to the lack of viable agricultural alternatives, it was shown that a tax on peanut production or a cut in the peanut seed supply would probably serve as catalysts to the process of diversification. But, whether pushed via taxes on agriculture, or pulled via government schemes to absorb agricultural labour, reduced cultivation caused by migration and diversification need not lead to improvements in the environment unless it is accompanied by agro-forestry innovations or other conservation projects. Reductions in the agricultural labour force could actually reduce the possibility for labour-intensive soil conservation (weeding, land preparation, contouring, walling, intercropping, etc.), increase the possibility for millet mono-cropping, and increase land tenure insecurity due to current usufruct laws. Without complimentary conservation programmes, it was concluded that a tax on peanut production and a reduction in the peanut seed subsidy, would have minimal environmental benefit, but significant social impact. Without extra-agricultural opportunities, the result of the tax and seed cut would be further impoverishment of the rural poor, and a shift in intra-compound income distribution. With migration and diversification opportunities, the fall in rural income caused by reduced peanut cultivation could be compensated for, but if migration is pursued, the cost to the family structure could be high.

It was also demonstrated that efforts to establish complementary conservation practices and foster active participation of the rural community, are complicated by the complexity of the compound farming system. Because of the diversity in the security of

the position of field managers in the compound and the possible splintering of incentive structures, subsidies on conservation projects such as tree planting, walling, contouring etc., could be dampened by as much as 45 per cent. For this reason, subsidies and taxes must be tailored to the incentives of the individual field managers for maximum success. As an alternative, it may prove more effective to encourage tree cultivation (or other conservation practices) through changes in the current usufruct laws.

The final policy examined concerns the individualisation of tenure. Evidence drawn from this study and elsewhere suggests that the benefits accredited to private registered land ownership, as contrasted to traditional ownership, have yet to manifest themselves. It appears that environmental, infrastructural and market constraints to efficient land management are currently more binding than the constraints that traditional tenure might pose.

The above findings require further qualification. A difficulty with the taxation of peanut production or seed use, lies in the mismatch between lever and effect. The environmental predicament addressed by the tax is soil depletion, which is the effect of peanut cropping. Ideally, therefore, it is soil depletion that wants taxing and not the production giving rise to the depletion. The problem is akin to taxing fuel with the aim of diminishing air pollution. Practical considerations concerning the collection of the tax, in these cases, outweigh the theoretical desirability of levying the tax on its target instead of a proxy. However, a price has to be paid for adopting the tax solution that appears the more practical. Peanut cropping is not the exclusive cause of soil depletion. Nor are all methods of peanut farming equally depleting. Furthermore, the direction of technological innovation prompted by an environment-related tax, is distorted by the use of a proxy. Unfortunately, this last point is lost given the short-run (comparative static) nature of the Social Accounting Model employed.

The short-run (comparative static) orientation of the SAM approach and its focus at the micro level, calls for a final observation. This approach neglects a dynamic (historic) and macro perspective on soil conservation and the process of desertification. Nonetheless, macro-dynamic factors such as population growth and low levels of economic development play a crucial role in the failing relationship between environment and economy in the Sahel. Rapid population growth has put great pressures on the fragile land. Poverty, in turn, is hindering technological relief from these pressures while permitting patterns of exploitation of the land that are subject to increasingly short time horizons. To make matters worse, the record shows a strong positive correlation between the rate of population growth and poverty, thus making for a vicious cycle. To break this cycle, will require policies of a wider focus in addition to those discussed in the micro context of this paper.

Appendix 1 - Outline of the Social Accounting Model (SAM)

A SAM, is a concise framework with which to present the economic activity of a village, region or country. In a single table, a SAM provides a snapshot view of both the circular flow of accounts and the input-output matrix of a given economy. Within the village, region, or country, a SAM records the transactions between institutions, the amount and source of factors used in production, the flow of value added, and the economic interaction between the modeled economy and the rest of the world. The SAM also registers the savings and investment pattern of the institutions in the economy.

The basic accounting principle of the SAM is that for every account, sources must equal uses. That is, all income must be spent or otherwise paid out, i.e., put into savings, investment or transferred to another account. This means that the row and column totals for every account must be equal. The five basic characteristics of a SAM are listed below.

- (1) A SAM is a square matrix containing the same number of rows and columns.
- (2) Each row and the corresponding column is called an account.
- (3) Accounts represent entities such as factors of production, institutions (households, firms, government and the rest of the world), or activities (production).
- (4) A column represents expenditures of an account and a row represents receipts of an account.
- (5) Column sums and the corresponding row sums are always equal.

Using the Peanut Basin data, two SAMs were constructed: one for the village section of Keur Marie, the other for the village section of Keur Magaye. The accounts within each SAM are identical. An outline of the SAMs and a description of each account are given below. The village SAMs themselves are included in Appendix 3, Tables 17 and 18. All entries in the SAMs represent CFA valuations.

Presenting a snapshot view of the circular flow of accounts of the village economy, the SAM provides a framework with which to examine the resource flows within each village and between each village and the rest of the world. As illustrated, the two village SAMs also represent a consistent (linear) framework with which to make comparisons of the socioeconomic structures of the two villages. The purpose of this framework is to illustrate the relationship between exogenous injections and endogenous income in the two villages. Such a model allows one to trace the impact of exogenous shocks on village income. Because of the structure of the SAM, the impact of these experiments can be traced through to their ramifications on every endogenous account in the SAM. Through these experiments, the model further serves to highlight the village socioeconomic structure.

The construction of the SAM model is easily understood by considering the decomposition of a SAM presented in Table 15.

Table 15
Decomposition of a SAM

	Endogenous Accounts	Exogenous Accounts
	Block N	Block x
Endog. Accounts	y_{11} y_{12} y_{13} y_{21} y_{22} y_{23} y_{31} y_{32} y_{33}	x_{11} x_{12} x_{21} x_{22} x_{31} x_{32}
	Block B	Block D
Exog. Accounts	y_{41} y_{42} y_{43} y_{51} y_{52} y_{53}	x_{41} x_{42} x_{51} x_{52}

Define "Y" as the vector of column totals of endogenous accounts, i.e., the column totals of block N plus block B. Define "N" as the vector of row totals of block N and "X" as the vector of row totals of block X. Recall that a basic feature of any SAM is that the row and column sums must balance. This means that:

$$Y = N + X \quad (1)$$

Noting that N equals AY, where A is the matrix of coefficients for block N (from the normalised SAM), equation 1 can be rewritten as:

$$Y = AY + X \quad (2)$$

Solving for Y:

$$Y = (I - A)^{-1} X \quad (3)$$

where $(I - A)^{-1}$ is the SAM multiplier, M.

In words, the relationship that has just been formulated is between total endogenous village economic activity and exogenous demand for village-produced goods and services. The column totals of the endogenous accounts equal M times the row totals for the exogenous accounts of Block X. Element m_{ij} in M represents the effect on sector (account) i of a unit increase in exogenous demand for sector (account) j. With this formula, any change in exogenous demand, or any exogenous injection can be traced through to its impact on the endogenous village economy.

The multiplier derived in equation (3) calculates the direct effects of an exogenous injection or shift in demand, but it also includes second and higher round effects. For example, an increase in exogenous peanut demand might imply increased consumption of

village goods and services on the part of peanut-exporting farmers. This increased demand could be traced through to higher incomes for those in service activities who might in turn consume more domestically grown millet and peanuts, which in turn implies higher incomes for millet and peanut farmers, etc.

The four primary limitations inherent in a SAM are as follows. First, village producers take prices as given. For such small villages as Keur Magaye and Keur Marie this is not an unrealistic assumption. Second, the input-output ratio is fixed, thereby constraining the SAMs to the realm of constant returns to scale. This problem needs to be addressed if production intensities are experimented with. Third, all income elasticities are unitary. This means that compounds will spend their next CFA in exactly the same proportion as they spent their last CFA. This is an important limitation that could lead to distortion in the analysis of consumption patterns in growth experiments. This problem has been discussed in the experiments. Fourth, the SAM model is a demand-driven one, meaning that increases in demand are met by increased village supply, i.e., there are no resource constraints. In the migration and diversification experiments, the possibility of reaching a labour constraint has been discussed however.

The scheme set out in Table 15 has been elaborated in Table 16 to describe the structure of the two villages studied. A brief explanation of the entries in Table 16 completes this Appendix.

Explanation of row entries

A. Activities

Peanuts - Approximately 36 per cent of all cultivated land in the two villages was planted in peanuts.

Millet - Approximately 53 per cent of all cultivated land in the two villages.

Other Crops - This category includes mango, sorghum, beans, corn, melon, vegetables, manioc, and byssap. These crops account for approximately 11 per cent of all cultivated land in the two villages.

Animal Services - This account registers the use of animal traction (cattle, horse, donkey) in the villages. The value of the use of animal traction services on a field was calculated at 2,500 CFA for the use of a horse or a bullock, and 2,000 CFA for the use of a donkey. These two rates were observed in the sample villages.

Services - Service industries in the village are well-digging, construction, teaching, and tea-making.

Commerce - The commerce engaged in by members of the villages consists exclusively of petty trade. The merchants bought oranges, fish, condiments, and miscellaneous commodities at relatively large markets and then sold their wares at smaller markets or in front of their compounds.

Table 16
Social Accounting Matrix of Village Structure

	I. Activities	II. Factors	III. Institutions	IV. Savings	V. ROW
I. Activities Peanuts Millet Other Crops Animals Service Commerce	<i>Block 1</i> Village Input-Output Table	<i>Block 6</i> Empty	<i>Block 11</i> Village Produced Consumption	<i>Block 16</i> Seed Stock Investment	<i>Block 21</i> Exports from Village
II. Factors Manager Labour Household Labour Compound Labour Village Labour Imported Labour Non-Ag. Labour Secure Fields Mod. Sec. Fields Insecure Fields Borrowed Fields Grazing Rights	<i>Block 2</i> Factor Value-Added	<i>Block 7</i> Empty	<i>Block 12</i> Empty	<i>Block 17</i> Empty	<i>Block 22</i> Empty
III. Institutions Large Compounds Medium Compounds Small Compounds	<i>Block 3</i> Inputs Supplied by Other Compounds	<i>Block 8</i> Distribution of Value-Added	<i>Block 13</i> Empty	<i>Block 18</i> Empty	<i>Block 23</i> Remit- tance and Salaries
IV. Cap Savings	<i>Block 4</i> Empty	<i>Block 9</i> Empty	<i>Block 14</i> Savings	<i>Block 19</i> Empty	<i>Block 24</i> Empty
V. Rest of the World Cooperatives Weekly Market Other Senegal	<i>Block 5</i> Imported Inputs	<i>Block 10</i> Imported Labour	<i>Block 15</i> Imported Consumption	<i>Block 20</i> Imported Investments	<i>Block 25</i> Empty

B. Factors

- Manager labour** - The amount of time, valued at the agricultural wage rate, that the field managers spent working on their own fields. The agricultural wage rate was calculated at 500 CFA per day for planting, the first weeding, and for harvest, and at 250 CFA per day for field preparation and the second weeding. These were the prices for each of these tasks in the villages. By convention, the labour time of children (less than 15 years old) was valued at half that of adults.
- Household labour** - The amount of time, valued at the agricultural wage rate, that members of the field manager's immediate household spent working on the manager's fields.
- Compound labour** - The amount of time, valued at the agricultural wage rate, that members of the field manager's compound (not including his/her immediate household) spent working on the manager's fields.
- Village labour** - The amount of time, valued at the agricultural wage rate, that members of the village spent working on the manager's fields.
- Imported labour** - The amount of time, valued at the agricultural wage rate, that workers from outside the village spent working on the manager's fields.
- Non-agricultural labour** - Value of labour time spent on non-agricultural activities. Time spent watching animals was calculated at 250 CFA per day to correspond to the agricultural opportunity cost of labour. The lower wage rate was used as herders are often marginal labourers.
- Secure fields** - The value of the land services of those fields supervised by managers possessing secure tenure rights. The value of land services was calculated by subtracting the value of labour time, seeds, pesticide and fertilizer from the value of the crop in question.
- Moderately secure fields** - The value of the land services of those fields supervised by managers possessing moderately secure tenure rights.
- Insecure fields** - The value of the land services of those fields supervised by managers possessing insecure tenure rights.
- Borrowed fields** - The value of the land services of borrowed fields.
- Grazing Rights** - The value of animal grazing land services. Like other land services, this is a residual calculation. It was calculated by subtracting the value of labour time spent watching the traction animals from the total value of animal services.

C. Institutions

- Large Compounds** - The compound is the repository of land value-added and managerial, household, compound, and non-agricultural labour value-added. It is the basic unit of consumption and the recipient of remittances and salaries from outside the village. The compounds in the sample have been divided into three categories; those with large sized land holdings; those with medium sized land holdings and those with small sized land holdings. Because of the large variation in average holding size in the two villages, these categories correspond to very different hectareage break-downs. In Keur Marie, the 6 big

land holders have areas ranging from 10 to 20 hectares while in Keur Magaye, the 8 big land holders have areas ranging from 20 to 60 hectares.

Medium Compounds - In Keur Marie, the 9 medium-sized landholders control areas ranging from 5 to 10 hectares, and in Keur Magaye, the 9 medium landholders have 10 to 20 hectares.

Small Compounds - In Keur Marie, the 7 small compounds have holdings ranging from 0 to 5 hectares, while the 9 small compounds in Keur Magaye have holdings ranging from 0 to 10 hectares.

D. Savings

Capital/Savings/Investment - This account enumerates the compound's "purchases" of investment goods such as animals, seed stock, equipment or construction.

E. Exogenous Accounts

Cooperatives - This account includes all government-sponsored peanut marketing services. The cooperatives supply peanut seed and pesticide (often on credit) at the beginning of the season and then purchase the majority of the farmers' peanut production at the end of the season. In Keur Magaye, these cooperatives also purchased some millet.

Weekly Market - Both the villages of Keur Magaye and Keur Marie are within walking distance of a major weekly market (the markets of Birklane and Gandiaye respectively). These markets are the primary sources of purchased consumption goods. Neither Keur Magaye nor Keur Marie have village markets or village stores.

Other Senegal - This refers to the world farther away than the weekly market. This includes the daily market at Kaolack which is about an hour's drive from each of the villages. Also included in this account are all other points in Senegal including the capital, Dakar. Salaries and remittances originate in this account.

Appendix 2 - Questionnaire

I. Compound Characteristics

Location:

Village name

Human Characteristics:

For each compound member, determine; ethnic, official office, age, religion, religious brotherhood, literacy, relation to compound head, and occupation. List number of males, females, children (less than 15 years old), elderly (greater than 65 years old), and number of households in the compound.

Capital Stock:

Animals and equipment

Extra-Agricultural Income:

For each compound member employed outside the compound, describe the type, location and duration of the job. Give income amounts for 1984, 1985, and 1986. For people who are not members of the compound but who regularly contribute to the compound, describe the type, location and duration of the job. Give the amount remitted to the compound in 1984, 1985, and 1986.

Food Grain Purchases and Gifts:

Give the amount of millet, sorghum and rice that was purchased and the amount given to the compound in 1986. List sources.

Domain Law:

Determine the compound head's opinion of the law. Have they had any land disputes? Do they still lend land? Leave land in fallow? Do they follow the law?

II. Compound Tenure By Parcel**Parcel Characteristics:**

Distance from compound, who cleared the parcel, any improvements, who made improvements, years the compound has "owned" the parcel, how the parcel was obtained.

Borrowed:

If yes, determine owner, years borrowed, if the compound will borrow the same parcel next year, is there payment made for the use of the parcel, a contract, in case of dispute who will arbitrate, and if the owner can take back the land at any time.

Lent:

If yes, determine who borrowed the parcel, who decided to lend the land and why, years lent to this borrower, total years lent, if the parcel will be lent next year, does the compound receive payment for the parcel, is there a contract, in case of dispute who will arbitrate, and if the compound take back the land at any time.

Fallow:

If yes, determine the number of years the parcel has been in fallow, why it is in fallow and the security of the fallow land.

III. Field Management and Tenure**Field Characteristics:**

Size and soil quality CROPS: Amounts planted and harvested in 1984, 1985, and 1986.

Crop and Input Management:

Who determined crop, quantity of seed planted, fertilizer use, and quantity of pesticide used? What amounts were applied?

Tools Used on Field:

List type and quantity. If borrowed, list payment amount.

Animals Used on Field:

List type and quantity. If borrowed, list payment amount.

Labour Inputs:

List who did each type of task (soil preparation, harvest, 1st weeding, 2nd weeding, unearthing, stacking, and beating), how long they worked, and if they received any payment. Was there a labour shortage for any task? Why?

Field Manager Tenure Status:

Determine the number of years the manager has worked the field, how the field was obtained, if there has been a change in the size of the field, who made the change, if the manager will work the same field next year, who could take the field from the manager, if they will take the field, if the manager's children will work this field, who decides the heirs to the field, and if the manager can give or loan the field.

IV. Distribution of Harvest and Revenue by Manager**Acquisition of Seeds:**

List source, quantity obtained, type of payment, credit, cost.

Division of Harvest:

List percentage of harvest that was sold, kept for personal use, used for seed, kept for general compound use, given to compound head, tithed, or other.

Sales Procedure:

Determine where the crop was sold and in how many transactions.

Amount of Sales Revenue:

List CFA amount.

Division of Sales Revenue:

List the percentage of sales revenue that was kept for personal use, given to the compound head, given to the household head, tithed, used for loan repayment or other.

Pesticide and Fertilizer Acquisition:

Determine source, quantity, payment type, credit and payment amount.

Appendix 3

Table 17: Social Accounting Matrix - Keur Marie (1/5)

	1. Peanuts	2. Millet	3. Other Crops	4. Animals	5. Service	6. Commerce
1. Peanuts	223,176					
2. Millet		26,669				
3. Other Crops			3,165			40,000
4. Animals	218,500	218,000	22,500			
5. Service						
6. Commerce						
7. Manager Labour	105,920	269,875	28,550			
8. Household Labour	265,143	455,125	22,938			
9. Compound Labour	81,875	79,500	20,500			
10. Village Labour	31,000	100,875	3,000	12,000		
11. Imported Labour	4,875	11,750	250			
12. Non-Ag. Labour				396,750	124,500	296,750
13. Secure Fields	808,613	1,423,700	31,513			
14. Moderately Sec.	119,875	32,650	72,300			
15. Insecure Fields	346,775	11,500	63,550			
16. Borrowed Fields	292,875	222,300	-9,150			
17. Grazing Rights				50,250		
18. Large Compounds	19,817		125			
19. Medium	19,817					
20. Small Compounds	19,817					
21. Capital/Savings						
22. Cooperatives	343,439	125				
23. Weekly Market	39,884	2,381	4,760		500	197,500
24. Other Senegal			1,000			1,725,000
25. Totals	2,941,400	2,854,450	265,000	459,000	125,000	2,259,250

Table 17: Social Accounting Matrix - Keur Marie (2/5)

	7. Manager Lab	8. Household Lab	9. Compound Lab	10. Village Lab	11. Imported Lab	12. Non-Ag Lab
1. Peanuts						
2. Millet						
3. Other Crops						
4. Animals						
5. Service						
6. Commerce						
7. Manager Labour						
8. Household Labour						
9. Compound Labour						
10. Village Labour						
11. Imported Labour						
12. Non-Ag. Labour						
13. Secure Fields						
14. Moderately Sec.						
15. Insecure Fields						
16. Borrowed Fields						
17. Grazing Rights						
18. Large Compounds	109,000	338,875	54,750	46,500		186,500
19. Medium	169,233	224,393	125,625	56,375		447,750
20. Small Compounds	126,113	179,938	1,500	44,000		183,750
21. Capital/Savings						
22. Cooperatives						
23. Weekly Market						
24. Other Senegal					16,875	
25. Totals	404,345	743,205	181,875	146,875	16,875	818,000

Table 17: Social Accounting Matrix - Keur Marie (3/5)

	13. Sec Fields	14. Moderately	15. Insec. Fields	16. Borrowed	17. Grazing
1. Peanuts					
2. Millet					
3. Other Crops					
4. Animals					
5. Service					
6. Commerce					
7. Manager Labour					
8. Household Labour					
9. Compound Labour					
10. Village Labour					
11. Imported Labour					
12. Non-Ag. Labour					
13. Secure Fields					
14. Moderately Sec.					
15. Insecure Fields					
16. Borrowed Fields					
17. Grazing Rights					
18. Large Compounds	999,575	176,225	114,175	248,850	25,125
19. Medium	1,051,500	48,600	307,650	91,500	17,587
20. Small Compounds	212,750			165,675	7,538
21. Capital/Savings					
22. Cooperatives					
23. Weekly Market					
24. Other Senegal					
25. Totals	2,263,825	224,825	421,825	506,025	50,250

Table 17: Social Accounting Matrix - Keur Marie (4/5)

	18. Large Comp	19. Medium	20. Small Comp	21. Investment	22. Cooperatives
1. Peanuts	109,313	78,811	3,480	113,407	2,413,213
2. Millet	1,079,073	1,093,983	654,725		
3. Other Crops	79,920	29,680	25,835		
4. Animals					
5. Service	68,750	42,500	13,750		
6. Commerce	159,088	98,345	31,817		
7. Manager Labour					
8. Household Labour					
9. Compound Labour					
10. Village Labour					
11. Imported Labour					
12. Non-Ag. Labour					
13. Secure Fields					
14. Moderately Sec.					
15. Insecure Fields					
16. Borrowed Fields					
17. Grazing Rights					
18. Large Compounds					
19. Medium					
20. Small Compounds					
21. Capital/Savings	194,015	113,416	13,476		
22. Cooperatives					
23. Weekly Market	2,990,058	1,407,114	202,997	107,500	
24. Other Senegal				100,000	
25. Totals	4,680,217	2,863,849	946,080	320,907	2,413,213

Table 17: Social Accounting Matrix - Keur Marie (5/5)

	23. Weekly	24. Other Senegal	25. Totals
1. Peanuts			2,941,400
2. Millet			2,854,450
3. Other Crops		86,400	265,000
4. Animals			459,000
5. Service			125,000
6. Commerce	625,000	1,345,000	2,259,250
7. Manager Labour			404,345
8. Household Labour			743,205
9. Compound Labour			181,875
10. Village Labour			146,875
11. Imported Labour			16,875
12. Non-Ag. Labour			818,000
13. Secure Fields			2,263,825
14. Moderately Sec.			224,825
15. Insecure Fields			421,825
16. Borrowed Fields			506,025
17. Grazing Rights			50,250
18. Large Compounds		2,360,700	4,680,217
19. Medium		303,820	2,863,849
20. Small Compounds		5,000	946,080
21. Capital/Savings			320,907
22. Cooperatives			343,564
23. Weekly Market			4,952,694
24. Other Senegal			1,842,875
25. Totals	625,000	4,100,920	

Table 18: Social Accounting Matrix - Keur Magaye (1/5)

	1. Peanuts	2. Millet	3. Other Crops	4. Animals	5. Service	6. Commerce
1. Peanuts	649,977					
2. Millet		33,264				
3. Other Crops			3,355			
4. Animals	375,000	187,000	25,000			
5. Service						
6. Commerce						
7. Manager Labour	376,875	261,963	43,100			
8. Household Labour	577,200	363,813	17,063			
9. Compound Labour	238,250	90,388	3,675			
10. Village Labour	38,000	26,438	3,125	81,000		
11. Imported Labour	119,625	72,500	1,250			
12. Non-Ag. Labour				192,225	428,000	197,500
13. Secure Fields	3,905,762	1,957,462	362,462			
14. Moderately Sec.	1,398,363	23,138	131,425			
15. Insecure Fields	1,990,626	190,075	226,000			
16. Borrowed Fields	1,438,675	-43,775	73,525			
17. Grazing Rights				313,775		
18. Large Compounds	8,031	250	1,120			200,000
19. Medium	8,030	249	1,120			100,000
20. Small Compounds	8,030	249	1,120			50,000
21. Capital/Savings						
22. Cooperatives	1,418,513	47,367				
23. Weekly Market	108,743	1,822	5,361		162,000	125,000
24. Other Senegal						
25. Totals	12,659,700	3,212,200	898,700	587,000	590,000	672,500

Table 18: Social Accounting Matrix - Keur Magaye (2/5)

	7. Manager Lab	8. Household Lab	9. Compound Lab	10. Village Lab	11. Imported Lab	12. Non-Ag Lab
1. Peanuts						
2. Millet						
3. Other Crops						
4. Animals						
5. Service						
6. Commerce						
7. Manager Labour						
8. Household Labour						
9. Compound Labour						
10. Village Labour						
11. Imported Labour						
12. Non-Ag. Labour						
13. Secure Fields						
14. Moderately Sec.						
15. Insecure Fields						
16. Borrowed Fields						
17. Grazing Rights						
18. Large Compounds	259,438	423,888	193,250	89,375		99,625
19. Medium	205,125	270,813	116,313	19,250		354,350
20. Small Compounds	217,375	263,375	22,750	39,938		363,750
21. Capital/Savings						
22. Cooperatives						
23. Weekly Market						
24. Other Senegal					193,375	
25. Totals	681,938	958,075	332,313	148,563	193,375	817,725

Table 18: Social Accounting Matrix - Keur Magaye (3/5)

	13. Sec Fields	14. Moderately	15. Insec. Fields	16. Borrowed	17. Grazing
1. Peanuts					
2. Millet					
3. Other Crops					
4. Animals					
5. Service					
6. Commerce					
7. Manager Labour					
8. Household Labour					
9. Compound Labour					
10. Village Labour					
11. Imported Labour					
12. Non-Ag. Labour					
13. Secure Fields					
14. Moderately Sec.					
15. Insecure Fields					
16. Borrowed Fields					
17. Grazing Rights					
18. Large Compounds	2,666,325	1,328,838	1,188,963	656,300	125,510
19. Medium	2,396,875	15,138	1,022,238	260,800	109,821
20. Small Compounds	162,486	208,950	195,500	551,325	78,444
21. Capital/Savings					
22. Cooperatives					
23. Weekly Market					
24. Other Senegal					
25. Totals	6,225,686	1,552,926	2,406,701	1,468,425	313,775

Table 18: Social Accounting Matrix - Keur Magaye (4/5)

	18. Large Comp	19. Medium	20. Small Comp	21. Investment	22. Cooperatives
1. Peanuts	231,219	62,128	5,508	94,372	8,480,042
2. Millet	925,126	1,622,040	588,050	2,199	
3. Other Crops	298,660	94,935	60,600	17,145	
4. Animals					
5. Service	298,100	182,900	118,000		
6. Commerce	79,625	50,375	32,500		
7. Manager Labour					
8. Household Labour					
9. Compound Labour					
10. Village Labour					
11. Imported Labour					
12. Non-Ag. Labour					
13. Secure Fields					
14. Moderately Sec.					
15. Insecure Fields					
16. Borrowed Fields					
17. Grazing Rights					
18. Large Compounds					
19. Medium					
20. Small Compounds					
21. Capital/Savings	296,093	103,860	272,958		
22. Cooperatives				15,000	
23. Weekly Market	5,576,589	2,824,883	2,104,474	374,195	
24. Other Senegal		4,000		170,000	
25. Totals	7,696,412	4,945,121	3,182,090	672,911	8,480,042

Table 18: Social Accounting Matrix - Keur Magaye (5/5)

	23. Weekly	24. Other Senegal	25. Totals
1. Peanuts		3,136,454	12,659,700
2. Millet	23,252	18,269	3,212,200
3. Other Crops	170,502	253,503	898,700
4. Animals			587,000
5. Service			590,000
6. Commerce	510,000		672,500
7. Manager Labour			681,938
8. Household Labour			958,075
9. Compound Labour			332,313
10. Village Labour			148,563
11. Imported Labour			193,375
12. Non-Ag. Labour			817,725
13. Secure Fields			6,225,686
14. Moderately Sec.			1,552,926
15. Insecure Fields			2,406,701
16. Borrowed Fields			1,468,425
17. Grazing Rights			313,775
18. Large Compounds		455,500	7,696,412
19. Medium		65,000	4,945,121
20. Small Compounds		18,800	3,182,090
21. Capital/Savings			672,911
22. Cooperatives			1,480,880
23. Weekly Market			11,283,067
24. Other Senegal			367,375
25. Totals	703,754	3,947,526	

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