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LIVESTOCK VERSUS FOOD GRAIN PRODUCTION IN SOUTHEAST UPPER VOLTA: A RESOURCE ALLOCATION ANALYSIS

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LIVESTOCK VERSUS FOOD GRAIN PRODUCTION IN SOUTHEAST UPPER VOLTA: A RESOURCE ALLOCATION ANALYSIS

by

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FORWARD

The desirability and feasibility of integrating livestock and crop enterprises on peasant farms has long been discussed in the agricultural development literature, but there has been a lack of detailed, farm-level research on livestock in general and on mixed farming in particular. This monograph starts to fill that gap. The research was conducted in the southern part of the West African Sahel, where mixed farming is seen by some as a major means of developing both the livestock and crop sectors. Delgado's results are important for that area and, perhaps, also for other areas throughout Africa. His major conclusion, which challenges much of the conventional wisdom, is that farmers under conditions common to much of the southern Sahel would not significantly increase their incomes by integrating crop and livestock enterprises, rather than keeping them separate. A major stumbling block for mixed farming is shown to be the labor constraint at harvest time when cattle kept on a farm would require intensive guarding to prevent crop damage. This is an important addition to most earlier analyses of peasant labor profiles which emphasize labor constraints during land preparation and weeding.

Delgado also sheds light on peasants' risk avoidance behavior and the opportunity cost incurred by the resultant minimum grain acreage planted to insure that subsistence is covered by home production. Moving into the realm of anthropology as well as economics, the monograph considers the symbiotic relationships between distinctly different ethnic groups, Fulani pastoralists and Mossi or Bisa cultivators, and thereby extends earlier work on specialization and comparative advantage in agricultural activities. Analysis of these and related issues, as well as the detailed descriptions of a relatively little known area and agricultural system make Delgado's work an important addition to the agricultural development literature.

This monograph is part of a three-year study of West African livestock economics undertaken by the Center for Research on Economic Development, University of Michigan, for the United States Agency for International Development under Contract AID/afr-c-1169. The full study consisted of four eighteen-month field studies, including Delgado's, two focusing on production and two on marketing, in addition to several investigations based on the existing data and literature. The geographic area of focus involved the five member states of the Conseil de l'Entente, Ivory Coast, Togo, Benin, Niger, and Upper Volta, but also included, in a more general fashion, Mali and Nigeria. The following documents have been produced as a result of this study:

K. Shapiro, ed., Livestock Production and Marketing in the Entente States of West Africa: Summary Report. (This volume contains an overview plus separate summaries of each monograph.)

A. Ergas, ed., Livestock Production and Marketing in the Entente States of West Africa: Annotated Bibliography. (Included as part of the summary report.)

MONOGRAPHS:

Delgado, C., Livestock versus Foodgrain Production in Southeast Upper Volta: A Resource Allocation Analysis.

Staatz, J., The Economics of Cattle and Meat Marketing in Ivory Coast.

Eddy, E., Labor and Land Use on Mixed Farms in the Pastoral Zone of Niger.

Herman, L., The Livestock and Meat Marketing System in Upper Volta: An Evaluation of Economic Efficiency.

WORKING PAPERS:

1. Ferguson, D., A Conceptual Framework for the Evaluation of Livestock Production Development Projects and Programs in Sub-Saharan West Africa.

2. Wardle, C., Promoting Cattle Fattening Amongst Peasants in Niger.

3. Swift, J., West African Pastoral Production Systems.

4. Sleeper, J., An Economic Analysis of the Role of Ox-Plowing and Cattle-Feeding in the Stratification of West African Livestock Production.

5. DeBoer, A.J., The Short Run and Long Run Position of Australian Beef Supplies and the Competitiveness of Australian Beef in International Trade.

6. Porter, R., The Uses of Economic Models in Analysis of the Cattle Sector.

These documents are available from the United States Agency for International Development, Bureau for Africa, Office of Development Resources (AFR/DR), New State Department Building, Washington, D.C. Some may be available from the Center for Research on Economic Development. The monographs and the summary report are also available in French.

Ann Arbor, Michigan
March, 1979

Kenneth Shapiro
Project Director

ABSTRACT

LIVESTOCK VERSUS FOOD GRAIN PRODUCTION IN SOUTHEAST UPPER VOLTA: A RESOURCE ALLOCATION ANALYSIS

Christopher L. Delgado, Ph.D.
Cornell University 1978

Policy makers concerned with the West African Savannah have emphasized the value of integrating cattle-raising into smallholder agriculture. Particular interest in this respect has been expressed in village livestock development in Southeastern Upper Volta. The small-scale cattle enterprise is extolled as providing the participating sedentary farmer with milk proteins, cash income from the sale of animals fattened on farm by-products, and crop yield increases from usufruct of the manure. Furthermore, farm cattle can be used for ploughing. However, the peasant households that own cattle in this area typically choose to forego these benefits by entrusting the animals to semi-sedentary Fulani herdsmen who live outside the village.

The principal hypothesis is that the high opportunity cost of seasonal labor in terms of food grains, the desire for self-sufficiency in millet, and the high seasonal labor requirement for grazing and supervising animals offer an economic explanation of why farmers prefer to entrust animals to the Fulani, rather than to look after them themselves. This hypothesis is tested using input-output data on actual farm practices during the 1976-77 agricultural year. A thirteen month farm management survey of forty-one Mossi and Bisa households from two villages in the Tenkodogo area provided detailed information on labor flows, land use patterns, and outputs, using semi-weekly interviews. A concomitant five month survey of twenty Fulani families provided information on cattle labor requirements and ownership patterns.

A linear programming model incorporating eleven crop and two small stock activities is constructed from the data. An hypothetical cattle enterprise is also included, based upon the results of the herder survey. The income from this activity represents the extra

returns to keeping the animals on the farm as opposed to entrusting them to the Fulani. The model is used to identify optimal production strategies and resource constraints under different assumptions concerning farmers' desires for self-sufficiency in food grains.

The basic model is modified to incorporate the crop yield increases and seedbed preparation decreases projected by research station personnel for animal traction. The new model farmer is also obliged to keep two steers on the farm. The weeding and harvesting labor requirements for crops are increased in accordance with the research station predictions. These changes permit testing the effect of animal traction on farm income in the event that it has the effects predicted by its principal proponents.

The basic model shows that a revenue-maximizing farmer will entrust his cattle to the Fulani, rather than keep them himself, regardless of the assumptions concerning food grain production. Furthermore, a rise in the minimum area of farmland put under food grains increases the opportunity cost of harvest labor resources in mid-November. Starting from grain production consistent with the lowest amount of millet cultivated by any sample member in 1976, the opportunity cost of the labor required to maintain two steers on the farm is estimated at 1.2 hectares of grain. The introduction of animal traction adds very little to the maximum attainable farm income, even when the cost of the equipment is ignored. Farm income actually decreases if farmers desire to produce food grains; it falls most when they use traction on the millet fields as well as on the cash crops.

In view of these considerations, efforts to increase livestock production in the research area should be directed to supporting the traditional cattle entrusting system. In the absence of this option, attention should be directed to peak labor-saving innovations in food grain output. This would then be the best means of introducing cattle into the farming system.

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The field study would not have been possible without the whole-hearted support of their Excellencies the Canton Chiefs of Loanga and Oueguedo. Bisa and Mossi protocol prevents mentioning their names. The author, however, feels privileged to count them amoung his friends. The same heartfelt thanks are due to the residents of Loanga and Oueguedo villages. In particular, the long-suffering sample members deserve special mention. They showed exemplary patience and concern in tolerating the presence of strangers in their midst, prying into their private affairs, and disturbing their rest twice a week for over one year. This study truly belongs to them.

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While the comments of the persons acknowledged above have certainly helped to improve this manuscript, naturally any remaining errors remain solely the responsibility of the author.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

Table		Page

Table		Page

Table | Page

LIST OF ILLUSTRATIONS

Figure		Page

CHAPTER 1

INTRODUCTION: THE PHENOMENON, THE PROBLEM AND THE APPROACH

This study examines the reluctance of peasant farming groups in Southeastern Upper Volta to keep cattle, despite the many benefits from increased sedentary livestock production. The first section of this chapter examines the purported benefits from increased sedentary livestock production. Next, the problem is raised that very few sedentary farmers in this region elect to keep cattle on the farm, although many own animals in herds kept outside the village by semi-sedentary herdsmen. This pattern is not uncommon in the Voltaic Savannah. The existing literature is briefly reviewed. A preliminary hypothesis is elaborated to the effect that labor conflicts between crops and livestock make keeping cattle on the farm an unprofitable enterprise. The chapter concludes by giving the outline of an approach to testing this theory with actual field data.

The Livestock Sector in Upper Volta

> The livestock sector in Upper Volta as in other West African countries serves a number of vital functions. It provides subsistence for a large number of pastoral and sedentary producers and a surplus of meat and milk for urban populations. It is a valuable source of foreign exchange not only from the export of meat, but also animal by-products, particularly hides and skins, for (sic) crop producers who tend livestock or make their fields available to the animals of migratory herders. It is a way to help to maintain soil fertility and to improve soil structure. Ownership of cattle and other livestock is an investment and form of savings for pastoral and sedentary producers that assures survival in times of stress, satisfies social obligations, and adds to social status. In normal times, national livestock production activity represents a considerable source of revenue to the government through direct taxation.

This assessment by a major international donor agency in the West

African Sahel succinctly portrays the crucial development role played by livestock activities in the Voltaic economy (USAID, 1975, p. D-34). Historically, policy makers focused attention on stockraising in the northern, or Sahelian, part of the country. However, the severe drought in the Sahel during the early 1970's served to underscore the fragile ecology of the area as a cattle producing region. Tyc (1975, p. 10) estimates that the herd in the northern (Sahelian) part of Upper Volta decreased by 32 percent between 1969 and 1974. He estimates that the herd in central and southern Upper Volta increased by 10.4 and 15.9 percent respectively, during the same period. This leads to an assessment for the end of 1974 of 408,000 head of cattle in the Sahelian north and 2,132,000 head in the center and south of the country.[1] Thus, one sixth of the Voltaic herd was to be found in the north at the end of the drought, while the rest were in the center and south, with over a quarter specifically in the latter.

These findings have led some observers to conclude that the growth in herd size and increases in slaughter rates that occurred during the fifties and sixties were a temporary phenomenon, due to above average rainfall in that period (USAID, 1975, p. D-34). During years of low or average rainfall, in this view, the northern pastoral system cannot be relied upon to produce further sustained growth in animal production, along with the attendant development linkages specified above. As a consequence, analysts have turned to the relatively more humid savannah area of the country in search of a forum for increased livestock production. In this context, one of the foremost observers of Voltaic livestock production activities has concluded: "The development of animal production should be sought essentially through a better integration of stockraising into agriculture."[2]

Since the report containing this quotation was issued (May 1975), Voltaic animal production policy has emphasized increased activities in

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[1]See Appendix I, Table A.1 for estimates of animal numbers by major region.

[2]Tyc (1975) p. 14, my translation of: "Le développement de la production animale doit être recherché essentiellement par une meilleure intégration de l'élevage dans l'agriculture."

southern areas (GOUV, MDR, 1976). Major initiatives envisioned on the production side have been improved veterinary services, state feedlots, and small-scale on-farm fattening operations.

The benefits to agricultural production stemming from organic soil fertilization are also a major motivation for introducing mixed farming practices in southern areas. An agricultural sector assessment for Upper Volta by USAID attributes three out of four major food production problems in the area to the generally low productivity of the Voltaic farming system (USAID, 1975, p. D-13). "Population pressures leading to serious over-exploitation of land resources and deteriorating soil productivity in some areas" are singled out as crucial problem facing the food crop sub-sector of agriculture (Ibid.). The ability to maintain a stable farming system is obviously of concern in a country that has just emerged from a major famine. Following this analysis, the same USAID report states that: "The soil fertility situation needs to be reviewed with a view to establishing a complete system for maintaining soil fertility" (Ibid., D-29).

Manure from livestock can provide a major input in maintaining and increasing crop yields over time (FAO/SIDA, pp. 19-95 and pp. 313-377). Under the right conditions, animal traction can help to break seasonal labor constraints on crop-oriented activity.[1] On-farm animal production can provide milk to a protein-deficient population. Finally, animals fattened from agricultural produce can provide, in theory, increased farm incomes. Thus, the mixed farming solution is doubly attractive, because it offers hope for a basically static or declining subsistence agricultural system, as well as providing a growth alternative to a drought-prone Sahelian pastoral system.[2] On many counts, then, encouraging on-farm management of livestock by peasant groups appears to be a key issue in rural development policy in Upper Volta in particular, and perhaps the West African Savannah as a whole.

[1]Geographic contiguity of the plots to be worked by the same team, the availability of suitable forage and a sufficiently deep layer of topsoil seem to be necessary, if not sufficient, conditions for the successful introduction of traction.

[2]This is basically the viewpoint expressed by the director of the Livestock Service of the French Ministry of Cooperation, in Robinet (1973), pp. 26-72.

The Problem

Despite the many advantages projected for the crop cultivator who keeps cattle on the farm throughout the year, remarkably few farming groups choose to do so, even though many peasants own cattle.[1] Almost all of the cattle owned by sedentary peasants in Upper Volta are entrusted to Fulani herdsmen, who serve as "herd managers" for the farming groups.[2] Study of the Fulani livestock production system can provide information on required resource inputs to stockraising in the Savannah. However, the Fulani cannot be considered as representative of peasant groups or as prototypes of the peasant mixed farmer envisaged as the model of rural development, even though they do grow small amounts of crops. The Fulani are a minority group in the Savannah and, in most areas, use land there at the convenience of the local peasant chiefs. They constitute ten percent of the Voltaic population as a whole, but less than seven percent of the population in the Savannah area of Upper Volta.[4]

It is the peasant agricultural production system which must be fully understood in order to design a model of mixed farming suitable

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[1]The term "peasant" is preferred to "farmer" since the former better describes the position of most Voltaic small-holder agriculturists in terms of relations with traditional authorities as well as a lack of mixed farming practices. The term also serves to underline essential differences with the herding Fulani groups.

[2]See "L'Elevage," Jeune Afrique, Atlas de la Haute - Volta, 1975, p. 34. The term "management" is used to describe the keeping and herding of animals, as compared with ownership claims over them.

[3]Most work relating to Fulani herding systems in Upper Volta is anthropological in nature and deals with the northern zone, as in Barral (1967), (1970), (1973), (1974). An excellent anthropological study of the Sahelian Fulani of Upper Volta is P. Riesman (1974).

The present author has attempted to fill a gap in the literature concerning the relations between Mossi peasants and Fulani herders in the Central-Eastern part of Upper Volta, in Delgado (1977). Rochette (1976) is an interesting study of the Fulani in the White Volta Valley, unfortunately based on only 3 weeks of fieldwork.

[4]See Appendix I, Table A 2.

for diffusion throughout the Savannah. Unfortunately, little enough is known about the farm management aspects of the peasant crop cultivation system. Practically nothing is known about the overall consequences for small holder output mixes of keeping cattle on the farm, as opposed to entrusting them to herdsmen living outside the village.

The little that is known about the peasant farming systems per se comes primarily from "village monographs" in the tradition of economic geography. Examples of these are Barral (1968), Remy (1967, 1972), and the very useful work by Lahuec (1970). Quéant and Rouville (1969), Phillipe (1975), Sawadogo (1974), and Delgado (1977) attempt to deal with the relationships between the farming and herding systems in the Savannah, from an ethnographic viewpoint. A few major works on specific topics include a substantial amount of work on the peasant farming system as background. The prime example of this is the definitive study in six volumes of Mossi migration patterns (O.R.S.T.O.M., 1975). Work dealing specifically with the consequences of associating agriculture and stock-raising in Savannah areas is confined to discussions of the benefits to crop production of organic manure and animal traction, and to the cash costs and benefits of sales of fattened animals.[1] It appears that the question of the opportunity costs of the non-cash resources used to maintain the animals, such as labor, has never been raised. The implicit assumption seems to be that either the animal traction component of on-farm livestock production alleviates seasonal labor constraints, or that labor is a free resource, the use of which can be increased without decreasing other outputs.

The benefits to crop production of animal traction are still something of an open issue in Upper Volta in the context of traditional peasant agriculture. In addition to data gathered under experiment station conditions (Dupont de Dinechin et al, 1969), which are enthusiastically pro traction, there are the disappointing results of a "pilot" farm project in the 1950s, and a major initiative to introduce donkey traction to the

[1]In another part of his report Mesnil makes a point concerning the poverty of soils in the peasant producing regions of central Upper Volta (1970, IV, p. 16). On his account, they are most suited to food grain, rather than cotton, production.

Mossi Plateau in the 1960s.

The first experiment ended after three years, when "the majority of the 500 or so farms thus established [with traction and other farm equipment] had reverted to the traditional pattern." (De Wilde et al., 1967, II, p. 373). De Wilde's conclusion from this experience in that "psychological" factors were largely to blame for the failure of the program. The main point was that the innovation implied by the technology of traction set the peasant apart from his peers, an allegedly unsustainable position in Mossi communal society (Ibid.).

The second experiment is extensively analyzed in a nine volume work by Mesnil (1970), reviewed by Remy (1972). The evidence from this experience is also the basis for the analysis of (De Wilde et al, 1967, II, Chapter 4). Of these, the work by Mesnil (1970) is noteworthy. He concludes that animal traction combined with cash crops are the sine qua non of agricultural development in Upper Volta. However, the package offered in the sixties failed because it was not economic from the viewpoint of the farmer (Mesnil, 1970, VIII, pp. 4-10). The solution according to Mesnil, then, is to offer a package which combines traction with an allegedly high value cash crop, such as cotton. The failure of the program in the sixties is then attributable, in this account, to the farmers' use of traction primarily on food grains and groundnuts. He goes on to conclude that a new technical package emphasizing animal traction and cotton should be elaborated in the context of a precise knowledge of the economic milieu, through village-level surveys (Ibid. pp. 11-14). Mesnil contrasts this approach to "sociologism" which attributes the failure of innovative programs to the cultural habits, traditions, and "mentality" of peasants (Ibid., p. 4). Mesnil cites this attitude as a typical administrative reaction to the failure of animal traction programs. It does not question the technical validity of the packages, but instead advocates increasing the means of persuasion at the farm level (Ibid.).

De Wilde et al. concludes from the experience in the sixties that: "The results available do not justify the unqualified conclusion that the use of the donkey-drawn cultivator has led to a marked increase in agricultural production." (Ibid., p. 389). Like Mesnil, they go on to conclude that traction has to be associated with cash cropping, in order to generate the cash necessary to pay back the loans made to buy the equipment (Ibid., p. 388). Since much of Upper Volta does not have soils well suited to cotton, the potential benefits to the farming system of animal traction remain unclear for a large part of the country.

On the other hand, the litterature is unequivocal concerning the advantages of on-farm livestock with respect to the potential of cattle manure for boosting yields of grain, legumes, and cash crops (Mc Calla, 1975; Dupont de Dinechin et al., 1969; Guinard, 1967). For illustrative purposes, Table 1.1 shows the results of an experiment conducted in Saria, central Upper Volta, measuring the effect of cattle manure on sorghum yields, without other additives.

TABLE 1.1

EFFECT OF CATTLE MANURE ON SORGHUM YIELDS
(Saria, Upper Volta, 1963)

Application of Manure in m.t./ha.	Yield of Sorghum in kg./ha.
0	356
6	756
12	1,0?6
24	1,065
48	1,265
72	1,307

SOURCE: Dupont de Dinechin et al., 1969, p. 284.

Although the results in Table 1.1 are for only one year, they clearly demonstrate a boost in yields attributable to cattle manure.

The cash income from the sales of fattened animals also constitutes a potential major benefit of livestock production for peasant farmers.

Robinet (1973, p. 27) concludes that the major advantage of the integration of livestock with agriculture is the acquisition of a new cash activity by the farmer, rather than increased agricultural production. However, results of small-scale fattening operations across Africa have shown that the level of gross cash margins per animal are highly sensitive to the per kilogram price of meat in urban areas, with fattening a somewhat marginal activity at 1973 prices (Sarniguet, Serres, and Letenneur papers in I.E.M.V.T., 1973). M'Bodji calculated an average gross cash margin of 4,260 FCFA per steer fattened one agricultural season, for the years 1969-1972, using the by-products of traditional agriculture in Senegal (I.E.M.V.T., 1973, p. 267).[1] Like the preceding studies which advocate livestock intensification in peasant areas because of animal traction and manure linkages, the studies on animal fattening cited here ignore the opportunity costs of non-cash resources used to maintain and feed stock.

In light of the benefits attributed to cattle-raising in peasant areas, it is curious that practically no predominantly farming-oriented ethnic groups keep cattle in Upper Volta. The consensus among Voltaic officials, as well as expatriate advisors, appears to be that "psychological" reasons, similar to the "sociologisms" cited by Mesnil (1970), prevent them from doing so. The major hypothesis to be explored in this monograph is that the high opportunity cost of labor at certain peak periods, coupled with a lack of easily available forage and a desire for self-sufficiency in on-farm food grain production, can offer an "economic" explanation of why peasants like to own cattle, but not to look after them themselves. If true, this would help to explain the very prevalent custom of entrusting cattle to Fulani herdsmen.

The existence of seasonal peaks of labor use in African agricultural systems with one rainy season is well known (Cleave, 1974, pp. 39-41; De Wilde (I), 1967, p. 23). Lahuec (1970, pp. 74-75) has documented these for central-eastern Upper Volta. Some evidence exists that it is

[1] Chapter eight will include estimates of various margins applicable to steer fattening for peasant agriculture in the research area.

the shortage of labor during one or two critical periods which determines the amount of the harvest (De Wilde (I), 1967, pp. 71-77). The implication is that labor available at certain critical times is a scarce resource, the allocation of which helps determine the pattern of outputs of the farming system.

To the extent that this is the case, the labor required to feed and water livestock during these periods of peak labor use is a resource taken away from other activities and thus occasions a fall in the production of the other outputs of the farm. This is especially true where the timing of agricultural operations must be rigidly adhered to, entailing little substitutability between labor inputs in different periods.[1]

In Upper Volta, approximately three-quarters of the area cultivated is under millet and sorghum, the principal food staples in the country (RHV-IRAT, 1972). Table 2.1 shows estimates for the percentage of land surface devoted nationally to each crop:

TABLE 1.2

PERCENTAGE OF TOTAL CULTIVATED AREA
IN UPPER VOLTA DEVOTED TO EACH CROP

Crop	% Area Cultivated
Sorghum	48
Millet	25
Peanuts	7
Maize	6
Rice	1
Others (principally cowpeas and other legumes)	11

SOURCE: RHV-IRAT (1972), p. 1.

[1]De Wilde (1967) and Ruthenberg (1976), among others, support the view that the timing of agricultural operations is crucial.

Given the predominance of millet and sorghum in farm output, it is likely that labor removed from the pool of available resources at peak weeding and harvesting periods is likely to decrease the amount of food grains produced. This is especially true if the type of labor required for stock work during the rainy season is fully transferable to crop work as is true for young adult labor. Preliminary results indicate that this may be the case (Delgado, 1977, pp. 60-65). To the extent that this is true, keeping livestock on the farm has an opportunity cost in terms of food grain. If the stock is fed by pasturing them on free land outside the village, the opportunity cost is measured through the reallocation of labor from food grains to herding. If the stock is fed with produced forage, then the opportunity cost is calculated taking both labor and land into account. A supplementary cost of maintaining stock in the village during the cropping season is the risk of crop damage by animals.

Farmers in the Savannah may be quite reluctant to incur a new high cost in terms of foregone food grain production. Hunter (1966, p. 33) presents chilling evidence of chronic seasonal famine in Nangodi, on the Ghana - Upper Volta frontier:

> In June, at the time of the second measurements with some 3 to 4 weeks of hunger to face, levels of nutrition had greatly deteriorated: 88% of the community was underweight...23% of the men and 36% of the women were "seriously" to "very seriously" underweight.

Within this context, there is little margin for miscalculating the ability of next year's market to supply staple grains for family nutrition, given the penalty of being wrong. The position of much of peasant Savannah agriculture at the margin of subsistence helps to explain the conventional wisdom on planting decisions in West Africa, to the effect that the farmer wishes to be assured of self-sufficiency in food grains, even in the event of below average rainfall.

If the farmer is typically reluctant to rely upon the market for his food supplies, then a high opportunity cost of livestock in terms of foregone grain production may explain why farmers typically will not raise cattle within the village. Should this be the case, there are at least two major implications for policy makers. First, a policy action designed to intensify livestock production on peasant farms should include a component dealing with grain availability throughout the year, for participating households. This might include improved on-farm storage facilities, and a guaranteed supply-price of grain during the "thin" season (soudure), before the harvest. Second, a national policy to improve the yield of food grains per labor hour supplied during the peak season might be the best way of increasing livestock production. The increase could be achieved by shifting scarce on-farm resources from grain cultivation to livestock production, while continuing to produce the same amount of grain as previously.

In sum, the issue of the feasibility of the intensification of livestock production by sedentary farmers, from the farmer's viewpoint, hinges not only upon the projected benefits, but also upon the possible opportunity costs in terms of foregone food grain. This issue has not been dealt with up to now, and doing so may help to clarify the policy actions necessary to achieve a goal of greater sales of southern-fattened animals from peasant farms.

The Approach

The hypothesis elaborated in the previous section can be tested by modeling the production opportunities available to a "typical"[1] peasant farm found in an area proposed by the Voltaic government for intensification of sedentary livestock production. The model should take into account the "real" costs of production in terms of labor requirements during different periods for a unit of output of each type of crop or livestock. Given the rigidity of the agricultural calendar in areas with one four-month wet season, information on labor requirements must make clear the timing as well as the quantity of labor inputs. Ruthenberg (1976,

[1]Further thought on the derivation of estimates for a "typical" farm will be given in Chapter 4.

p. 80) indicates that yields are highly sensitive to a few days delay in essential operations. If this is the case, it is then necessary to know at the very least the fortnightly labor requirements for each activity over the calendar year. A smaller period of analysis is even better, but very costly form a computational standpoint. The supply of any additional resource that is scarce enough to constrain output should also be included in the formulation of the model, along with factor supplies required to produce one unit of each activity. One example of this might be arable land within the village boundaries.

The model can be analyzed in a linear programming context, under different assumptions about the willingness of farmers to forego grain production in favor of activities with a higher expected cash return. This procedure serves to identify the slacks and constraints for each resource and the opportunity cost of scarce (fully used) resources. The exercise will indicate those resource allocations which maximize annual farm income under different assumptions about farmer production goals. An extensive sensitivity analysis will deal with the implications of changes in assumptions concerning farm prices, crop yields, labor requirements for cattle, and the effect of animal traction on the latter two.

The linear programming methodology to be used is straightforward, yet the value of the results thus generated depends very much on the quality of the data. Precise information of the type required was not available for Upper Volta as of the summer of 1975. Dupont de Dinechin _et al_. (1969) and RHV-IRAT (1972) contain gross estimates of the number of "man/days per hectare" required to produce sorghum and groundnuts. These figures are given without documentation and appear to represent the estimates of expatriate personnel working under experiment station conditions. The voluminous work by Ancey contains a wealth of painstakingly compiled information on the economic aspects of Mossi society (Vol. III of ORSTOM, 1975). However, it is difficult to use much of it, since the series presented rarely correspond to the data requirements of a U.S. farm management survey conceptual framework. Labor times devoted to specific tasks are not disaggregated beyond "care of fields" and are not related to the land areas involved. Lahuec (1970) is perhaps the most valuable work encountered in this context. He conducted a year-long survey of resource use in a village of central-eastern Upper Volta over the 1968 growing season. The data on land use, agricultural practices, and incomes are quite useful, although the small sample of eight households may limit its ability to be generalized. It is unfortunate that an apparent lack of data processing facilities limited Lahuec's analysis of his labor data. The latter are not related to the field area concerned, to the type of crops, or to the tasks involved.

In order to generate the data necessary for an adequate test of the hypothesis elaborated in the previous section, the investigator designed and implemented a project to gather micro-level farm production data in the Savannah area of Upper Volta over a twelve month period. The project sought to provide detailed data that are as exact as possible from a sample large enough to provide sufficient observations for valid statistical inference. Besides the parameter values necessary for testing the principal hypothesis, the study attempted to generate the usual farm management data on yields; use of purchased inputs; the household labor force and the division of labor; harvests and sales; and the allocation of land areas of different types to different uses. This data, presented in chapters four through seven, may serve to provide a baseline for establishing the patterns of traditional agriculture within the research area in the absence of the influence of any major outside agricultural development program.

The field research area was chosen according to criteria made explicit in chapter two. The chapter also details the physical and ethnographic characteristics of the research site. The conceptual framework for data collection is the classic farm management survey based on repeated interviews (Collinson, 1972; Norman, 1973a; Shapiro, 1973; Cleave, 1974). The design and implementation of data collection are the subjects of chapter three. The chapter deals in detail with specific data collection objectives and methods, the research calendar, enumerator training, sample selection and characteristics, the data actually collected, and the problems of organizing the mass of information thus produced into a form suitable for analysis.

Chapter four examines the availability of different types of labor and its allocation to different ends for each stratum of the sample. Labor allocations of an average household are defined for different tasks, types of workers and end products. Chapter five outlines land availability and allocation to different uses for average farms within each stratum of the sample. Chapter six explores the availability and use of capital, treating livestock as a capital investment. Chapter seven portrays the extent and nature of the agricultural production of an average farm in Tenkodogo during 1976. Chapter eight shows how the basic linear programming production model of the peasant farm in Tenkodogo is constructed. Chapter nine gives the results of the maximization procedures used in running the model under different assumptions concerning the desired level of food grain production. An extensive sensitivity analysis is performed, showing the effect of changes in prices, yields, and labor requirements upon optimal solutions. Chapter ten introduces animal traction in order to model a combined enterprise involving ox ploughing and sales of mature cattle. In the absence of direct observations concerning animal traction, which is rarely used in the sample area, the effect of ploughing on yields and labor requirements is taken from an authoritative paper by pro-traction personnel in the major agricultural research station in Upper Volta. The final chapter concludes that farmers in Tenkodogo and similar areas do better to entrust their cattle to Fulani herdsmen, rather than attempting to keep the animals themselves. Efforts are made to show which assumptions are critical to this conclusion and under what conditions intensification of livestock production by sedentary farmers can best be expected to succeed.

CHAPTER 2

THE FIELD RESEARCH SITE

This chapter deals with the choice of research site, its characteristics, and its populations. The first section examines the criteria for the choice of site. These consisted of the geographical attributes required of an area to make it a suitable zone for testing the major hypothesis elaborated in the first chapter. In particular, the site had to be in an area where mixed farming was both technologically feasible and encouraged by the Voltaic government. Next, the location and characteristics of the chosen site were discussed with particular attention to climate, population density, crops, soils, and livestock densities and diseases. The research area in the southern portion of Eastern Upper Volta is presented as representative of much of the Savannah area of West Africa. A higher than average population density is the exception to the rule. However, this may help to elucidate future problems in other West African areas.

The final three sections of this chapter provide an introduction to each one of the three ethnic groups living in the research area. These are comprised of the Mossi and Bisa peoples, who are sedentary agriculturalists, and semi-sedentary Fulani herdsmen. The Mossi are the predominant ethnic group of Upper Volta and closely resemble their Bisa neighbors with respect to agricultural practices. The Fulani are the major herding group for all of West Africa.

Criteria for the Choice of Research Site

Six basic criteria were used to select the research site. They are discussed in order of importance. First, the location chosen had to be in a Savannah area, with physical characteristics that would permit choices among various activities. The possibilities needed to include livestock, millet and cash crop production. The latter were considered in order to give peasants a cash-earning option other than livestock.

The basic objective was to select an area with characteristics such that observed livestock activity reflects a choice between viable enterprises, as opposed to an area where livestock represents the only way to earn cash. On the other hand, the area chosen had to be far enough north to include larger breeds of cattle with strong Zébu features. These animals are typically unable to withstand the diseases carried by the insect population in the southern most areas of Upper Volta.[1] As a practical matter, the cash crop restriction meant an area with more than 800 millimeters of annual rainfall, while the livestock restriction implied a zone with less than 1,000 millimeters.[2]

Second, the area chosen needed to be in a region that was of interest for future policy intervention, since the purpose of the exercise was to be of use in such planning. In this vein, areas for possible consideration were confined to the perimeter of the USAID-financed Upper Volta Village Livestock Project.[3] This meant that the research location would have to be in one of the O.R.D.'s of Kaya, Koupela or Fada N'Gourma.[4]

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[1]Foremost among these is trypanosomiasis. Moving from north to south, the large Zébu cattle of the Sahel need to be increasingly interbred with trypano-resistant varieties from the south. The greater the degree of inter-breeding, the smaller the animals become, but presumably they are more disease-resistant. The small southern breeds, such as the N'Dama, tend to be poor milk producers. See G. Williamson and W. Payne (1974) pp. 154-155.

[2]This is not to deny that both livestock and cash crop activities exist outside these rainfall limits, but merely to constrain the research location to an area where either activity could be the primary occupation of a rural family.

[3]The field interventions of this project are scheduled to begin in 1977 and are designed to encourage livestock production by sedentary villagers in a Savannah area.

[4]The term "O.R.D." will be used throughout this monograph for "Organisme Régionale de Développement," or regional development authority. There are eleven O.R.D.'s in Upper Volta under the control of the Ministry of Rural Development, which also has administrative authority over the Livestock Service. The O.R.D.'s are, in most cases, run with heavy technical and financial support from one of several foreign donor agencies. Like all other officials in the Voltaic bureaucracy, the Director of an O.R.D. reports directly to the prefect (provincial governor) of the district that the O.R.D. covers.

This corresponds to roughly the eastern quarter of the country, excluding the northern portions. The location chosen needed to be close to one of the three branches of the Volta River, since the elimination of onchocerciasis will one day make these lands a prime area for government-sponsored agricultural programs. However, the site had to be one where traditional agriculture was practiced, since a study of a pilot village might lead to conclusions that could not be generalized with respect to other areas.

Third, the location chosen needed to include villages of different ethnic groups, within a feasible commuting distance of each other. The latter was defined as twenty-five kilometers, the maximum distance between enumerator outposts suitable for simultaneous supervision by the principal investigator. The purpose was to isolate those farming system characteristics which might be attributable to ethnic custom or tradition, rather than to the characteristics of the terrain.[1]

Fourth, the research site had to be accessible to a fairly good road leading to a major city. This restriction was made to ensure that the farming system studied had an outlet for food grains and cash crops, as well as livestock.[2]

Fifth, it was considered desirable that some prior data exist on the area, but not so much that the study was in itself unnecessary. The heavy research investment made by French researchers in the central part of the Mossi plateau, for example, made further effort in this area less important than in other parts of the country.[3]

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[1]The idea is that two or more ethnic groups which farm the same soils, with the same weather and other environmental conditions, will make the same adjustments to their farming techniques over the millennia, except for differences of "custom and tradition." This is not to deny that in many instances, customs and tradition within a given ethnic group reflect an adaptation, conscious or unconscious, to environmental conditions.

[2]An interesting characteristic of livestock is that its production is particularly suited to remote areas without access to roads. Cattle can always be trekked out, but grain and vegetable marketings are quite sensitive to the availability of transportation facilities.

[3]Most notable among the studies is the multidisciplinary Inquiry on Mossi Migration, O.R.S.T.O.M. (1975) in three parts comprising six volumes. The work by Mesnil (1970) on the failure of the SATEC animal traction experiment in the early 1960s also deserves mention.

Location Characteristics of the Chosen Site

The research site chosen is in the sub-prefecture of Tenkodogo, in the center-east district of the country (see figure 2.1).[1] The greater research area, from which villages were selected and within which all subsequent interviewing took place, comprises 450 square kilometers in a rectangle approximately thirty kilometers long and fifteen kilometers wide (see figure 2.2). The town of Tenkodogo is close to the midpoint of the eastern boundary of the rectangle.

The ethnic composition of the area consists of Mossi and Bisa peasant-farmers and Fulani herdsmen, with few exceptions. The Mossi predominate in the north and east of the region, while the Bisa are found to the south and west. The Fulani are scattered throughout the area in isolated pockets. The exact research site, for which no precise measurements are available, is defined by the contours of Oueguedo canton and environs, inhabited primarily by the Mossi; and Loanga, inhabited primarily by the Bisa.[2]

Estimates for the 1976 population in the greater research area are contained in Appendix A, Table A.3. These show that approximately 37% of the population of nearly 19,000 people in the greater research area are Mossi, 59% are Bisa, and 4% are Fulani. In the cantons of Loanga and Oueguedo proper (excluding Pouswaka and Gando) approximately three percent of the population are Fulani. The Oueguedo (Mossi) canton is densely populated, at 95 inhabitants per square kilometer. The Loanga (Bisa) canton has the lower population density of 36 inhabitants per square

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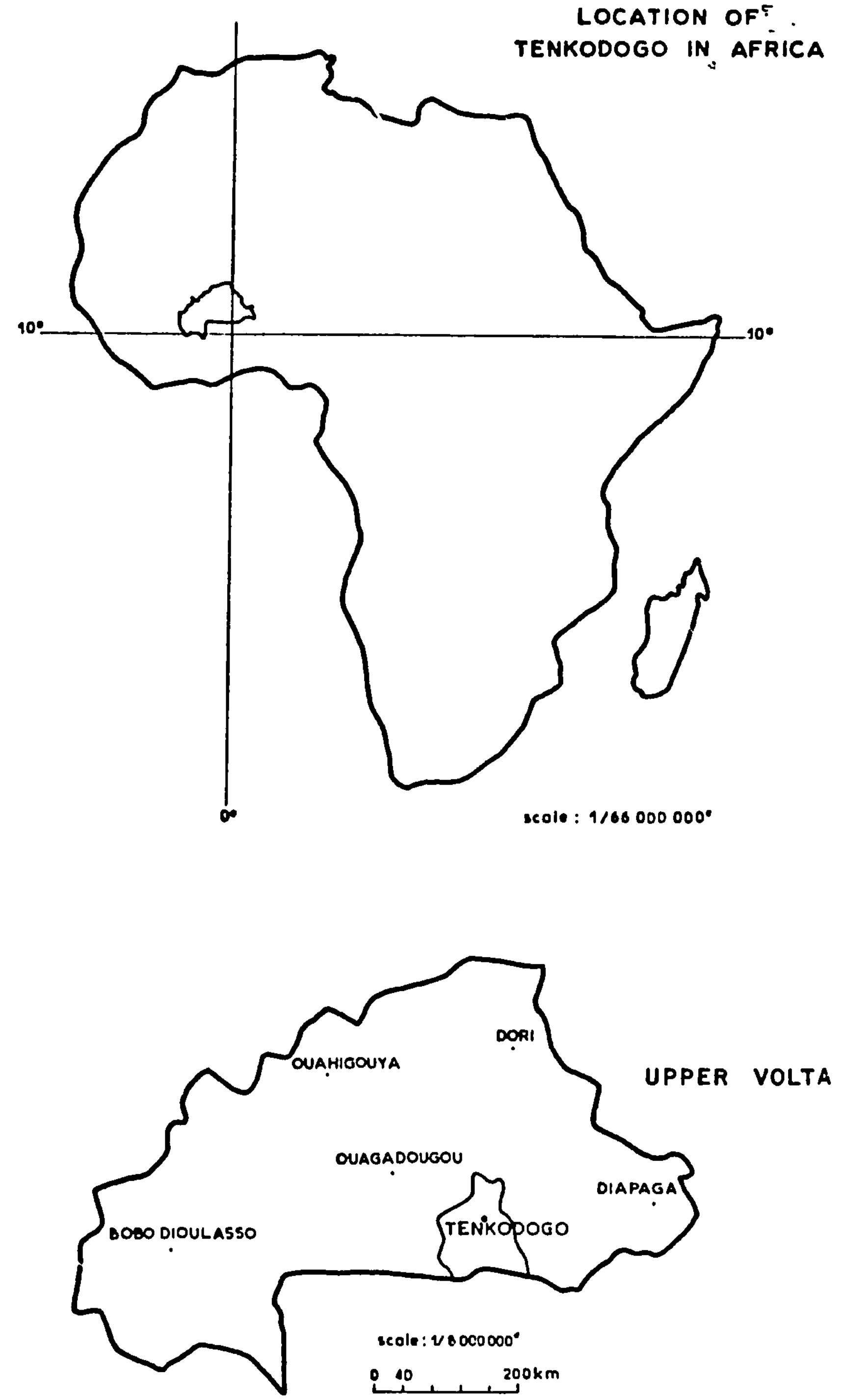
[1]The Center-East Administrative district (Préfecture) corresponds exactly to the borders of the "Koupéla" O.R.D., so-called because O.R.D. headquarters are situated in the sub-prefecture of Koupéla.

[2]Besides the cantons of Loanga and Oueguedo, as defined by the Voltaic administration, the greater research area includes the independent villages of Pouswaka and Gando which, for political reasons, report directly to the Chief of Tenkodogo. These villages form a part of the greater Oueguedo region geographically and economically, and are in fact separated from Tenkodogo by Oueguedo village. Since many of the Fulani herders who keep cattle for peasants living in Oueguedo reside in this region, it was included in the greater research area. This makes use of secondary data more difficult, since data for Pouswaka and Gando are often aggregated into totals for Tenkodogo canton.

FIGURE 2.1
LOCATION OF
TENKODOGO IN AFRICA



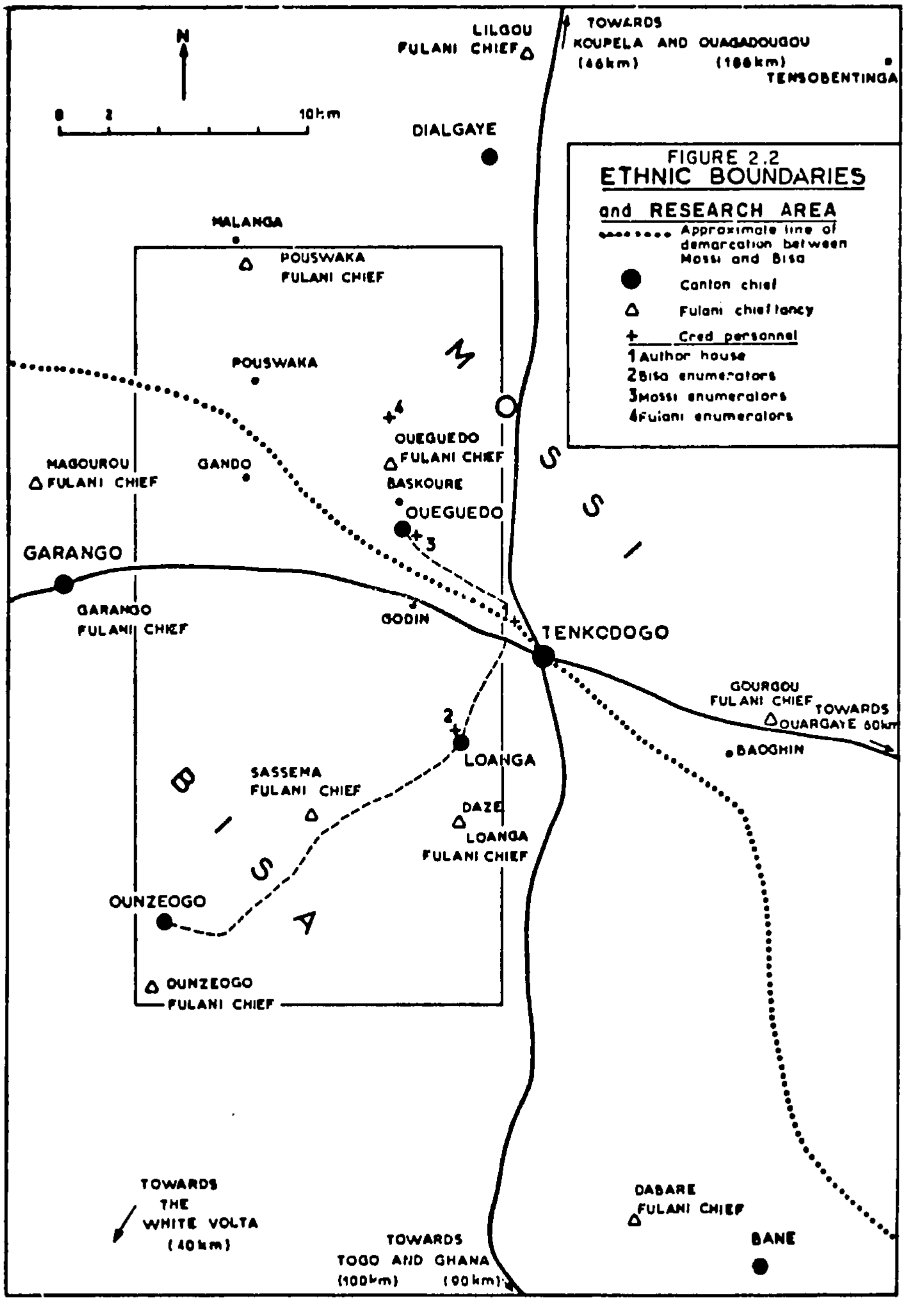


FIGURE 2.2
ETHNIC BOUNDARIES
and RESEARCH AREA
Approximate line of demarcation between Mossi and Bisa
Canton chief
Fulani chieftancy
Cred personnel
1 Author house
2 Bisa enumerators
3 Mossi enumerators
4 Fulani enumerators
N
0 2 10km
LILGOU FULANI CHIEF
TOWARDS KOUPELA AND OUAGADOUGOU (46km) (188km)
TENSOBENTINGA
DIALGAYE
MALANGA
POUSWAKA FULANI CHIEF
POUSWAKA
MOSSI
OUEGUEDO FULANI CHIEF
BASKOURE
OUEGUEDO
MAGOUROU FULANI CHIEF
GANDO
GARANGO
GARANGO FULANI CHIEF
GODIN
TENKODOGO
GOURGOU FULANI CHIEF
TOWARDS OUARGAYE 60km
BAOGHIN
LOANGA
SASSEMA FULANI CHIEF
DAZE
LOANGA FULANI CHIEF
BISA
OUNZEOGO
OUNZEOGO FULANI CHIEF
TOWARDS THE WHITE VOLTA (40km)
TOWARDS TOGO AND GHANA (100km) (90km)
DABARE FULANI CHIEF
BANE

kilometer, primarily because of large sparsely inhabited tracts along the eastern banks of the White Volta. The overall population density for the research area is approximately 41 inhabitants per square kilometer.

The town of Tenkodogo is roughly two-thirds Bisa and one-third Mossi. The traditional ruler of central eastern Upper Volta, the chief of Tenkodogo, is one of the three Mossi kings. With a population of 8,000 people, the town is a district headquarters for the Voltaic administration (chef-lieu de préfecture). A consumer-oriented market is held every three days, with large numbers of people attending from Oueguedo and Loanga. The villages are respectively eight kilometers to the northwest and five kilometers to the southwest.

An all-weather road through the town was completed in 1974, linking the Togo frontier (100 kilometers to the south) with the capital, Ouagadougou (185 kilometers to the northwest). Tenkodogo is at an ethnic crossroads in Upper Volta, since the region is astride the southern-most limit of the Mossi "Plateau," a name applied to the northwest-southeast band running across Upper Volta that contains most of the Mossi population. Gourmantché territory begins some fifty kilometers to the east of the town.

The land around Tenkodogo is representative of the Savannah, approximately 700 kilometers inland from the Ghanaian coast at the longitude of Accra. The trees are primarily deciduous fire-resistant varieties.

After the rainy season, abundant grass cover is available, including high quality fodders such as Andropogon Gayanus in wetter areas (Benoit, 1974, pp. 20-23). Grasses rarely grow over one meter and large areas are consumed by bush fires every dry season. Mango and shea nut trees are found in abundance.

The research area is primarily crop-oriented. Where there is a conflict between crop growing and stockraising, it is usually the latter which suffers (as we shall see). A majority of the inhabitants of the area derive their cash incomes from crop sales rather than livestock, even if the latter is defined to include poultry (O.R.S.T.O.M., 1975, II (3), Figures 17 and 18).

Rainfall in the area is sufficiently high to permit the growing of cash crops. A 25-year average of annual rainfall is 950 mm in 80 days of rain.[1] The principal limitation on cash crops appears to be the low fertility of the soils. Soils in the northernmost parts of the greater research area are typically composed of a thin layer of tropical ferruginous soil over clay and sand. To the south, soils are dark, with a content of over 30 percent clay on top of granite-derived clay and sand mixtures.[2] Formerly fertile soils are poor over the entire area due to intensive cropping with little fertilization and insufficient fallow. The crops most often sold are peanuts, rice from lowland rainfed plots, vegetables, and red sorghum.

The principal food crops are pearl millet (the staple), cowpeas, and a variety of an indigenous groundnut that resembles chickpeas in its processed form (pois de terre). Small amounts of maize are cultivated on organically fertilized garden plots. A small amount of cassava is grown as a hedge against crop shortfalls. The research region is more than self-sufficient in overall cereals production in years of average rainfall, as indicated in Table 2.1. Taste and price factors, however, may encourage farmers to produce red sorghum and rice in exchange for pearl millet produced in other regions. The conventional wisdom indicates that the Tenkodogo area is a potential "bread basket" for the Koupela O.R.D. (Garey and Storm, 1972).

Estimates of the livestock population of the area are given in Table 2.2. These figures must be used with caution since no systematic survey of the livestock population of the research area has ever been made, to the author's knowledge.[3] The approximate herd density in the greater

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[1] Jeune Afrique (1975) pp. 14-15. In 1976, rainfall was under 800 mm in 56 days.

[2] Data taken from O.R.S.T.O.M. 1/500000 soils maps of the area. See O.R.S.T.O.M., (1968).

[3] A census of a number of herds in the Oueguedo-Pouswaka area, reported later in this document, indicated that mean herd size is 28 head. When multiplied by the 52 Fulani families (the only group to keep cattle in the region) on the tax rolls in this area, the figure of 1,456 is obtained. Given the high degree of inaccuracy inherent in such calculation, this is amazingly close to the figure of 1,440 reported by the Livestock Service and reproduced in Table 2.2.

TABLE 2.1

CONVENTIONAL WISDOM ESTIMATES OF CEREALS PRODUCTION CAPACITY
AND CONSUMPTION IN THE TENKODOGO AREA
(in a Year of Average Rainfall)

Gross Production	Sub-Prefecture	Koupela O.R.D.
Millet	10,400	18,000
White and Red Sorghum	16,700	40,100
Maize	1,500	4,000
Rice (Paddy)	1,200	8,700
Total Cereals	29,800	70,800
Estimated Amount Necessary for Consumption Within Area (1976)	22,200	76,600
Potential Surplus Available for Sale	7,600	-5,800

SOURCES: The basic data for 1972 are from A. Garey and L. Storm (1972) p. 34. The figures are compounded annually at a growth rate of 2%, which can be taken as the overall growth rate of the Voltaic population during the seventies (Jeune Afrique, 1975, p. 22). This assumes that production grows at the same rate as population growth, which may not be the case at all. These figures are cited only as an example of the conventional wisdom.

research area is 9 head per square kilometer. This corresponds to roughly one-head of cattle per five people. Cattle density is highest in Loanga canton, which includes large, nearly unpopulated, stretches of the White Volta Valley. The density figures may be compared to national estimates for 1974 of 6.3 animals per square kilometer in the southern Savannah and 12 in the central Savannah (Table A.1, Appendix A). Using the same classification of areas, Tenkodogo would fall near the line of demarcation between central and southern zones. Thus, it can be inferred that the research area carries approximately an average load of cattle.

The Tenkodogo region is subject to trypanosomiasis-bearing insect infestation. For this reason, most of the cattle kept are of mixed breeds, with smaller trypano-resistant varieties well represented. The presence of tsetse flies only becomes apparent when moving into the southern portion of the greater research area, near the White Volta. It is also in this region that onchocerciasis has had a visible effect on the human population.[1]

In sum, the research area is on most counts, typical of the Sudano-Savannah belt stretching across West Africa immediately to the south of the Sahel. It is a little too dry to be of much value as a major cash crop area, yet its agriculture makes it self-sufficient in food, with a small surplus during years of average rainfall.

The rainfall for 1976 measured at the O.R.D. field station in Tenkodogo was considerably below average, particularly during the crucial period from the end of July through the beginning of August (Table A.4, Appendix A). On the other hand, rainfall in September and October was very high, which interfered with the pollination of the millet ears and lead to very low grain formation on each plant (Ibid.). During the 1976 harvest, there was a widely held belief within the research area, later confirmed by fact, that 1977 would be a deficit year when most farm families would have to either drastically reduce consumption or purchase grain from outside sources.

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[1]See Appendix B, Figure B.1, for the relation of the research area to onchocerciasis control programs.

TABLE 2.2

ESTIMATED NUMBERS AND DENSITIES OF PERMANENT CATTLE POPULATION IN RESEARCH AREA 1975

	(a) No. of Cattle	(b) Approximate Density of Cattle Pop. in Head Per KM^2	(c) Approximate No. of Resident Cattle Per Head of Permanent Pop.	(d) Revised Discussion Estimates for Total Dry Season Live-Stock Pop. Including Transients
Oueguedo Canton Proper	480	8.0	0.09	480 ($8/KM^2$)
Greater Oueguedo Area (Canton & Pouswaka & Gando Villages)	1,440[e]	8.6	N.A.	1,440 ($8.6/KM^2$)
Loanga Canton & Dependencies	2,630	9.3	0.26	4,000 ($14.2/KM^2$)
Greater Research Area (Defined in Figure 2)	4,070	9.0	0.21	6,200 ($13.8/KM^2$)
Koupéla ORD	85,000	9.6	0.24	133,000 ($14.7/KM^2$)
Upper Volta	2,500,000	9.5	0.43	2,602,000

SOURCES:

(a) Data from the Livestock Service field office in Tenkodogo and headquarters in Ouagadougou.

(b) Areas are approximations only. The decimal figure should not be construed as implying that the estimates are correct to one decimal place, but rather to provide comparable figures *vis à vis* national data.

(c) For human population, see Appendix A, Table A.3 (Figures deflated for 1975).

(d) Discussion estimate only, based on Livestock Service estimate that in 1975 45,000 transients, including refugees from the north, were still in O.R.D., compared to a permanent cattle population of 85,000.

(e) In an earlier paper, the author estimated their figure at 1,230, using raw data from Livestock Service field officers' reports. The figure here is slightly different, probably owing to the inclusion of a larger area in the statistical calculations.

The one characteristic of the research area which may be unrepresentative of the Savannah area as a whole, as opposed to Upper Volta in particular, is the relatively high population density of 41 inhabitants per square kilometer. However, the problems associated with population density are precisely those which exacerbate the difficulties of intensifying livestock activities in Savannah areas. Since increasing population density is likely to occur in the Savannah of the future, it is in this kind of environment that the constraints on increasing livestock production in southern areas should be defined.

The remaining three sections of this chapter will examine some of the principal characteristics of the three ethnic groups living in the research area. These are the Mossi, the Bisa and the Fulani.

The Mossi of Oueguedo

The Mossi are the largest ethnic group in Upper Volta, comprising just under half the Voltaic population of six million (Jeune Afrique, 1975, pp. 22-26). Oueguedo is one of the most southeasterly cantons of the ancient Mossi empire, with the Bisa to the south and west, and Yana and Gourmantché to the east on the other side of Tenkodogo.

The Mossi empire consists of three loosely related kingdoms, of which Tenkodogo is one. Social organization is hierarchical, with chiefs accorded a significant amount of respect. The canton is the basic unit of both traditional Mossi and European-inspired administration. The chef de canton is crowned by the Mossi king, although his official appointment is a prerogative reserved to the Voltaic administration. In practice, the administration consults traditional authorities and village elders before naming a canton chief. Appointments are for life.

Usually, but not always, the canton chief is succeeded by the eldest son of his first wife. If the eldest son is judged unacceptable by the village elders, the next son of the same mother is considered. In theory, any male of the region is eligible. In practice, candidates are chosen only from the extended family of the old chief.

The authority of the canton chief over his subjects in Mossi areas is considerable. In Oueguedo, the civil duties of the canton chief include the collection of taxes and administration of traditional justice in civil cases involving marriage, inheritance, and land disputes. He proposes candidates for village chieftainships to the central administration. He "owns" all the land of the canton and distributes usufruct over it to the village chiefs, who in turn distribute it to the actual users. The chieftainship of Oueguedo village is exercised by the canton chief of Oueguedo, just as the village of Loanga is directly ruled by the canton chief of Loanga.

Although the canton chief can, in theory, withdraw land traditionally farmed by a given family, this is very rarely done if the land is in use. Once planted, the harvest belongs to the planter. A major danger in leaving a field fallow for more than one year is that other members of an extended family may enter a claim over the land before the canton chief, who is entitled to redistribute the plot, and may actually do so upon the advice of the head of the lineage concerned. This presents a real danger in the case of plots in or close to the village, since there is fierce intra-village competition for this land among the families, as well as among young men of the same family.[1] The author found no fallow land in the center of Oueguedo village in either the 1976 or 1977 growing seasons. In addition, sample members report that in-village fields have been continuously cultivated since they can remember. The declining fertility of the soil in in-village fields is evidenced by the short stalks of millet with tiny heads. Pressure on land resources has forced most families in Oueguedo village to cultivate "bush fields" farther away from the center. Usually three to nine kilometers distant from the farmer's compound, they are much larger than the in-village fields. Since there is less competition for bush field land, there is less reluctance to leave bush fields fallow. While crop rotation is rarely practiced, preliminary research results indicate that bush fields are generally left fallow for several years, following three to five years cultivation.

The Mossi respect for authority is evident in the structure of the family. The basic family consists of the eldest brother of a line, his

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[1] ORSTOM classes Oueguedo among the areas with more than 40% of the land occupied. See ORSTOM (1975), II, (3), Figure 9.

wives, sons, and their wives and children, and unmarried daughters, as well as his younger brothers and their wives and children, except married daughters. Since the society is polygamous, this group can be quite large. The relative "age" of a half-brother is determined by the order of precedence of marriage of the brother's mother. The relative "age" of a cousin, in this context, is determined by the age precedence of the child's father. Thus, if a boy's father is younger than yours, he is your little cousin ("petit frère") even if he is twenty years older than you. The head of this family unit is the basic arbiter of family land and marriage decisions and his word is binding on all family members.

Within this extended family, there exists a more basic unit which serves to decentralize authority concerning production decisions. This "family" is best translated by "household," and in Oueguedo usually corresponds to those people who live within one compound. This is very convenient for research on production practices, since the compound is an easily enumerable unit from the standpoint of isolating the labor force that works on a given set of fields. Throughout this study, a household is defined as those people who are fed from the same fields and who all must work on the collective fields of the head of household. During the growing season, a head of household in Mossi areas (Zak'Soba) determines the daily tasks of all household members from before sun-up until about three in the afternoon. The research implication is that the agricultural activities of the entire household for most of the day can be accurately determined by interviewing the head of household, who functions as production manager. During the day, household members generally work on the fields of the head of household, which are all collective fields in the sense that the entire household works on them and eats from them.

Household members are free to cultivate their own personal plots after three in the afternoon, except during the periods of greatest labor demand when everyone stays on the collective fields until dark. Personal fields very often contain cash crops. The product of the collective fields belongs to the head of household, to dole out to his wives as he sees fit. The product of personal fields belongs to the cultivator. Often a head of household will send his wife to market produce from collective fields and let her keep a commission. Women can also earn money for themselves and their children by selling gathered shea nuts or processed foodstuffs, such as millet beer.

Periods of peak labor demand witness the practice of the "Labor Invitation" (Sosoaga), which is fundamental to the Mossi social and economic system. The head of household issues invitations to his friends and neighbors to come help him cultivate his fields. The practice is most common at the times of weeding and harvesting. By issuing such an invitation, the head of household is assuming obligations vis à vis participants, the symbolic expression of which is to offer them copious amounts of millet beer and sometimes food, after work. A man who has many obligations owing to him (as in those accruing from a prospective son-in-law who is obligated to work for his future in-laws) and who has access to a supply of red sorghum for millet beer, has considerable control over the social means of production.

Inheritance in the Mossi society of Oueguedo is from father to eldest son. If there is no son, the inheritance goes to the next oldest brother. The estate which passes in this manner consists of the land and livestock controlled by the deceased as well as the services and obligations to younger brothers and children of the deceased. One practical consequence of this is that younger brothers must seek land of their own from the head of the extended family, or else from the village chief.

One explanation for the prevalent phenomenon of the migration of young Mossi men to the coastal countries in search of work is their desire to escape the all-pervasive paternal authority and pressure on land. The definitive French study of the subject of Mossi migration found that 24 percent of the total male Mossi and Bisa population were not present in the regions of birth (O.R.S.T.O.M., 1975, II (2), p. 49). Nearly 40 percent of the young men from 20 to 24 years old were absent over the entire Mossi Plateau (Ibid., p. 50). The typical migrant is a young bachelor - 80 percent of the migrants are under 25 years of age - seeking to earn enough money to return to his homeland to marry and settle down (Ibid., pp. 65-76). Oueguedo is no exception to these findings, with many of the heads of household having sons in the Ivory Coast. The French study estimated that 45% of the men 15 to 39 years of age in the Oueguedo area were absent on migration during 1973 (O.R.S.T.O.M. (1975), II (3b), Figure 4.

Cash incomes are low among the rural Mossi, as is the case for most West African Savannah peasant groups. Detailed information on the subject for 1974 is available for the Mossi community in Zorgho, 50 kilometers to the north of the research area (O.R.S.T.O.M. (1975), III, pp. 84-86). This shows an average annual cash net income of 28,324 CFA per household.[1] Sales of unprocessed foodstuffs account for 27 percent of the total.[2] Nearly one third of the income came from cash remittances of relatives working away from the village. Net sales of livestock, meat and fish accounted for 7 percent of income.

Cattle ownership is a very sensitive topic among Mossi peasant families. While many households own cattle, the state of the family herd is usually a well-guarded secret. Conversations with peasants divulged three main reasons for this. First, livestock holdings are equivalent to family savings. Knowledge about amounts are secrets passed from father to eldest son. Often, women in the family do not know (or are not supposed to know) the number of animals involved. Second, cattle holdings are taxed at the rate of 200 CFA per animal. Goats and sheep were not taxed in 1976. The average farmer is as anxious to have his true holdings examined by an outsider as a fee-paid professional in the U.S. is to have a tax audit of his checking account (for the same reasons, in many cases). Third, members of a communal society such as the Mossi are reluctant to release information that might revert to their neighbors about their relative wealth. They fear such information could lead to jealousy as well as to increased claims on their "lending" capacity.

Many Mossi peasants own cattle in Oueguedo, but the author could find none who kept their cattle at home at any time of the year.[3] Cattle are typically entrusted to Fulani herdsmen, who keep them outside of the village most of the year.[4] Despite efforts by the O.R.D., there was no

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[1]During the 1976-77 interviewing period 240 CFA = US $1, on average.

[2]Two percent of the total was attributable to the sale of millet-sorghums.

[3]Estimates of Mossi cattle holdings will be dealt with in a later section.

[4]The nature of this relationship is dealt with extensively in Delgado (1977).

significant adoption of bovine animal traction in the canton by 1976.

On the other hand, most families keep sheep and goats in the village year-round. The sheep and goat droppings are almost always used as fertilizer on fields near the compound. During the rainy season, these animals are attached to stakes in the village, away from crop stands. They browse on the grasses that they can reach. After the millet harvest in November, the millet stalks are woven into fences around garden plots. At this time, staked small ruminants and corraled pigs are released to browse on the stubble. During the dry season, small ruminants are fed peanut and cowpea stalks and leaves, which are stored out of their reach on straw and wood shade platforms. Bran from millet beer brewing is usually fed to swine.

The first perception of the Mossi society of Oueguedo is of a peasant-farming culture, based on smallholder plots, largely oriented to producing subsistence grain, with a small amount of cash crops. The latter are sold along with the odd chicken and surplus grain in order to meet the basic requirements for cash, such as taxation and medicine. During the wet season from May until October, the village of Oueguedo proper presents itself as a diffuse agglomeration of walled compounds lost among the tall stands of sorghum on in-village fields. Each compound contains several huts and a small stand of maize is planted around the outer wall. Beyond the maize, a mixture of red sorghum, pearl millet, and cowpeas is grown over an area of perhaps one half of a hectare. Members of the compound can be seen cultivating small, irregularly shaped patches of pearl millet and cowpeas, peanuts, and chick peas throughout the village, but generally away from the walls of compounds. In lowland areas, small plots of rice, sweet potatoes and manioc are to be observed, along with mango trees and a considerable proportion of fallow ground, unlike elsewhere in the village.

During the dry season, from November until April, the green mass of the sorghum and millet gives way to a dreary wasteland of bare hummocks, containing only the roots of the millet stalks. The air is foggy from the high dust content of the atmosphere, blown along by a ceaseless dry wind from the northeast. Surface water soon disappears into the cracked earth and the village wells run dry. It is a common sight at this time to see the women of the village carrying ponderous earthenware jars of water several kilometers on their heads. The brownish liquid is from muddy holes freshly dug in lowland areas, where an occasional herd of emaciated cattle browses, searching for grasses along the dry watercourses. The cattle are driven by Fulani herdsmen, who are very different in appearance from the peasants, with long ochre boubous and bell-shaped straw hats. They roam over the village fields in search of scarce pasture. The herdsmen can often be seen scurrying ahead of the animals, to stay between them and the juicy leaves of a peasant garden plot protected only by a thin fence of woven millet stalks. Meanwhile, the peasants watch warily over their gardens, weaving straw under the coolness of a shade tree, perhaps reflecting already upon next year's planting.

The Bisa of Loanga

The population of the canton of Loanga is composed of three percent Fulani herdsmen and ninety-seven percent Bisa peasant-farmers (Table A.3, Appendix A). The latter account for a little less than five percent of the population of Upper Volta (*Ibid.*, Table A.2). They occupy the land east of Tenkodogo and as far south as Toga and Ghana. Long ago, Loanga village was the capital of the Bisa people. Then, according to legend, Mossi warriors surprised the chief on a market day. The chief's heir managed to escape to a hilly area twenty kilometers to the east, near Garango. The dynasty he founded was still having sporadic encounters with the Mossi chief of Tenkodogo at the time of the French Conquest, around the turn of the century. The Bisa of Loanga, however, remained colonized by the Mossi of Tenkodogo and, outwardly at least, imitated many of their manners. The author often overheard peasants in Loanga speaking among themselves in *Moré*, rather than in Bisa.[1] Despite the outward similarity of institutions, however, there are marked differences of personality between the Mossi of Oueguedo and the Bisa of Loanga.

[1]Bisa is part of the Mande linguistic family, which also includes the Samogo and the Bobo-fing of western Upper Volta. Moré, the language of the Mossi is part of the Voltaic language group. See Pégard (1966).

In this vein, the Bisa adopted the Mossi model of canton chief with the encouragement of the French colonial and later the Voltaic administration which gave him the same legal powers as his Mossi counterpart. Nevertheless, a distinct difference in attitude can be observed between the subjects to the two chiefs. The word of the Mossi canton chief is law. In Loanga, people often answer the chief's request for labor help because of personal respect for the individual. While both Mossi and Bisa peasants prostrate themselves on the ground in greeting their chiefs at audiences, the Bisa speak using the informal "thou" which would be a grave insult to a Mossi Chief. It is probable that a Mossi Chief would have more latitude for enforcing an unpopular development program than a Bisa Chief.

Within Bisa society, the head of an extended family of brothers, comparable to the Mossi extended family, has much of the authority over family members that is reserved to the chief in Mossi society. The participation of Loanga in this study was authorized by a council of family heads advising the Chief, whereas in Oueguedo the Chief took the decision alone and informed the village afterwards.

The Bisa of Loanga fall within the "Mossified" section of the Bisa zone defined by Tauxier.[1] As such they practice the same system of inheritance, land tenure, and labor invitation as the Mossi. The Bisa production unit in Loanga is also organized around the household, as defined in the previous section. However, there is one major difference in this respect. Whereas household and compound are for most purposes the same in Oueguedo, there may be several households in any given compound in Loanga, where a compound can be very large. This means that care must be taken in enumerating the potential labor force available to work on a given set of fields.[2]

The farming system employed by the Bisa is not noticeably different at first glance from that of the Mossi in terms of technology or crops grown.[3]

[1]One of the early French administrators of Tenkodogo. See Tauxier (1924) pp. 165-170.

[2]The author counted nearly one hundred people living in the compound of the Chief of Loanga.

[3]This assertion is evaluated more fully below.

The resource availabilities in terms of climate and soils are approximately the same, as is the proximity from Tenkodogo. While population density is much lower in Loanga canton than Oueguedo canton, the density of land occupation within two or three kilometers of the two villages is not noticeably different to a casual observer. Loanga canton includes large tracts of uninhabitated land along the White Volta river.

Unfortunately, Bisa attitudes towards the privacy of livestock holdings are not noticeably different from their Mossi neighbors either. Anthropologist Odette Pégard writes of the Bisa of Garango (twenty kilometers west of Tenkodogo):

> Generally, only the head of household knows the size of his herd, along with the Fulani who looks after them. He will tell the secret to his heir (his eldest son) before his death.[1]

Interestingly enough, Loanga has the same percentage of Fulani herdsmen to population as Oueguedo, even though the density of cattle per square kilometer is significantly lower in the latter (Table 2.2 above and Table A.3, Appendix A).

The Fulani of Greater Oueguedo

The Fulani are a pastoral group spread over the length and breadth of West Africa. They are also the predominant population in the truly Sahelian part of Upper Volta, in the Djibo-Dori-Sebha axis and the second most numerous ethnic group in Upper Volta after the Mossi (Jeune Afrique (1975) p. 26). Scattered pockets of Fulani live in the savannah areas of Upper Volta, the most important concentrations being in the Nouna-Bobo-Dioulasso axis in the west, the Ouagadougou-Kaya axis in the center, and the two isolated pockets of Kantchari in the far east and Tenkodogo in the center east (*Ibid.*, pp. 28-29).

[1]Pégard, (1966) p. 129. (My translation from the French).

The Fulani in the research area live in groups of one or two isolated compounds, usually in bush areas away from Mossi or Bisa settlement. Among the Fulani, a compound refers to a geographically distinct cluster of woven-straw huts. Unlike the Mossi and Bisa, there is no wall around the "compound." Very often a Fulani compound consists of only members of a nuclear family, or several nuclear families with the same husband in the case of polygamy.

Although Loanga canton contains a sizable number of Fulani inhabitants, results concerning the Fulani in this monograph are based on the herdsmen living in greater Oueguedo, in the northern half of the research zone. The author made a number of visits to the Fulani in the southern part of the research area. As a practical matter, it was difficult to interview the Fulani in both Oueguedo and Loanga on a regular basis, because of their isolation. Research efforts were concentrated upon the Fulani inhabitants of Oueguedo rather than spreading resources too thinly.

The Fulani exhibit a well-known suspicion of outsiders meddling in their affairs--perhaps to a greater extent than other ethnic groups do in Upper Volta. To obtain accurate research results, the investigator needs to proceed slowly and to avoid exhibiting too overt an interest in sensitive parameters such as herd size, at least in the early stages of interviewing. In response to this viewpoint, the author approached the Fulani of Oueguedo very cautiously, and was eventually rewarded by an understanding and a welcome he will never forget, as was the case among the peasants of Oueguedo and Loanga.

Unpublished research by Tahirou Diao, a Fulani born in the Oueguedo area, indicates that the herdsmen of that region arrived from the Macina area of Mali in the 18th century.[1] This was before the arrival of the current ruling Mossi family. The Fulani of Oueguedo should be considered permanent residents of the area, rather than recent arrivals from the north. This last finding may be contrasted with research on the Fulani living on the east bank of the White Volta Valley, whose case may be analogous to

[1]Cited with permission. For details, Mr. Diao can be contacted via the Catholic Relief Service Office in Ouagadougou. This finding was confirmed by both the canton chief of Oueguedo and Fulani community members.

that of the Fulani in Loanga living in the remoter parts of the canton. During a census conducted in July 1976, Rochette (1976, p. 10) found that 40 percent of the Fulani in the area had arrived within the last three years, 20 percent within the last two years.

The Fulani of Oueguedo were politically absorbed by the Mossi conquest of Tenkodogo. Thus, the Mossi and Bisa canton chiefs of the Tenkodogo area--vassals of the Mossi king of Tenkodogo--each have "their" Fulani, a qualifier still in use today.[1] Each peasant canton chief has a Fulani advisor, called the Fulani chief. The Fulani chief reports to the canton chief.

In Oueguedo, the principal role of the Fulani chief is to act as a go-between for the herdsmen and the canton chief. In particular, he collects the taxes and remits them to the latter. If the canton chief has received a complaint concerning a herdsman, it is the responsibility of the Fulani chief to bring the accused to him for judgement.

In some respects, the Fulani chief appears much like a Mossi village chief. However, his Fulani "subjects" are spread over several villages. While the peasant village chief has considerable real power in the allocation of land, the Fulani chief must operate primarily through moral suasion. Furthermore, the Mossi peasants readily accept the authority of the village and canton chiefs. The Fulani herdsmen, on the other hand, appear to have a more independent position vis-à-vis both.

Nevertheless, real power resides with the canton chief and it behooves all who wish to continue living in Oueguedo to avoid his wrath. By Mossi custom, the descendants of Fulani families who occupied land in Oueguedo before the arrival of the ruling Mossi clan have a right to some land. In practice the precise location of that land depends on the good will of the canton chief. This is even more true in Loanga where the claim to historical land rights is vaguer.

The Fulani in the research area are all Muslims, in contrast with the Mossi and Bisa, who are primarily Animist, with a moderate number of Christians and a small number of Muslims. There is some fraternization

[1]Being called this, incidentally, galls the Fulani more than any other qualifier, in my experience. See Diao, op. cit.

between Muslim peasants and Fulani herders, but little intermarriage. There is a moderate degree of intermarriage between Mossi and Bisa peasants within each religious category.

The Fulani family structure is renowned principally for the independence of the women members and the individualism shown by sons, who often move far away from parental authority after marriage. A woman's male relatives have particular responsibilities towards her children, in matters of cattle ownership and inheritance.

The Fulani of Oueguedo may be classified as "semi-sedentary" in their herding practices, since part of the family unit occupies the family compound year-round.[1] On the other hand, some of the young men take the herds to better pasture and water points in early May, returning two months later to help with cultivation.

While peasant society in Oueguedo and Loanga is primarily preoccupied with crop production, the Fulani have three major functions. First, they are cultivators. Second, they are herd managers for Mossi peasants and civil servants. Third, they are cattle owners and stock raisers. During the rainy season, the Fulani of Oueguedo usually cultivate fields in a circle around the compound. Cattle are kept at night in a thorn-bush corral, just beyond the fields. The Fulani claim to particularly dislike agricultural activity, but admit to its necessity.[2] The crop mixtures planted resemble those of the neighboring Mossi. Red sorghum is planted in the immediate vicinity of the compound. The location of the corral from the previous dry season is planted with maize and sometimes cotton. The rest of the cropped area around the compound is intercropped with red sorghum, millet, and cowpeas.

These results can be compared with the findings of Rochette (1976, p. 3) for the White Volta Valley area 50 miles northwest of the research

[1]This follows the classification scheme used by Rochette (1976). In the White Volta Valley, he also found sedentary Fulani (where the herd never moved any distance) and migrants, where men and herds were on the move six months of the year.

[2]In this, the Fulani of Oueguedo resemble their northern cousins in the Djibo area. See Riesman, (1974), p. 76.

site. He found that the Fulani there very rarely grow red sorghum, but do grow white sorghum. In Oueguedo, white sorghum is almost never grown. Both the peasants and the Fulani claim that this is because yields are low.[1] Unlike the peasants, the Fulani will eat red sorghum as a food grain, since the gritty dumpling it produces is palatable with milk, but reputedly unappetizing without.[2] All the Fulani interviewed, however, claimed that millet was the staple.

Red sorghum is grown intensively in the whole Tenkodogo area, since yields are reportedly very good.[3] The principal use for red sorghum is for making beer which the Fulani, as Muslims, are not supposed to drink. However, red sorghum may be considered a "cash crop," even if not sold. The Fulani can receive help in their agricultural tasks from their peasant neighbors by having a peasant woman brew beer with their sorghum. They then distribute it to the work force in the fashion of Mossi labor invitations. Most families affirm that they need to buy two to three sacks (about 250 kg total) of millet a year.

The primary occupation of the Fulani is stockraising. They function in this capacity both as herd managers for Mossi cattle owners and as livestock owners themselves. The cattle under the care of one household are usually kept in one corral, adjacent to the compound. The Fulani prefer to keep the number of head in one corral under forty, to provide some insurance against the spread of disease, for easier control and, perhaps, greater discretion. A relatively rich household may have several corrals. A compound may also have several smaller corrals if married sons elect to stay in the compound of their father.

A typical household herd contains about forty animals, two thirds of which may belong to peasants.[4] In return for herding services, the

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[1]Probably due to a mineral deficiency in the soil.

[2]The peasants eat red sorghum only as a last resort, as in the case of U.S. food aid in 1974.

[3]This assertion will be supported further on in this study.

[4]The rest of the results in this chapter are based on interviews of a random sample of twenty herding families in the Oueguedo area. For a fuller discussion, see Delgado (1977), pp. 32-43.

Fulani occasionally receive small gifts of cash (500 CFA) and cola nuts; the usual renumeration is usufruct of the milk from the cows. Women sell all the surplus milk on their own account, while the head of household has sale rights over the crops, with the exception of small amounts of cotton grown by the women. The milk yield is often so low from December until May that the herders leave all the milk to the calves.

Besides the milk from cows belonging to peasants, a traditional element of the remuneration for herding services, has been the usufruct of the manure in the corrals. Every Fulani to whom the author spoke confirmed that dung is collected and spread on the fields. Recently, however, peasant proprietors have begun to request use of manure, sending their children with baskets to collect it. This appears to be a manifestation of the awareness of the declining fertility of in-village soils, in addition to the expansion of market gardening and the traditional use of manure as a building material. Cattle droppings form an essential ingredient of indigenous cement. The Fulani, for their part, resent these requests and regard usufruct of the cattle manure as their right--a proprietor who wants some should pay for it.[1]

Management decisions concerning the portion of the herd belonging to peasants are most often left to the herder, with final approval coming from the owner. Purchases and sales of healthy animals are made at the request of the proprietor. A peasant expresses the desire to buy an animal to his herdsman, who transmits the interest to other herdsmen by word of mouth. The radius of search may include herds transitting south and sellers up to 50 kilometers away. When the herdsman finds the type of animal sought by the peasant, he negotiates over the price with the seller. The latter is another herdsman who may be representing either himself or a peasant. When a tentative price is agreed upon, the herdsman brings the prospective proprietor to see the animal, or simply gets his agreement based on description and price. The peasant gives the money to the herdsman who concludes the transaction and collects the animal.

[1]I am indebted to Tahirou Diao for this point.

When a peasant proprietor wishes to sell a given animal, he informs his herdsman. The Fulani locates a buyer. In the case of very old cattle, this may be an agent for a butcher from Tenkodogo. Animals in their prime are often sold to collectors from the cattle market in Pouytenga, 50 kilometers north of the research area. The herdsman reports a prospective price to the owner who either accepts or declines. There is no easy way to know whether the actual sale price corresponds to the amount of money the peasant approves. If the proprietor is pleased with the sale price, he may give 1000 CFA to the Fulani.

Urgent sale cases occur when an animal is sick. Judgement as to the animal's chances are left to the herdsman. Most of the Fulani interviewed said that they would sell an animal without warning the proprietor, if necessary. The remainder said that all the proprietors of their herds were sufficiently close that they would make every effort to get approval before sale. When a sick animal dies in the bush, the Fulani brings the head of the animal to the proprietor as proof of the death. When a sick animal is sold, the proprietor must accept the herdsman's word on the price received, which may be one fifth of that of a healthy animal. If an animal belonging to a peasant is sick, but not in danger of death, the herdsman treats the animal and eventually informs the owner. If an animal is taken to the veterinary service in Tenkodogo, the proprietor is warned in advance since he must pay for vaccinations and medicine.

The herdsman can decide when to begin milking a cow and when to wean a calf without informing the proprietor. The herdsman must inform the owner of all births. The offspring always accrue to the proprietor and are almost never given to the herdsman. It is difficult for the herdsman to cheat in this matter, since proprietors visit the herds often enough to be aware of calvings.

The annual migration in search of better pasture is the herding operation that requires the greatest bond of trust between peasant proprietors and herdsmen. The majority of Oueguedo herds leave the area of peasant settlement for over two months, beginning in early May and ending in July. At this time the herds may be 60 kilometers away from the peasant owners. All management decisions must be made by the herder alone. The herdsman cannot abandon the rest of the cattle to bring back the head of a dead animal for the proprietor to see, yet many animals die at this time when animals are weakest, just after the dry season.

One third of twenty Fulani families interviewed denied informing owners when they leave on transhumance. The other two-thirds replied that they informed either the owners or the Mossi chiefs of Ouéguedo or Pouswaka before leaving. If an owner objected to his cattle being taken, his animals are left with Fulani household members who stay in Oueguedo, to fend as best they can. An owner very rarely interferes, however, with the management of the cattle by the herdsmen.

Besides herding cattle for the peasants, the Fulani breed and keep their own cattle. Property rights over cattle among the Oueguedo Fulani are basically the same as for Fulani elsewhere in Upper Volta.[1] Formally speaking, all cattle in the household corral that do not belong to peasants or other owners outside the household "belong" to the head of household. However, each family member can "own" cattle within the household herd, in the same sense that an automobile may belong to an American teenager, even if it is registered in his parent's name. The head of household can sell his own cattle and that of his unmarried sons without the consent of the latter, although this will provoke dissention within the family. In theory, the husband cannot sell cattle belonging to a wife without her consent, although he can exert considerable pressure on her to agree should the need arise.

Unmarried children and wives cannot sell their own cattle without the consent of the head of household. A married son living in the compound will not sell any of his cattle kept in his father's herd without informing him in advance. When children marry, they acquire full property rights over the cattle they own. Cattle belonging to a daughter are moved to the corral of her husband at the time of marriage. A son can choose to build his own corral and compound, at which point his cattle transactions are completely independent of his father. If a woman seeks a divorce or if she abandons her husband, her cattle revert to him. If the husband seeks to repudiate the wife, without due cause in the view of her family (such as flagrant adultery), he must return her cattle to her male relatives.

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[1]For the western region, an excellent account is contained in Queant and C. de Rouville (1969), I, pp. 181-89. For the north, see Riesman (1974) p. 95.

The Fulani of Oueguedo have five legal ways of acquiring ownership of cattle. These are inheritance from a parent, gifts from a father or a maternal uncle to a child, acquistion from a son-in-law as bridewealth, gifts from a proprietor of cattle for herding services (rare), and purchase of young cattle with proceeds from the sale of old stock. Often, cattle acquired as bridewealth will be returned to the son-in-law in the form of a gift to the children of the match at their birth.[1]

In conclusion, the field research site is rich in ethnic diversity and economic role differentiation. It provides a forum for observing the production requirements for cash and subsistence crops, as well as for livestock. The next chapter deals with the methodology, problems, and product of data collection within the research area.

[1]Although not necessarily the same animals.

CHAPTER 3

THE DATA COLLECTION METHODOLOGY AND PRODUCT

The chapter begins with an analysis of the data collection objectives and methods of the farm management survey conducted by the author during the 1976-77 agricultural year. A second section discusses the nuts and bolts of enumerator selection, training and placement. Enumerator performance was found to be surprisingly satisfactory. A third section outlines the procedures used for sample selection and the composition of the sample chosen. The latter, in its final form, consists of forty-one Mossi and Bisa peasant families. An extra sample of twenty Fulani families is chosen for providing data needs relative to livestock. A fourth section outlines the range of data collected. The final section in the chapter discusses the choice of fortnights as the basic period of analysis and some technical problems in aggregating semi-weekly household interviews. This section also provides a key chart for relating fortnightly periods to the 1976-77 agricultural calendar.

Data Collection Objectives and Methods

Objectives.-- The first objective of data collection was to provide accurate information on the inputs and outputs of the agricultural production processes at work in the peasant society of the research area. The inputs include all labor, land, financial and physical capital, and technology. The latter is understood in the broad sense of the timing and nature of operations, as well as the implements used. The outputs include data on total and average yields of all crops, sales of poultry and eggs, sales of meat and livestock, sales of processed foods and non-agricultural products and services. In brief, the study sought to obtain all the data necessary to the calculation of a set of factor requirements for each output under a given technology, the returns to factors in different activities, and the opportunity costs of each output. The second objective of data collection was to provide as much information as possible on the inputs and outputs of the production process of the Fulani herdsmen. Ideally, herders would be treated just like the Mossi and Bisa in this respect and answer the same questions from the same questionnaires. The third objective of data collection was to gather information on quantifiable parameters likely to affect peasant and herder decision-making. These include the monthly level of rainfall, price trends, trends in soil degradation, historic patterns of field use, tax levels and the like. The fourth objective was to acquire information on key institutions related to production processes. Prime examples of these are the "labor invitation" during periods of peak labor use and the entrusting of cattle to Fulani herdsmen.

A Measurement Problem: "Flow" and "Stock" Data.-- While one or two interviews may suffice to determine the number of agricultural workers present in a given household in 1976, clearly they cannot provide information on the amount of labor provided last July on field X. Since the amount of labor furnished by each worker may be highly variable over seasons [1] and since the timing of agricultural labor input may be as important as the quantity,[2] it is important to have some form of data collection procedure operating at the time the labor is being performed. The same general observations apply to fertilizer use, insecticide inputs, and sales or purchases. Outputs of the agricultural system in the Savannah also typically occur over a period of months.[3] These variables measure phenomena of a "flow" nature, and a "quasi-continuous" data collection procedure is necessary in order to obtain accurate results.

A twice-weekly interviewing procedure was adopted to fulfill this objective. Basically this involved visiting each household in the sample at least twice a week, to ask them about all labor performed since the last interview, as well as information pertaining to the use of fertilizer

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[1] This is the very meaning, of course, of the term: "peak season labor requirements."

[2] See Ruthenberg (1976), p. 80.

[3] In Tenkodogo, the harvest of red sorghum begins in early September and that of pearl millet ends in late December.

and insecticide, sales, purchases, and harvests during the previous three or four days. The interviewing procedure follows the methodology developed by Shapiro (1973, pp. 88-153). The considerations underlying the frequency of interviews are the high cost factor which tends to discourage over-frequent interviewing, and the accuracy concern, which would indicate daily interviewing under ideal conditions. The solution adopted appears to represent a reasonable compromise.[1]

In contrast to "flow" data, a number of variables are susceptible to measurement by "one-shot" interview techniques, at least in theory. These phenomena may be categorized as "stock" variables. Examples pertinent to this study are land holdings, cattle ownership, field histories, capital stock, and the like. Although some of this information may be sensitive, the data for the year can be gathered with accuracy during one or two interviews once the sample member is predisposed to answer the questions. Except for very sensitive data on cattle holdings, the most satisfactory solution proved to be administering the questionnaires once at the beginning of the interviewing period and then revising them at the end. It was not judged feasible to plunge in at the beginning with a herd inventory questionnaire. This type of information gathering is best done at the end of the interviewing period, when the relationship between the principal investigator and enumerators on the one hand and the rural community on the other are somewhat solidified.

The Twice-Weekly Interview.[2] -- Enumerators visited each farm twice a week for a full year. Data collected during these visits were recorded on forms such as that partially reproduced in Figure 3.1. Each form was used once, for one visit to one farm. Thus, each farm generated two forms

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[1]By dint of experience, four days is the maximum period over which farmers can accurately recall all the tasks performed by themselves and their families on collective plots. Should one member of the household not be available during the interview, members of the family generally answer for him or her, provided that the period referred to is not more than several days prior to the interview.

[2]Since the methodology used was developed by Shapiro (1973, Chapter 3), the exposition in this sub-section is virtually identical to that by Shapiro (1973, pp. 104-118). The information has been included as a convenience to the reader.

per week or 104 in a year. The forms allowed both a convenient way to record hours of labor allocated to different activities and other flow data, and an easy way to code that data for immediate keypunching.

Each person in the household was asked to recall all his or her activities, from sun-up to sun-down, since the previous interview. A typical interview took place in the evening and covered the activities of the previous two days as well as the day of the interview. Since the enumerators did not work on Sundays, one of the two weekly interviews covered four days rather than three.

The enumerator recorded each activity as it was described and did not translate it into standard categories. A list of standard categories and codes was subsequently elaborated, based upon lengthy conversations with the enumerators prior to the commencement of the field interviewing, and also upon the experience of the first three weeks. Some new codes were added over the year of interviewing as new activities were encountered. The final list of codes is reproduced in Figure 3.2. The manual designed to initiate enumerators to interviewing is reproduced in Appendix C.

The manual for enumerators also contains a standardized key for translating expressions of time used by inhabitants of the research area into hours of the day. The procedure was elaborated by a roundtable discussion involving the project enumerators. Besides linguistic distinctions between different times of the day, additional help was obtained by noting the time children left school, the height of the sun, and religious observances such as daily prayers.

The composition of the household was determined according to the principals stated in Chapter 2. The names of members were listed on a form (Questionnaire A, Appendix C), along with their age and relationship to the head of household. This enabled the enumerator to prepare the column headings of the interview sheet prior to visiting the household. The enumerators also listed all the fields that the family intended to plant during the growing season of 1976, and revised the list one month into the agricultural period. Questionnaire B (Appendix C) was used to give a number to each field cultivated by the household. Information on crops planted was included, along with an estimate by the head of household

C | NOM DE L'ENQUÊTEUR : Bonkoungou Jean-Christophe

MENAGE 47 SEMAINE 29 JOUR 5

PERIODE DU : 16.11.76 AU : 19.11.76

AGE	39	40
SEXE	M	F
CODE	02	05
NOM DU TRAVAILLEUR	Minoungou Marcel	Sorgho Maria

TERRAIN	CULTURE	CODE	ACTIVITÉ	CODE JOUR	M[1]	M[2]	S		TOTAL	[illegible]	M[2]	S		TOTAL
02	Petit mil	01	couper les épis	18	8				08	7				07
			Voyages entre champs	80	1				01					
			S'occuper des porcs	32	3	3	3		09					
02	Petit mil	51	récolte en paniers moyens	02										
01	Petit mil	01	couper les tiges	17			4		04					
01	Petit mil	01	ramasser les épis	18								6		06
01	Petit mil		récolte en paniers moyens	02										
			écraser le mil égrené	52							5			05
			préparation du repas	68							2			02
			Détente	76	-	9	5		14	5	5	6		16

FIGURE 3.1

An Actual Interview Sheet From A Semi-Weekly Visit

	08		99		07					
	Innvitées (6) Femmes		Reculte		Invités (5) Hommes					
		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL
2		42								
			30	30						
					20	20				
	30	30								
			5	05						

FIGURE 3.1 (continued)

of the area of the field, and its approximate distance from the compound. In most cases, these characteristics were sufficient to distinguish a given field in conversation with the farmer. In the case of two similar fields planted close together, containing the same crops and out of sight of the compound, additional information was required, however. This was provided by placing a color-coded stake in at least one of the fields in question. It could thus be established, in a typical interview, that on Wednesday, Awa weeded field number 5, containing millet and cowpeas, from sun-up (6 a.m.) until the school recreation period (10 a.m.), or a period of 4 hours.

Besides labor allocations, the twice-weekly questionnaire served to record the quantity of fertilizer applied to a given plot. This was done by substituting a fertilizer code ("98") in the place of the labor code in an extra column of the sheet. A code representing the unit of measurement replaced the activity code for the line in question. By a similar procedure, data on harvests, sales and purchases could be recorded under a labor code "99" with the "activity" code specifying the type and unit of magnitude of the transaction.

The Supplementary Questionnaires.-- In addition to the questionnaires A and B, outlined in the previous section, "one-shot" questionnaires D, E, H, I, J, and K (reproduced in Appendix C) were used to supplement the data in the twice-weekly questionnaire C. The information thereby obtained pertains (respectively) to: monthly commodity prices, yield plot results, herd inventories, herd management, field histories, capital goods.

Questionnaire D was designed to collect monthly commodity prices, but the desired product resembled data gathered by the O.R.D. field station at Tenkodogo so closely that it was dropped in the interest of efficiency. Questionnaire E was used to record data on approximately 170 yield plots. These were initiated as a check against yields derived from the twice-weekly questionnaire. The questionnaires on herd inventories, herd management, and capital goods could each be completed in one visit to the household concerned. Questionnaire J on field history had to be filled out for each field. This involved several trips to each household in order to complete the series.

FIGURE 3.2

LIST OF ACTIVITIES CODED IN SEMI-WEEKLY INTERVIEWS

I. Crop Mixture And Product Codes

01 - Pearl Millet
02 - White Sorghum for Human Consumption
03 - Red Sorghum
04 - Maize
05 - Rice
06 - Cowpeas
07 - Groundnuts Other Than Peanuts
08 - Cassava
09 - Sweet Potatoes
10 - Red Sorghum, Millet, Cowpeas and Peanuts
11 - Fruits (Mangoes, Guavas, etc...)
12 - Tomatoes
13 - Onions
14 - Red Sorghum and Rice
15 - Peanuts and Red Sorghum
16 - Vegetables Besides Onions, Tomatoes and Okra
17 - Red Pepper, Other Spices, Salt
18 - Peanuts
19 - Cotton
20 - Tobacco
21 - Red Sorghum and Cotton
22 - Cotton and Maize
23 - Maize and Tobacco
24 - White Sorghum and Cowpeas
25 - Millet and Cowpeas
26 - Red Sorghum and Cowpeas
27 - White Sorghum, Millet and Cowpeas
28 - Pepper and Tomatoes
29 - Pepper, Onions and Tomatoes

FIGURE 3.2 (cont.)

30 - White and Red Sorghum
31 - Objects in Baked Earth (Pots and Jugs)
32 - Large Livestock
33 - Sheanut Butter, Other Wild Crops
34 - Wooden Objects (Hoe Handles, etc.)
35 - Straw Objects (Mats, etc.)
36 - Metal Objects (Hoe Blades, etc.)
37 - Chemical Products (Soap) and Other Merchandise
38 - Edible Oils
39 - Cloth and Clothes
40 - Electrical Machines (Radios, Sewing Machines)
41 - Bicycles and Mopeds
42 - Millet Beer
43 - Red Meat
44 - Small Livestock and Fowl
45 - Kerosene
46 - Red Sorghum, Millet and Cowpeas
47 - Red Sorghum, Millet, Cowpeas and Cotton
48 - White Sorghum, Cotton and Cowpeas
49 - Mixed Groundnuts

II. Activity Codes

(a) Field Work Codes

01 - Bush Clearing
02 - Burning
03 - Removing Roots
04 - Leveling
05 - Ridging (3rd Weeding)
06 - Ploughing
07 - Spreading Manure

FIGURE 3.2 (cont.)

08 - Sowing
09 - Separating
10 - Weeding
11 - Transplanting
12 - Draining
13 - Watering
14 - Spraying Insecticide
15 - Fencing
16 - Guarding Fields
17 - Harvesting: Cutting the Stalks
18 - Harvesting: Cutting the Heads of Grain
19 - Threshing
20 - Drying
21 - Selling Harvest
22 - Providing Labor Help in Neighbors' Fields
23 - Transportation of Agricultural Products

(b) Stockraising Work Codes

24 - Sweeping the Chicken Coop, Selling Chickens
25 - Gathering Eggs
26 - Fetching Water for Fowl
27 - Fetching Termites for Feeding Fowl
28 - Feeding Fowl
29 - Watering Small Stock
30 - Cutting Grass for Feed
31 - Herding Small Stock
32 - Taking Care of Pigs
33 - Watering Large Livestock
34 - Training and Exercising Horses
35 - Building Stables
36 - Looking for a Lost Animal
37 - Taking Cattle for Salt Licks
38 - Milking Cows
39 - Health Care of Animals

FIGURE 3.2 (cont.)

(c) Hunting and Gathering Codes

40 - Fishing Activities
41 - Hunting Activities
42 - Gathering Sheanuts
43 - All Other Gathering of Wild Fruits, Roots, etc...

(d) Upkeep of Material Activity Codes

44 - Repairing Agricultural Tools
45 - Making Tool Handles
46 - Gathering Manure, Fetching Seeds
47 - Cleaning of Agricultural Produce
48 - Sorting of Produce

(e) Household Chore Codes

49 - Sewing and Washing Clothes
50 - Fetching Water for Household Use
51 - Fetching Wood for Fuel
52 - Shelling Cereals with Mechanical Mill
53 - Shelling Cereals with Mortar
54 - Grind Flour with Mortar
55 - Grind Flour with Mill
56 - Preparation of Meal, Other Than Making Flour
57 - Other Household Chores
58 - Go to Dispensary, Being Immobilized Due to Physical Condition
1 day = 12 hours

(f) Non-Agricultural Labor Code

59 - Repair and Construction of Wells
60 - Straw Weaving Handicraft Work
61 - Weaving Hut Construction Materials (Mats, Walls, Roofs)

FIGURE 3.2 (cont.)

62 - Gathering Straw for Weaving and Construction
63 - Construction and Repair of Buildings
64 - Metal Work
65 - Fabrication of Earthenware
66 - Repair of Machines, Bicycles etc...
67 - Commercial Activity in Village (Selling)
68 - Preparing Food and Beer for Sale
69 - Making Bricks
70 - Other Nonagricultural Work in Village for Money
71 - Other Nonagricultural Activity Outside Village for Money
72 - Nonagricultural Labor Help Supplied to Neighbor
73 - Go to Market
74 - Transport of Nonagricultural Products

(g) Other Codes and Additions

75 - Bathing in Watercourse
76 - Leisure Activities, Drinking Millet Beer
77 - Attending Nonreligious Meeting
78 - Religious and Customary Activities
79 - Go to School
80 - Travel to and Between Fields
81 - Watering Gardens
82 - Being Away on a Trip (1 day = 12 hours)
83 - Shelling Peanuts and Other Non-Cereals
84 - Seeding Cotton and Kapok
85 - Weaving and Spinning

FIGURE 3.2 (cont.)

III. Unit Measurement Codes

01 - Large Basket
02 - Average Basket
03 - Small Basket
04 - Kilograms
05 - Dish (Local Measurement)
06 - Tin Grain Measuring Can (Local Measurement)
07 - Grain Sack
08 - Litre
09 - Gourd
10 - Large Pot
11 - Average Pot
12 - Hundreds of CFA Francs Earned
13 - Hundreds of CFA Francs Paid
14 - Pile (Local Measurement = 1 kg of Cotton)

IV. Labor Category Codes

(a) Household Labor

Age-Sex Category			Code
	7-14 years	:	01
MALE	15-60 years	:	02
	61 + years	:	03
	7-14 years	:	04
FEMALE	15-60 years	:	05
	61 + years	:	06

FIGURE 3.2 (cont.)

(b) Invited Labor, Visitors, School Children Home on Vacation Older Than 14

Category		Code
Male	:	07
Female	:	08

(c) Hired Labor

	Code
	09

Conversion of Weights and Measures.-- The measurement of harvests presents a particularly thorny methodological problem for farm management surveys (Norman, 1973, pp. 22-26; Collinson, 1972, pp. 278-283). The yield plot method gives highly variable estimates on average yields in areas with a high degree of intercropping, as in Tenkodogo (Ibid.).

In addition to yield plots, this study used a variant of the "Five-Unit Method" (Norman, 1973, p. 25). This involved enumerating the total number of units of volume of each crop removed from each field and recording them on the regular interview sheet. The problem was then to go from the units of volume of freshly harvested produce (usually in ears) to conventional units of weight of dry storable produce (usually grain). A two-step procedure was used in order to remain within the bounds of feasibility. Each enumerator was issued identical units of measurement, consisting of: (a) a metal bowl which was by volume exactly one-seventh of a "tine." The latter is a standard local grain measure equal to approximately four gallons by volume. (b) "Small", "medium" and "large" baskets which approximated as closely as possible the size of baskets used by local farmers to transport produce from the fields to the processing area next to the compound. This equipment had the double advantage of being light and inexpensive. During the interviews, the enumerators asked farmers to estimate the amount of produce harvested within the previous half-week. The farmer was then asked to show the enumerator the unit of volume used. In turn, the enumerator visually compared the volume of the farmer's unit to that of one of the survey units, and listed the total harvested in terms of survey units.

Conversion factors were calculated for each of the latter. This was done in both Loanga and Oueguedo villages by asking five different farmers to set aside the volume of a given crop corresponding to one of the survey unit volumes. The portions of the harvest to be set aside were chosen randomly, under the supervision of the enumerator. When the crop samples had dried (after about one week), they were threshed or otherwise processed into their final storable form. The samples were then weighed in kilograms. The weights for a given crop and unit obtained in each village were sufficiently close to justify the use of one overall conversion factor, for analytical convenience.[1] The conversion factors retained are listed in Table B.1 of Appendix 3. The weight of the harvest from a given field was calculated by multiplying the total harvest of each crop in survey units by the appropriate conversion factor. The average yield is then computed by dividing the total yield in kilograms by the area of the field in hectares. The result can then be compared to yield plot results.

Measuring Field Areas.-- The measurement of field areas turned out to be one of the most time consuming of all tasks in the survey. While aerial photographs exist for areas adjacent to the research area, no work less than twelve years old is available for either Oueguedo or Loanga. The investigator and the enumerators began by measuring the irregularly shaped fields using compasses and twenty-meter tape measures. An example of a scale drawing of a field, chosen at random from the author's files, is reproduced in Figure 3.3, and is typical of the shape (but not the size) of fields in the Tenkodogo area. The final sample contained 738 fields.

It was soon apparent that a measurement technique dependent upon using tape measures and scale drawings to calculate field areas was not feasible, given the time required to complete each sketch and then measure the surface using a polar planimeter. Pacing was then substituted for tape measurement by using an "average" stride for each enumerator. This was based on at least twenty different measurements of twenty paces, over different kinds of terrain. The distances and angles measured were recorded on computer coding sheets, and the areas were calculated by a computer in Ann Arbor.[2] Checks of differences in measurement between pacing and tape measurement of distances show no substantial difference, on the average. There are small variations in the estimates of the area of a given field calculated by computer and the area calculated using a scale drawing and polar planimeter. However, no trend could be discerned as would be the

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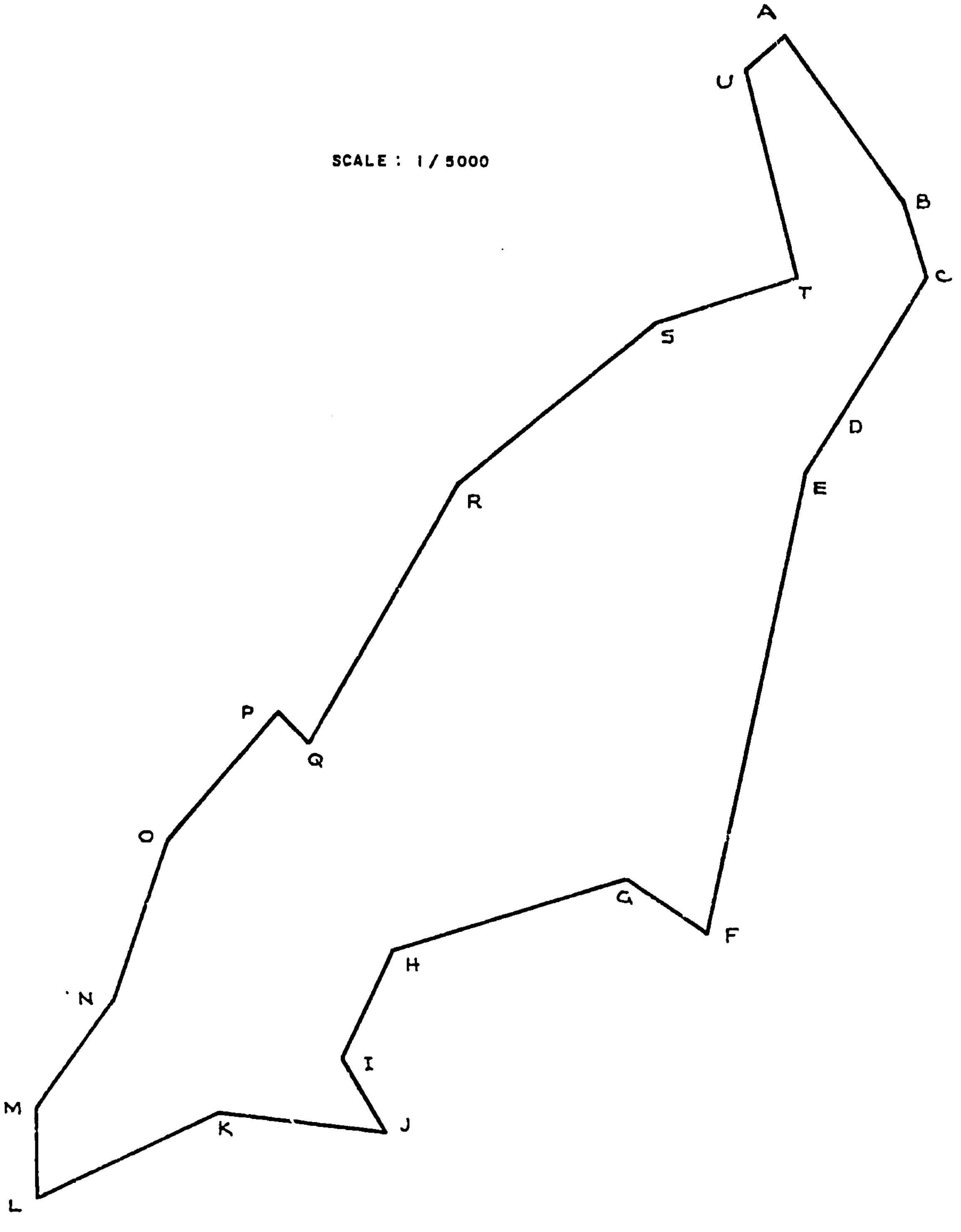
[1]This was the simple average between the two village measures. On most crops, the differential between the two estimates was less than 10% of the average estimate.

[2]The basic computer code for doing this was written by K. Shapiro and documented in Shapiro (1973), pp. 119-136.

FIGURE 3.3

REPRODUCTION of a SKETCH of a MILLET FIELD in TENKODOGO



case if one technique consistently led to a larger estimate than another. Differences in the results from the two techniques are most likely due to operator error in the use of scale drawings.

The Research Calendar and Enumerator Training

The Research Calendar.-- The principal investigator arrived in Upper Volta in October 1975 to serve as an Assistant Professor of Economics at the Ecole Supérieure de Sciences Economiques of the University of Ouagadougou, for the 1975-1976 school year.[1] The first five months in-country served to acclimatize him intellectually and physically, and to obtain research permission from the Minister of Plan and Rural Development, upon the request of the Minister of Education. The month of March 1976 was spent making contacts at all levels from the Ministry of Rural Development to the O.R.D. field office level, as well as finalizing the choice of research site.

The author made his first trips to the villages of Loanga and Ouegeudo in the first days of April 1976. The canton chiefs were briefed on the project and permission was obtained to refurbish a compound in each area for the use of the enumerators. Enumerator selection and training were accomplished in Ouagadougou during the first two weeks in April and the men were installed in the villages by the end of the month.

Explanation of the project at all-village meetings and sample selection occurred during the first week of May. The enumeration of sample household members and field holdings required at least one week, not counting visits by the enumerators to each field. The unusually early advent of the rainy season on May 9 forced a hurried beginning of the twice-weekly interviews.[2]

[1] Under a program of the Center for Research on Economic Development of the University of Michigan, with the financial support of USAID.

[2] The Ouegedo enumerators were in position a week before the Loanga staff, and thus were able to begin interviews immediately after the big rainfall of May 9. The Loanga enumerators also conducted interviews at this time which subsequently had to be discarded, because of the poor quality of the results. Accordingly, data for the first fortnight of interviewing for Loanga has not been used. For analytical purposes, the Bisa of Loanga were assumed to make the same labor allocation between crops and activities during the first fortnight as their Mossi neighbors.

Familiarization of the enumerators with the main questionnaire had been achieved previously.

The enumerators interviewed sample members twice-weekly from May 9, 1976 until May 8, 1977. In addition to the regular interviews, which usually took place between six and nine in the evening, the enumerators administered the supplementary questionnaires and measured fields and harvests during the day.

Enumerator Selection and Training.-- Research funds permitted the hiring of five enumerators.[1] An appeal was launched over the national radio station for experienced enumerators belonging to the Mossi, Bisa and Fulani ethnic groups. The ethnic group restriction reflected concerns expressed by local authorities to the effect that any staff resident in one of the villages should be of the same ethnic group as the villagers. Twenty individuals presented themselves for interviews conducted by the principal investigator at the Centre Voltaique de Recherche Scientifique, Ouagadougou.

The interviews lasted approximately fifteen minutes each and sought to distinguish between experienced and inexperienced individuals. The conversation most often concerned relations between civil servants and peasants at the village level. The author specifically sought to avoid individuals with patronizing attitudes toward the rural population, or people who for some other reason would not be suitable for one year's service in the bush.

It is both interesting and discouraging that no Fulani enumerators came to be interviewed. The most likely explanation for this is that both CVRS and ORSTOM had recently completed massive studies on the Mossi and Bisa regions, thus ensuring the presence of a large supply of trained but unemployed enumerators. This was not the case with the Fulani.

The nine most promising Mossi and Bisa candidates were invited for further training prior to a possible job offer. The author conducted a ten day training session at the classrooms of the University. The programme of the session is reproduced in Appendix C. Training sought to

[1]The net monthly cost per enumerator, including housing, taxes, vacation and all allowances except transportation was $145/month on a 12 month basis.

achieve a double goal. First, the nearly two weeks spent discussing ideas together served to identify those individuals most suitable for selection. Second, the training session helped to initiate the principal investigator into the "location specific" aspects of the research. The preliminary list of work categories and the ways of converting local time expressions into hours of the day are cases in point. Besides teaching the author much he did not know, this approach served to bolster enumerator morale.

Five enumerators were offered jobs at the end of the training period. Two Bisa were to be stationed in Loanga and two Mossi in Oueguedo. A fifth (Mossi) enumerator stationed in Tenkodogo, would serve as a support person and replacement in the case of illness. The enumerators selected come from diverse educational backgrounds, with one who had failed his Baccalauréat (high school degree) and one who had only had six years of primary schooling.

An Evaluation of Enumerator Performance.-- The success of the training program may be judged by the fact that four out of the five individuals performed well throughout the year, often under very trying circumstances. The one bad experience was an enumerator hired as a second staff member for Loanga. This individual's problems were serious and he was dismissed after two months. The successful enumerators adjusted well and did not hesitate to ask questions when they did not understand a particular issue.

Probably the single most important factor in successful data gathering is staff morale. The principal investigator spared no effort in this respect and feels strongly that the investment was justified in terms of results. A regular feature of supervision of the project was a semimonthly meeting of the entire project staff at the author's house. The agenda of the sessions included group discussion of research problems encountered in the villages and the recording of a common solution. This procedure was invaluable in finalizing the code manual, as well as providing a forum for airing complaints and forestalling intra-staff grievances.

Sample Selection and Characteristics

The Original Research Design and the Herder Study.-- The original research plan was to select a sample stratified over the Mossi, Bisa and Fulani ethnic groups. However desirable this approach, its lack of realism soon became apparent. Difficulties in obtaining a suitable Fulani enumerator fostered doubts about the feasibility of using a Fulani stratum in the sampling. This state of affairs was compounded by the geographical location of Fulani compounds, deep in the bush areas of greater Oueguedo and Loanga, far away from enumerator housing. Research funds could not provide the Mopeds (motorized bicycles) required for regular enumerator visits. It was a demanding task to initiate the survey among sedentary farmers using enumerators from the same ethnic group and under the protection of a favorably disposed chief. Even these elements were lacking in the proposed Fulani stratum; accordingly, it was dropped.

During the course of the research, a Fulani from the greater Oueguedo area, who did not finish school, proved to be both able and willing to serve as an enumerator and interpreter. By this time, the project had functioned eight months in the region without visible repercussions of a negative nature for sample members. The author was able to gradually contact Fulani families resident in the greater Oueguedo area. The appreciation of the U.S. dollar relative to the CFA franc during the 1975 to 1977 research period permitted the subsidization of a Moped and the hiring of the Fulani staff member.

By February 1977, it was too late to initiate twice-weekly interviews, since the agricultural season and thus the period of peak labor use was over. However, it was still desirable to learn as much as possible about livestock practices in the Tenkodogo area. Thus, a random sample of twenty Fulani households was chosen, which represented a little less than two fifths of the permanent Fulani residents of that region.[1] Only one household of the twenty-one approached refused to cooperate.

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[1] According to the tax rolls of the Fulani chiefs of Oueguedo and Pouswaka.

The Fulani stratum was visited repeatedly by the author and the Fulani enumerator during the first five months of 1977. Answers were obtained from a specialized herder interview, containing fifty-seven questions and designed to be administered in six visits per household (Questionnaire L, Appendix C). The herdsmen were also interviewed on those supplementary questionnaires which were relevant to their situation (all of Appendix C, except forms E, H, I, J).[1]

The Design of the Peasant Sample.-- The elimination of the Fulani from consideration for twice-weekly interviewing during the 1976-1977 season meant that the available enumerators could all be used in the Mossi and Bisa parts of the research area. It had been decided earlier to give the same weight to the Mossi and Bisa strata; therefore, research personnel were divided equally between the Mossi and Bisa parts of the research area.

Each enumerator was judged able to handle five regular interviews a day, in addition to field measurements and the supplementary questionnaires. In retrospect, this figure appears to be about right for peasant groups. Since the interview is repeated twice during the week, each enumerator could handle fifteen households. Given that one enumerator was required as a general support person in Tenkodogo, and since research funds did not permit hiring additional enumerators in 1976, the total sample size was effectively limited to approximately sixty peasant households. The plan was to sample independently thirty Bisa households from the Loanga area and thirty Mossi households from the Oueguedo area for the purpose of making useful statistical inferences based on sample variances. Ideally, the sample frame for each stratum would be composed of all the households resident in the appropriate part of the research area. The textbook sampling procedure then dictates that thirty names of heads of household be

[1]The cooperation subsequently obtained from the Fulani was excellent. As an outgrowth of this initiative, the author was able to obtain agreements from a subsample of twelve Fulani households to participate in twice-weekly interviewing during the agricultural season of 1977. The project was therefore able to accomplish in 1977 that which was not possible in 1976. Funding to finance this additional research was obtained from the Regional Economic Development Services Organization (West Africa) of USAID. This research is still in progress, under the supervision of the Voltaic counterpart who participated in this study, Mr. Laurent Ouedraogo of ORSTOM, Ouagadougou. Results will be forthcoming in a report to REDSO/WA of July, 1978.

drawn at random from the frame. The next step would be to present oneself to the sampled households, to elicit their cooperation.

At this point, two major practical problems arise. First, the goal of interviewing five households a day per enumerator requires that the households be situated within reasonable proximity to each other, if they are intended for interviewing on the same day. This distance may be taken as a circle of one kilometer radius. The figure takes into account the fact that interviewing during the agricultural season is constrained to the hours of darkness, from six to nine in the evening - practically the only time the head of household is home. It is difficult to ask staff to travel on a regular basis more than a few kilometers in the dark, on a bicycle, with the added likelihood of rainfall. Thus, each enumerator can handle three clusters of five households each. For the same reasons that the households in each cluster need to be relatively close together, the center of each cluster cannot be more than two or three kilometers from the enumerator compound in any direction.

The second major practical problem in sampling concerns the maintenance of enumerator morale throughout the research period. It was decided to house the enumerators by pairs following the practice of the Rural Economy Research Unit in Northern Nigeria (Norman, 1973, p. 17). The hardships of living away from family in a rural area, under rudimentary conditions, are somewhat mitigated by the companionship of another staff member.

The consequence of these practical considerations in enumerator placement is that a staff of two enumerators per canton should be concentrated in one village in each canton. This follows from the constraints imposed on the perimeter of action of the two enumerators. This is limited to a circle of approximately three to four kilometers in radius. It is not feasible to include households with compounds outside these bounds in the twice-weekly interviewing schedule. Livestock herds and bush fields maintained by sample members outside the sampling area can be visited during the daytime on an occasional basis.

The canton of Oueguedo contains twelve administrative villages, while Loanga has twenty-two. Ideally, the village sampled in each canton should be chosen randomly from the list of villages. In practice, this was not possible, given the novelty of a farm management survey in the area. The canton chiefs each expressed a strong desire that the research should take place in the villages that they controlled as village chiefs, as well as regional chiefs. The cooperation of the canton chiefs was a sine qua non of the study, and the author preferred to concede this point rather than to force the issue. Thus, the villages of Oueguedo and Loanga proper were selected for sampling.

These two villages have the advantage that they are comparable in every respect except ethnic identification. Both villages have the same degree of access to Tenkodogo market during the rainy season. They are built on opposite sides of an almost imperceptible valley formed by the watershed on the Tcherba river.

Soils and climate are approximately the same, as is the density of population within the circle of four kilometers radius defined by the enumerators' compound in each village.[1] The similarities between the two villages suggest that major differences in farming practices between them are attributable primarily to social, rather than physical, characteristics of the two areas.

Selection of Sample Households.-- The major concern in household selection was to include households which would provide truthful and complete information, as well as representative data. While random sampling helps ensure obtaining the latter, the first two elements can never be taken for granted. Unlike "one-shot" interviews, the inconveninece to sample members of repeated-visit surveys is considerable. Kenneth Shapiro (1973, p. 97) makes the point nicely, speaking of his sample in Tanzania:

> The extent of of their sociability may be judged by imagining how American families might react if asked to give up an hour of their time twice a week for a full year; to recall all their activities since the previous interview; to provide full information on all their earnings and purchases; to aid people in measuring their land; to provide details of their educational, occupational and residential history; to take a test on their agricultural knowledge; and so forth.

[1]Even though the canton of Loanga as a whole is much less densely populated than the canton of Oueguedo. See Table A.3, Appendix A.

An essential requirement for a household participating in a farm management survey is that it do so on a volunteer basis. Peasant families would never refuse giving some answer when approached by strangers operating under the authority of the canton chief. It is truthful answers that are required. To obtain this type of information, sample members must be aware of and accept the goals of the study. This last requirement is only coincidentally compatible with random sampling based on tax rolls.

The sampling procedure involved a two-step approach. The principal investigator first paid particular attention to briefing all the civil servants in Tenkodogo who might have contact with the villagers such as school teachers and nurses about the goals of the project. This was in addition to the courtesy calls paid to higher functionaries. The rationale behind this was that it is to the local, lower level civil servants that the chiefs will turn to discuss the meaning of the study and its advantages, after the first visit to the village by a foreigner. Coincidentally with briefing the civil servants, the principal investigator visited the canton chief in each location in the company of an agent from the O.R.D. field office. The investigator presented the projected study in French. The O.R.D. agent later repeated the outline in More for the benefit of village elders who had come to listen to what the stranger had to say. The chief in each location was asked to call a meeting of all the heads of household in the village. The meetings were scheduled to take place two weeks after the first visit of the investigator to the village. The purpose of the delay was to permit full discussion of the project within the village in the meantime.

The O.R.D. agent presented the project and its objective, in More, at both of the heavily attended all-village meeting. After thirty minutes discussion, during which the canton chiefs also spoke in favor of the study, volunteers were asked to raise their hands. About two-thirds of those present (approximately sixty people) volunteered, at each meeting. The investigator chose the canton chiefs first, as a necessary courtesy.[1] Then he walked among the crowd designating individuals with

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[1]The canton chiefs and their immediate families were nominally included in the survey, but excluded from analysis as being atypical of the peasant households.

raised hands at random, until thirty households had been obtained in each village. A map was made of Loanga village showing both sampled and unsampled compounds later in the survey. The resulting drawing, reproduced in Figure 3.4, shows the geographical spread of compounds sampled over the area of the village. The sampling procedure appears to have given a representative cross-section of the village. Besides geographical spread, no obvious factors (such as a preponderance of close relations of the canton chief) were present to mar the ability of generalizing the results. The same appears to be true of the Oueguedo sample.

Households Retained at End of the Research Period.-- Households were dropped from the final sample for any one of three reasons. There were cases where the household was obviously unrepresentative of the population, as the canton chiefs were; cases where the information from a household was obviously unreliable, for any reason, and cases of staff error leading to a grossly incomplete set of interview records.

Under the first category, the interviews of the canton chiefs of Loanga and Oueguedo, and of the older brother of the chief of Oueguedo were not analyzed along with the rest of the data. These individuals clearly had atypical access to land and the labor services of their subjects.

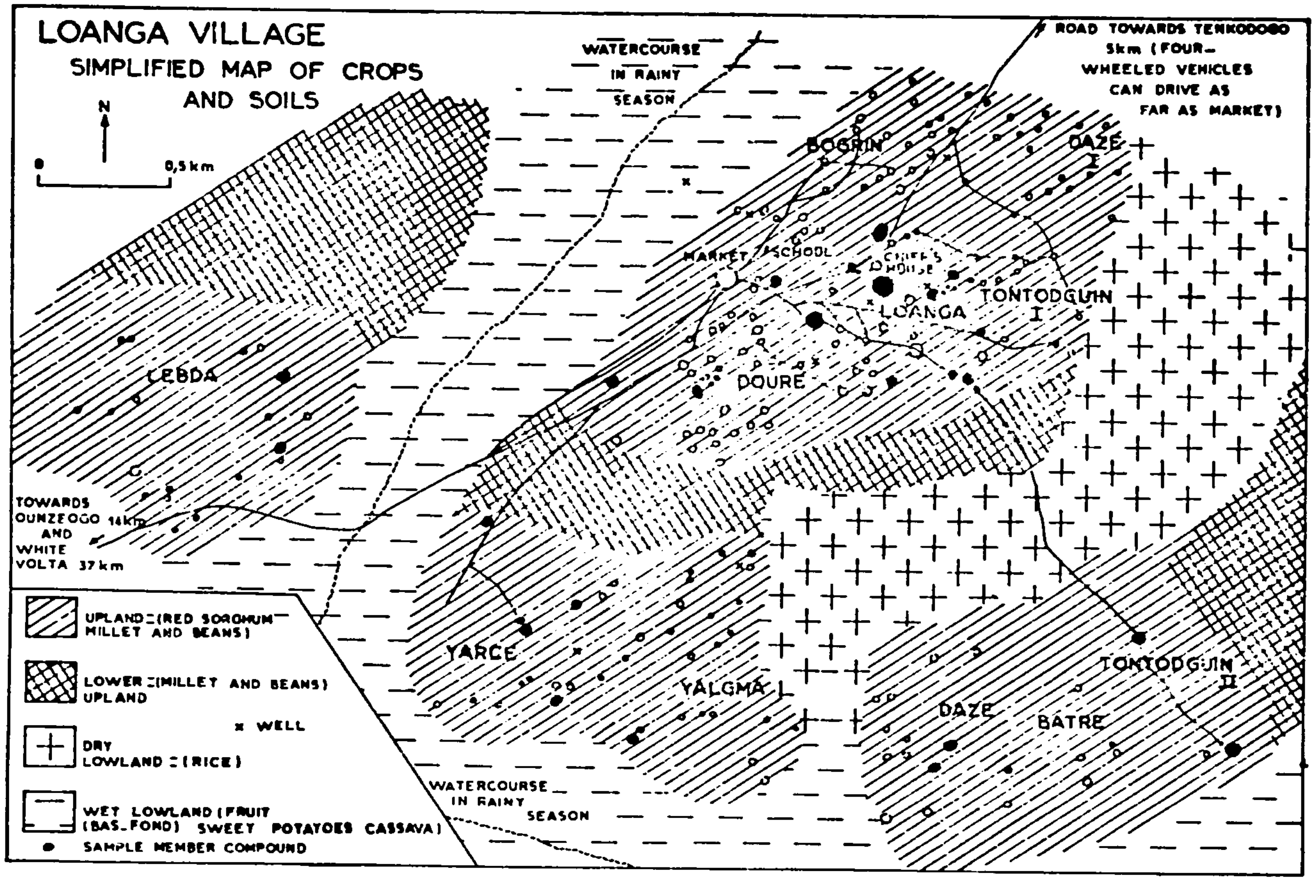
Under the second category, no peasant household had to be dropped because of refusal to cooperate fully. This was a major tribute to both the steadfastness of the population of the Tenkodogo area and the concern shown by project staff members for sample member morale. Notwithstanding the cooperative attitude displayed by sample members, the reliability of data collected by one of the enumerators in Loanga was seriously questioned and the households included in his area had to be dropped.[1] Although this was a serious blow, the author felt that the validity of statistical results hinged more on the quality of the data than upon some ficticious number of degrees of freedom. Including this suspicious information would clearly go against the avowed purpose of obtaining a more precise estimate of reality.[2]

[1]To avoid arousing bad feelings among the sample households dropped, the author and another enumerator in Loanga continued to visit them regularly, but not twice-weekly.

[2]For a discussion of how the existence of random measurement error produces inconsistent estimators in ordinary least squares regression analysis, see J. Johnston (1972), pp. 281-291.

FIGURE 3.4

LOANGA VILLAGE: SIMPLIFIED MAP
OF CROPS AND SOILS



Finally, two households from the Mossi sample had to be dropped because four months of their questionnaires were lost during data processing in Ouagadougou. The author became aware of the loss only during the editing of the master data in Ann Arbor. Remedial action was out of the question at this time.

The final sample retained for analysis consisted of twenty-six Mossi households in Oueguedo and fifteen Bisa households in Loanga. Accurate flow data on labor input is restricted to this sample. However, results from the supplementary questionnaires include, where appropriate, a consideration of the dropped households and results from the herder sample of twenty households. In all, information is used from a greater sample of eighty-one Mossi, Bisa and Fulani families.

The Data Collected

"Flow" Data for Peasant Households.-- The flow data collected on peasant farms from May 1976 until May 1977 includes:

(i) All labor hours devoted by males and females in three age categories to all activities during the daylight hours, including hired and cooperative ("invited") labor.

(ii) All fertilizer or other non-labor input to all fields cultivated by the sample members;

(iii) Sales and purchases of any items (In practice. only one third of the sample gave complete information on this subject. The enumerators were reluctant to request this information, since the question often offended sample members);

(iv) All harvests of all crops grown on sample fields.

"Stock" Data for Peasant Households.-- The interviews on subjects which did not require twice-weekly visits provided information on the following relationships:

(i) Composition of the work force for each household, by sex, age, and relationship to the head of household;

(ii) A list of all fields with the crops planted in them, including the type of terrain, the area of the field, and the name of the "owner."

(iii) Yields obtained on 170 yield plots;

(iv) Conversion factors for local measures of volumes, for each crop;

(v) Field histories for 180 fields including data on cropping patterns and problems in previous years;

(vi) Inventories of large and small stock owned by the household and explanations of net changes in herd sizes;

(vii) Information of management practices with respect to large and small stock;

(viii) An inventory of capital goods, including implements.

Other Micro-Data for the Tenkodogo Area.-- Besides the data gathered by project enumerators, the author made use of primary data gathered by the O.R.D. field office in Tenkodogo. This included data pertaining to:

(i) monthly commodity prices on Tenkodogo market;

(ii) monthly rainfall and temperature levels;

(iii) information on purchased agricultural inputs;

(iv) commodity production figures for the Tenkodogo area.

Repeated Interview (but not twice weekly) Data from the Fulani Herder Stratum.-- The Fulani sub-study of the project generated the following data for Fulani herdsmen:

(i) Composition of the household work force by age and sex;

(ii) Field holdings of each household, by crop and area;

(iii) Division of labor by age and sex group;

(iv) Approximate labor inputs to different tasks;

(v) Some preliminary and approximate data on yields;

(vi) Size of Fulani herds;

(vii) Extent of peasant ownership of cattle;

(viii) Patterns of cattle management agreements and decision making between herders and peasants;

(ix) Animal husbandry practices of the semi-sedentary Fulani, by season;

(x) Problems of stockraising in the Tenkodogo area.

A Note on Data Processing and Organization

The use of the twice-weekly questionnaire reproduced in Figure 3.1 (pp. 47-48) permitted the coding of "flow" data in the field. At first, the enumerators were asked to code their own sheets. It soon became apparent, however, that coding took too much time and the rate of error was high. The back-up enumerator in Tenkodogo became a specialist in coding under close supervision of the author. Together, they reviewed every sheet from the beginning of the study.

The codes from the twice-weekly questionnaire were keypunched and verified in Ouagadougou, at the Centre National de Traitement de l'Information (CENATRIN). The information in condensed form occupies a tape of over 16,000 eighty-column records. Each record contains the information from approximately three lines of the twice-weekly questionnaire.[1] Records were sorted electronically and checked visually by the author.

The next step was to expand the data set into a series of "cases," each one containing one and only one piece of information. A typical labor case consisted of eight variables, equivalent to one eight-dimensional observation. The variables were: household number, field number, week of interview, day of interview, plot number, crop code, activity code, and the three (or four) day total of labor hours devoted to the labor allocation defined by the other variables. Over 74,000 such cases were generated. Each variable within each case was scanned electronically for "illegal" values specified by the investigator. Data on harvests, sales, purchases, and fertilizer use were put into separate files.

Given the huge size of the data set, the next step was to aggregate the three day[2] labor totals into fortnightly totals, for cases involving the same household, field, plot, crop, activity and labor type. Fortnights were chosen as the basic time period, rather than the more conventional

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[1]Precise information on the mechanics of data processing is available from the autuor, on request.

[2]For clarity of exposition, interviews will be assumed to cover three days of information. In fact, every other interview covered four days.

monthly periods.[1] This is because periods of peak labor use during the study appeared to occur within fortnightly periods, as stated in chapter one. If a period of intense activity is immediately followed by a period of slack, then the use of monthly periods would hide the peak period labor requirement. Since livestock require a fairly constant labor input, at least within a given season, the "smoothing out" of labor peaks in agriculture tends to hide labor conflicts between agricultural and pastoral activities. The latter, of course, are of prime interest to this study.

The task of aggregation into fortnights is not as straightforward as it may appear. Only one third of the sample was interviewed on a given day. However, each interview covers activities on the day of the interview as well as those of the two previous days. The implication is that an error is incurred in aggregating interviews into fortnights by simply adding together information bearing interview dates contained between the beginning and the end of the fortnight. This is because totals from interviews marked June 20 will be added to the fortnight 4, beginning June 20. However, the activities of one third of the sample, for June 18 and 19, are also included on these sheets. In other words, totals for the June 20 to July 3 "fortnight" in fact include information pertaining to part of the sample for June 18 and June 19. They also exclude information for part of the sample relating to July 1 and 2. Table 3.1 lists the calendar dates corresponding to each fortnight period chosen for aggregation.

Farm management surveys which aggregate into monthly periods tend to ignore this problem, presumably on the theory that the percentage error is small.[2] Use of a fortnightly period doubles the error, such that nearly one tenth of the household/days interviewed are aggregated into the wrong fortnight.[3] This can lead to the variation in labor allocation pattern

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[1]As in virtually all the studies analysed by J. Cleave (1974).

[2]Shapiro (1973) and Norman (1973) are cases in point.

[3]A heuristic approach to the error incurred runs as follows: (a) There are 41 households x 14 days of activities per interview = 574 household days. (b) The household/days agregated into the wrong fortnight can be expressed as: (41/3 x 2 days + 41/3 x 2 X 1 days) x 2 end periods = 54.67 household/days. (c) Then the percentage of total household days aggregated into the wrong fortnight becomes 54.67/574 = 9.5%.

TABLE 3.1

CALENDAR OF THE 1976-77 AGRICULTURAL YEAR
(Divided into Fortnights)

Calendar Dates	Fortnight Code	Principal Activity of Sample
9 May - 22 May 1976	1	Sorghum Planting Begins May 9, Fields Prepared for Rice, and Planted
23 May - 5 June	2	First Weeding of Sorghum, then Millet Planted
6 June - 19 June	3	Groundnuts Planted
20 June - 3 July	4	Second Weeding of Sorghum and Millet, Cowpeas Planted, Rice Weeded and Transplanted
4 July - 17 July	5	
18 July - 31 July	6	Third Weeding and Ridging of Cereals
1 Aug. - 14 Aug.	7	
15 Aug. - 28 Aug.	8	Weeding of Root Crops, Cotton, Tobacco and Vegetables
29 Aug. - 11 Sept.	9	Maize Harvest
12 Sept. - 25 Sept.	10	Sorghum Harvest
26 Sept. - 9 Oct.	11	Relative Slack
10 Oct. - 23 Oct.	12	Cowpea Harvest
24 Oct. - 6 Nov.	13	Groundnut Harvest
7 Nov. - 20 Nov.	14	Millet Harvest, Rice Harvest
21 Nov. - 4 Dec.	15	
5 Dec. - 18 Dec.	16	Fence Construction Around Gardens
1976 - 1977 19 Dec. - 1 Jan.	17	Drying, Transport, Threshing, Storage of Cereals and Legumes, Period of Ceremonial Duties Begins (Sacrifices to Ancestors and Celebrations for the Dead)
2 Jan. - 15 Jan.	18	
16 Jan. - 29 Jan.	19	
30 Jan. - 12 Feb.	20	
13 Feb. - 26 Feb.	21	Non-Agricultural Work and Ceremonial Duties
27 Feb. - 12 Mar.	22	
13 Mar. - 26 Mar.	23	
27 Mar. - 9 April	24	Manure Spread on Fields, Other Field Preparation, House Repair, Peak Period Ceremonial Duties
10 April - 23 April	25	
24 April - 7 May 1977	26	

over time being mistaken for variations in labor allocation across households. Since agricultural activities are highly variable from week to week, this can be a real problem.

Although the original data sheets contained daily labor allocations, only the three day totals were keypunched. Therefore, there is no exact way of going back to the daily figures. A compromise solution was employed. A computer routine was written to identify interview sheets dated on one of the first two days of each previously defined fortnight. The labor totals for each activity on those sheets were divided by three. For interviews dated as the first day of the fortnight, the resulting figures were added twice to the totals for the previous fortnight and once to those for the current one. For interviews dated as the second day of the fortnight, the resulting figures were added once to the totals for the previous fortnight and twice to those for the current one.

This is clearly a "second-best" procedure. It assumes that the three day labor totals for a given activity were compiled by equal labor allocations during each day of the interview period. It ignores the distinction between three and four day interviews. Clearly, a degree of error still exists, but presumably less than there would be in the absence of an adjustment procedure.

After aggregation, the basic file of labor flow data contained over 23,000 cases. Labor allocations to different crops and activities were calculated from this basic "dataset." The next chapter concerns factor availabilities on each farm and attempts to quantify the "stock" aspects of the production system for each ethnic group.

CHAPTER 4

LABOR

This chapter examines the components of the household labor force and argues for the pooling of Mossi and Bisa, but not Fulani, labor data. The division of labor by ethnic group is established from actual labor allocations by different age and sex groups. The latter half of the chapter portrays the allocation of household labor by task and by product, including crops and livestock. Two major points concerning the supply and allocation of labor arise here. First, July is the period of peak labor use. At this time, women and men work equally hard. During non-peak seasons, women work harder than men, on average; however, both groups are employed in nonagricultural tasks that have been put off during the agricultural season. The division of labor is not rigid and often changes depending on the season and thus upon overall labor demands. The available evidence indicates that there may be considerable elasticity of labor supply over a short period. This arises from all workers working longer hours <u>and</u> non-crop tasks being temporarily delayed. However, there is no indication that the extra labor hours supplied in the peak season are sustainable throughout the year. Second, the major labor inputs to food crops, to cash crops, and to livestock occur during the millet weeding period in July and the harvesting period in November. These requirements are fairly inflexible, the former because of the nature of rainfall and weed growth, the latter because fields are unfenced, making unharvested crops vulnerable to free-ranging livestock.

Numbers of Workers per Household, by Age and Sex Categories

All people over eight years of age belonging to sampled households were defined as workers and are henceforth referred to as "sample members." The three age categories are defined as 8-14 years, 15-60 years, and older than 60 years. The data suggest two hypotheses. First, the mean number of workers per household is approximately the same for Mossi and Bisa peasants, at just over five workers. Second, the mean number of Fulani workers is significantly higher at just under seven persons per household. This section subjects these statements to more rigorous examination. Table 4.1 contains the summary statistics pertaining to the average number of workers in each category for households within each stratum counted at the beginning of the survey. Each line is calculated by taking the mean of values for each household within the stratum. The mean over households of the total number of workers in each household is given on the last line as the appropriate figure for estimating the average number of laborers available per household.

The first hypothesis is formulated more specifically to the effect that the means for Mossi and Bisa households are the same and that the (unknown) population variance is the same for the two groups. That is: $H_0 : \mu_1 = \mu_2$, given $\sigma_1^2 = \sigma_2^2 = \sigma^2$ where 1 and 2 refer to the Bisa and the Mossi respectively, and μ and σ have their conventional meanings of mean and standard deviation. Then the pooled mean-square estimator of σ^2 is given by (Dixon and Massey, 1969, p. 116):

$$S_p^2 = \frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2}$$

Where S_1^2 and S_2^2 are the sample variances of the Bisa and Mossi sample means. A two-sided test is performed with the statistic

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S_p \, (1/N_1 + 1/N_2)^{1/2}}$$

distributed with $(N_1 + N_2 - 2)$ degrees of freedom. A test based on the data presented in Table 4.1 was unable to reject the hypothesis, as stated, at the 10 percent level of significance. The data fail to indicate that the Bisa and Mossi households have different size labor forces, on average. In the absence of other information, Mossi and Bisa households will be assumed to be of the same average size.

The second assertion can be formulated more specifically as the

TABLE 4.1

AVERAGE NUMBER OF WORKERS IN EACH HOUSEHOLD BY AGE AND SEX CATEGORY

Stratum: No. of Households		Bisa N = 15				Mossi N = 26				Bisa + Mossi N = 41				Fulani N = 12*			
Category		Mean	S.D.	Max	Min	Mean	S.D.	Max	Min	Mean	S.D.	Max	Min	Mean	S.D.	Max	Min
MALES	8-14	.87	.99	3	0	.50	.58	2	0	.63	.77	3	0	.58	.79	2	0
	15-60	1.73	.96	4	0	1.62	.80	4	1	1.66	.85	4	0	1.92	1.31	5	1
	61+	.33	.49	1	0	.08	.27	1	0	.17	.38	1	0	.58	.51	1	0
FEMALES	8-14	.73	.80	2	0	.35	.49	1	0	.48	.64	2	0	.75	.87	2	0
	15-60	1.67	.82	3	1	2.27	1.19	5	1	2.01	1.09	5	1	3.25	2.80	7	0
	61+	.47	.64	2	0	.12	.33	1	0	.24	.49	2	0	.67	.98	2	0
Mean Total Family Work Force (Across Households)		5.80	2.70	11	2	4.88	2.12	9	2	5.22	2.36	11	2	6.83	3.33	13	2

*Although the Fulani sample consisted of twenty households, eight interview sheets containing household census information were inadvertently left in Upper Volta. The information on other questions is based on interviews of twenty households, unless otherwise indicated.

hypothesis that the mean number of workers in a Fulani household is greater than the mean of Mossi and Bisa households combined. To test this, the null hypothesis is stated as follows: $H_0 : \mu_3 = \mu_4$, given that $\sigma_3^2 = \sigma_4^2 = \sigma^2$ where the subscripts 3 and 4 refer to the combined Mossi-Bisa stratum and the Fulani stratum, respectively. A one-sided t-test uses the estimators for pooled mean-square error and the t-statistic given above. The test permits the rejection of $H_0 : \mu_3 = \mu_4$ in favor of the alternative hypothesis: $\mu_4 > \mu_3$, at the 5 percent level of significance. Thus, the data support the view that the Fulani have more workers, on average, per household than the surrounding peasant populations, according to a decision rule which is wrong less than 5 percent of the time.

Similar tests on the equality of the means of the number of males (15-60 years old) between the Mossi and Bisa peasants, and the Fulani fail to indicate rejection of the null hypothesis that $\mu_3 = \mu_4$, at a 10 percent significance level. Thus even though the data indicate that there are more Fulani workers per household than is the case among the Mossi and Bisa, there appear to be about the same number of males in the prime 15-60 category.

However, the number of men in the 18 to 30 age group is significantly lower among the Mossi and Bisa as opposed to the Fulani. In Loanga, 33 percent of sampled households contain no males in this category, and the figure for the Mossi of Oueguedo is 35 percent. However, 58 percent of the sample households among the Fulani of Oueguedo contain young men in this category. This suggests perhaps that the young Fulani men are less likely to engage in year-long migration to coastal countries than their peasant counterparts.

Constancy of the Labor Force Over the Year

The labor force present in the household was enumerated at the beginning of the study and constantly monitored during the three-day interviews. There was little overall change thoughout the course of the year.

Children who were not yet eight years old in May 1976 were not added to the labor force, even if they attained that age during the course of the survey. Young men who returned from migration during the survey were treated as visitors, with their labor allocation recorded as that of any other visitor since most of them arrived in February after the termination of the 1976 agricultural season. Young men who left the household with the stated intention of being away more than three months were dropped from the labor force.

The combined sample of Mossi and Bisa households contained 68 men in the 15-60 year old category. Two of these left their village at the end of the rainy season (September, 1976) and two left at the end of the harvest period (January) with the stated purpose of seeking work. The departures were approximately compensated for in the sample by young men returning from migration, leaving the annual average household labor force unchanged for the purposes of this study. The small sample size precludes drawing general conclusions from these results concerning migration.

Total Household Work Hours by Category of Worker

This section discusses the total availability of each kind of labor hour to sample farms each fortnight, and the periods of peak labor use. Results pertain to the Mossi and Bisa combined stratum. The similarities between Mossi and Bisa households pointed out in the previous section and the practical consideration of length of exposition support the pooling of data for the two ethnic groups in this context. The two strata are briefly separated once more during the discussion of land availability in chapter five.

The peak period of family labor usage occurs in the month following the first big rains of the year. During 1976, this corresponded to fortnight 1 and 2, or the latter part of May and the beginning of June. The entire family is mobilized to put the crops in the ground as quickly as possible. Prime adult labor usage peaks at the time of the second major weeding of cereals, principally millet. During 1976, this corresponded to the middle and end of July, or fortnights five and six. Men and women in their prime (15-60 years old) work at hard labor an average of nine to ten hours a day, seven days a week, at this time. This does not include resting periods or meals. Table 4.2 lists the total hours contributed by each labor category to the total hours worked by an average household in the combined Mossi and Bisa stratum. These figures were obtained by calculating the hours worked by each labor category during each fortnight, for each household. Values were averaged over households to get the values in the composite Table 4.2. The totals include labor hours allocated to all activities except purely social ones, such as drinking millet beer with friends, visiting, or attending meetings.

During the peak period of the fifth fortnight, 34 percent of the labor hours were provided by males in the 15 to 60 years old category, while 39 percent were provided by women in the same age group. These figures should be interpreted in the light of Table 4.1, which showed that, on average, there are more females than males present on the farm. A second, smaller period of peak labor use occurs during fortnights fourteen and fifteen, corresponding to the seventh of November until the fourth of December. This is the time of the millet harvest. Women in their prime provide 50 percent of the labor hours during this period, as compared with 32 percent from males in the same age category. The explanation for the differences between the two peak periods may reside in the difficulty of the tasks undertaken. During the weeding period, everyone is supplying a maximum effort to that task. During the harvest period, men accomplish the physically arduous task of cutting the millet stalks at the base with a machete, while women gather the stalks and cut off the heads of grain with a sickle. The use of "invited" or cooperative labor is at its peak during the fifth fortnight, when this category provides nearly 10 percent of the total work hours performed on the average household. The use of hired labor is almost negligible. The one instance in fortnight 23 refers to hired labor employed on mango plantations.

During the peak periods, no one is taking it easy. The labor totals of Table 4.2 are deflated by the average number of workers of each category present on a farm, to get rough estimates of the number of labor

TABLE 4.2

TOTAL HOUSEHOLD WORK HOURS BY CATEGORY OF WORKER, EACH FORTNIGHT, AVERAGED OVER ALL HOUSEHOLDS

Fortnight[a]	Males 8-14	Males 15-60	Males 61+	Females 8-14	Females 15-60	Females 61+	Total Family	Invited[b] Labor	Hired[c] Labor
1	54	215	17	31	277	17	675	0	0
2	57	206	22	39	293	23	738	0	0
3	56	212	20	36	274	16	616	0	0
4	57	215	17	30	249	15	582	42	0
5	55	223	18	32	256	16	598	57	0
6	59	200	17	31	231	15	554	49	0
7	54	186	13	26	225	13	517	2	0
8	39	150	11	22	176	10	408	16	0
9	27	124	7	11	156	7	332	31	0
10	22	113	8	10	144	11	306	4	0
11	29	97	4	10	121	4	265	2	0
12	36	106	12	14	160	7	336	9	0
13	38	123	11	17	187	11	387	12	0
14	38	135	8	16	204	11	412	8	0
15	44	140	9	20	216	12	440	6	0
16	36	114	5	19	194	9	377	4	0
17	31	104	3	18	175	8	339	0	0
18	27	95	4	17	163	9	315	0	0
19	36	116	6	20	203	10	392	0	0
20	36	114	7	20	192	9	377	0	0
21	37	104	8	17	184	9	358	0	0
22	45	127	7	20	196	10	405	2	0
23	41	106	8	22	196	8	382	1	1
24	42	127	8	22	208	10	416	0	0
25	44	112	7	25	197	9	394	0	0
26	33	89	5	24	161	10	321	0	0

[a] Fortnight 1 begins on May 9, 1976.

[b] Help from friends and neighbors, all ages and sexes combined.

[c] Hired on a daily cash basis - men in the 15-60 category were the only people involved.

hours furnished by a person in each labor category.[1] The results are given on a daily basis in Table 4.3, assuming a seven day work week. It is not always easy to conceptualize the fullness of labor use implied by ten hours of hard physical labor during the weeding season, excluding breaks, seven days a week. This is equivalent to weeding at stoop labor from sun-up continuously until mid-morning, taking a short break, working until three P.M., taking another short break, and then working until sundown. It is unlikely that the farmer could supply more hours of labor at this time, at any price.

Figure 4.1 graphs total labor hours supplied by the entire family labor force and hours supplied by prime age men and women. The curve for women lies wholly above that for men. Part of this is attributable to a greater number of women in the labor force. Table 4.3 shows that, on the average, a man works as many hours a day as a woman, during the first eleven fortnights covering most of the rainy season. However, women work longer hours than men on average during the rest of the year, largely at domestic activities. The scope for increasing labor input per household is provided primarily by increased use of male labor during the dry season. This point will be discussed further in this chapter, while discussing labor allocations to domestic household activities at different times of the year.

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[1]Clearly this is not the same as calculating the mean over households of the number of hours worked by each person in a given labor category, since the ratio of two means is not the same as the mean of a number of ratios. The procedure used here is an expedient deemed sufficient for the purposes at hand. The two procedures give exactly the same result if and only if for each fortnight and labor category:

$$\frac{\Sigma X_n}{\Sigma W_n} = \frac{1}{41} \Sigma \frac{X_n}{W_n}$$

where X_n is the total labor hours allocated by the labor category in question, during the fortnight in question, and W is the number of workers in the same labor category, for household n. This is generally the case only if there are the same number of workers in a given category in each household.

TABLE 4.3

ESTIMATE OF AVERAGE HOURS WORKED IN A DAY BY A WORKER IN EACH CATEGORY, BY FORTNIGHT

	Males			Females		
Fortnight	8-14	15-60	61+	8-14	15-60	61+
1	6	9	7	5	10	5
2	6	9	9	6	10	7
3	6	9	8	5	10	5
4	6	9	7	4	9	4
5	6	10	7	5	9	5
6	7	9	7	5	8	4
7	6	8	6	4	8	4
8	4	6	5	3	6	3
9	3	5	3	2	6	2
10	2	5	3	2	5	3
11	3	4	2	2	4	1
12	4	5	5	2	6	2
13	4	5	5	3	7	3
14	4	6	3	2	7	3
15	5	6	3	3	8	4
16	4	5	2	3	7	3
17	3	5	1	3	6	2
18	3	4	2	3	6	3
19	4	5	3	3	7	3
20	4	5	3	3	7	3
21	4	4	3	3	7	3
22	5	5	3	3	7	3
23	5	5	3	3	7	2
24	5	5	3	3	7	3
25	5	5	3	4	7	3
26	4	4	2	4	6	3

See text for methodology.

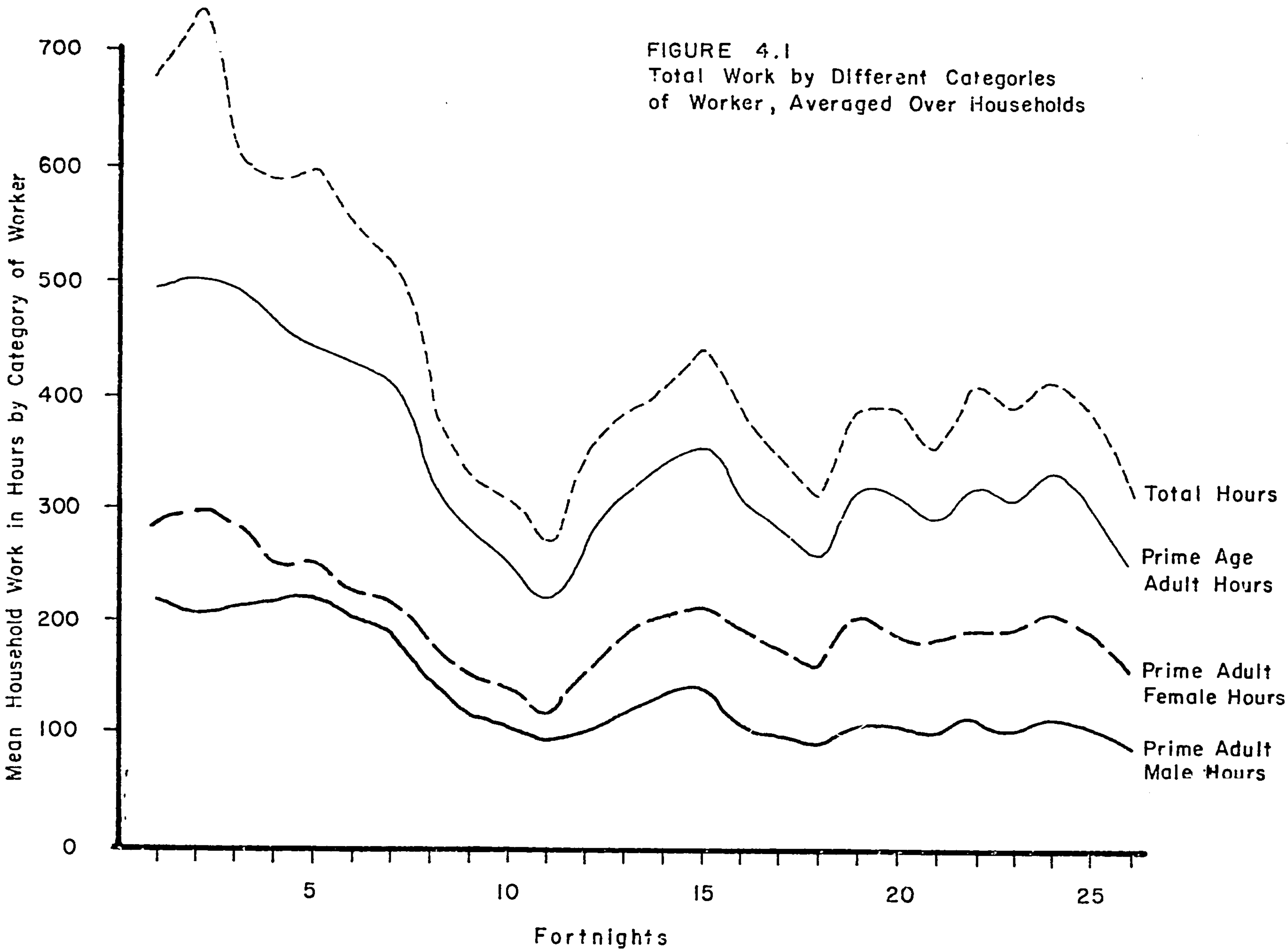

FIGURE 4.1
Total Work by Different Categories
of Worker, Averaged Over Households

The Mossi and Bisa Division of Labor by Age and Sex During the Wet and Dry Seasons

This section examines the age and sexual division of labor among the farming groups. The major finding is that there is considerable flexibility among the peasant groups as to which activities are "women's work" or "men's work," although the flexibility appears to be a little greater in the case of the Bisa as compared to the Mossi. Among the Bisa, women's roles include assuring the family water supply and meal preparation. However, all other roles are shared with the men, during some part of the year. The Mossi women have these two tasks as their responsibility, in addition to fetching the family fuel supply and "other" domestic work (laundry and house cleaning). Mossi women predominate throughout the year in commerce, principally through the sale of processed foodstuffs. The Mossi men predominate over the women in straw weaving and pottery, while the Bisa men do not. Men from both ethnic groups predominate in livestock work, responding to cooperative work invitations, construction, and watering and guarding fields (principally vegetable gardens threatened by livestock).

The division of labor on farms sampled among the Mossi and Bisa varies according to ethnic group and season. The total number of hours spent by each age and sex category of labor were aggregated over fortnights one to thirteen (the wet season), and fortnights fourteen to twenty-six (the dry season), for each ethnic group. Tables 4.4 through 4.7 show the percentage of total hours spent on each work activity by each labor category, over the wet and dry seasons. The activities are listed in each table according to whether they were predominantly performed by males, females, or both. The criterion for classification of an activity as male or female is that at least three-quarters of all hours devoted to that activity come from the group in question. If neither group is predominant on this criterion, the activity is classified as being performed by both groups. A summary of the results in Tables 4.4 through 4.7 is presented in Table 4.8.

It is noteworthy that metal work is the only activity performed exclusively by males over both seasons. Meal preparation is almost always the exclusive domain of females. Otherwise, there is no basis for judging an activity to be the exclusive prerogative of one group or the other. However, some activities are engaged in predominantly (as defined above) by one group, throughout the year. Other activities are performed by one group during the wet season and another during the dry season, most likely reflecting changes in the opportunity cost of labor. An example of this would be the field preparation task among the Mossi, which is evenly split between men and women during the wet season when the opportunity cost of labor is high, and which is a predominantly male activity during the less hectic dry season.

There is considerable substitutability between male and female labor devoted to the principal agricultural bottlenecks of weeding and harvesting during the wet season with respect to the number of hours supplied.[1] Among the Mossi households, 56% of the hours spent weeding in the wet season are from males, whereas the figure in the dry season is 98%. Thus, women will weed cereals, legumes and vegetables along with the men when the demand for labor is high, but men alone will weed the irrigated vegetables during the slack season. Among the Mossi, women account for 48% of the hours spent harvesting crops during the wet season. The comparable figure for Bisa women is 54%. Even though there are slightly more women than men present on Mossi and Bisa farms on average (Table 4.1), these results suggest that caution should be exercised when using "man-equivalents" of less than one for evaluating the agricultural labor-supplying capacity of a female worker.

The Use of "Man-Equivalents" for Non-Prime Male Workers

Many farm management studies use coefficients of less than one to evaluate the "man-equivalency" of women, children and old people in terms of their capacity to supply farm labor, relative to prime age

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[1]This assertion will be further documented in the next chapter, in the discussion of labor allocations.

TABLE 4.4

MOSSI DIVISION OF LABOR DURING THE WET SEASON
(Percentage of Total Hours Spent on a Given Task Attributable to Each Labor Category)

Predominantly Male Activities

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Spread Fertilizer[a,b]	5	64	11	0	18	0
Water Crops	3	86	0	0	10	0
Construct Fences	3	86	3	0	5	0
Guard Fields	15	65	0	0	20	0
Go to Agricultural Work Invitation	2	77	3	0	16	0
Poultry Work[b]	0	100	0	0	0	0
Small Stock Work	57	15	0	11	12	0
Large Stock Work	14	71	0	0	14	0
Weave Straw[a]	10	84	2	0	2	0
Construction	7	68	2	0	19	2
Metal Work[c]	0	100	0	0	0	0
Pottery	0	100	0	0	0	0
Go to Non-agricultural Work Invitation	5	94	0	0	0	0

Predominantly Female Activities

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Gathering Wild Crops[b]	2	9	0	0	87	0
Fetch Water	6	4	0	0	89	0
Fetch Wood[a]	1	18	0	0	79	0
Meal Preparation	0	0	0	0	98	0
Other Domestic Work	8	0	0	3	73	14
Commerce[a]	2	20	0	0	76	0

TABLE 4.4 (cont.)

MOSSI DIVISION OF LABOR DURING THE WET SEASON (%)

Activities Undertaken By Both Men and Women

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Prepare Fields	5	47	2	1	40	3
Sow Seeds[c]	3	39	0	1	52	2
Weed[b]	4	51	1	1	39	1
Travel Between Fields	6	43	0	2	47	0
Attend Meeting	7	44	1	4	40	1
Go Visiting	8	39	1	3	45	2
Harvest Crops	4	45	0	1	47	0
Transport Harvest[b]	6	41	0	0	50	0
Spin Cotton[a,b]	0	60	0	0	39	0

[a]Activity classified in different category as compared to Bisa wet season.

[b]Activity classified in a different category as compared to Mossi dry season.

[c]Rows may sum to less than 100 because of rounding error.

TABLE 4.5

BISA DIVISION OF LABOR DURING WET SEASON
(Percentage of Total Hours Spent on a Given Activity Attributable to Each Labor Category)

Predominantly Male Activities

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Water Crops	1	68	29	0	0	0
Construct Fences[b]	4	78	16	0	0	0
Guard Fields	12	62	18	1	4	0
Go to Agricultural Work Invitation	0	90	7	0	1	0
Poultry Work	5	44	39	10	0	0
Small Stock Work	31	40	6	16	5	0
Large Stock Work	21	59	5	5	8	0
Construction	0	60	19	0	19	0
Go to Non-agricultural Work Invitation	3	84	7	3	2	0

Predominantly Female Activities

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Fetch Water	1	17	2	6	67	4
Meal Preparation	0	1	0	4	87	5
Other Domestic Work[b]	11	2	1	13	67	3
Spin Cotton[a,b]	0	0	0	55	26	18

TABLE 4.5 (cont.)

BISA DIVISION OF LABOR DURING WET SEASON (%)

Activities Undertaken by Both Men and Women

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Prepare Fields[b]	7	32	3	4	46	6
Spread Fertilizer[a,c]	8	31	8	5	45	0
Sow Seeds[c]	4	37	9	1	44	3
Weed[c]	6	41	7	4	37	3
Travel Between Fields[c]	5	52	5	2	30	5
Harvest Crops	4	36	2	4	48	2
Transport Harvest	4	49	4	2	33	5
Gather Wild Crops[c]	3	28	0	0	25	42
Fetch Wood[a,b]	0	24	3	12	58	0
Attend Meeting[c]	23	45	10	5	14	0
Weave Straw[a]	0	23	9	0	56	10
Commerce[a,b]	2	54	11	2	25	2
Go Visiting	15	31	7	12	29	4

[a]Activity classified in a different category as compared to Mossi wet season.

[b]Activity classified in a different category as compared to Bisa dry seasons.

[c]Activity not practiced in dry season.

Rows may sum to less than 100 because of rounding error.

TABLE 4.6

MOSSI DIVISION OF LABOR DURING THE DRY SEASON
(Percentage of Total Hours Spent on a Given Activity Attributable to each Labor Category)

Predominantly Male Activities

	Males 8-14	Males 15-60	Males 61+	Females 8-14	Females 15-60	Females 61+
Prepare Fields	3	68	6	0	21	0
Weed[b]	2	94	2	0	0	0
Water Crops	5	90	2	0	0	0
Construct Fences[a]	2	88	8	0	0	0
Guard Fields	5	94	0	0	0	0
Go to Agricultural Work Invitation	3	81	3	0	11	0
Small Stock Work	76	12	0	10	0	0
Large Stock Work	31	68	0	0	0	0
Weave Straw[a]	16	77	3	0	2	0
Construction	5	66	2	0	26	0
Pottery[a]	33	56	10	0	0	0
Go to Non-agricultural Work Invitation	1	89	2	0	6	0

Predominantly Female Activities

	Males 8-14	Males 15-60	Males 61+	Females 8-14	Females 15-60	Females 61+
Transport of Harvest[a,b]	8	21	0	2	67	0
Poultry Work[a,b]	0	0	0	0	100	0
Fetch Water	4	9	0	4	80	0
Fetch Wood	4	14	0	0	80	0
Meal Preparation	0	0	0	1	98	0
Other Domestic Work[a]	1	0	0	7	87	3
Spin Cotton[a,b]	0	7	0	0	90	0
Commerce[a]	7	21	0	1	70	0

TABLE 4.6 (cont.)

MOSSI DIVISION OF LABOR DURING THE DRY SEASON (%)

Activities Undertaken by Both Men and Women

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Spread Fertilizer	6	34	0	0	57	0
Travel Between Fields	1	43	0	0	53	0
Harvest Crops	3	49	3	1	41	0
Gather Wild Crops[b]	27	27	0	1	44	0
Attend Meetings[a]	26	27	0	10	35	0
Go Visiting	11	39	1	4	42	0

[a]Activity classified in a different category as compared to Bisa dry season.

[b]Activity classified in a different category as compared to Mossi wet season.

Rows may seem less than 100 because of rounding error.

TABLE 4.7

BISA DIVISION OF LABOR DURING THE DRY SEASON
(Percentage of Total Hours Spent on a Given
Activity Attributable to Each Labor Category)

Predominantly Male Activities

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Prepare Fields[b]	9	57	3	3	25	0
Water Crops	14	61	21	0	1	0
Guard Fields	0	100	0	0	0	0
Go to Agricultural Work Invitation	7	65	26	0	1	0
Poultry Work[a]	5	50	44	0	0	0
Small Stock Work	15	69	11	1	2	0
Large Stock Work	6	87	0	0	5	0
Attend Meeting[a,b]	30	39	6	6	14	2
Construction	10	67	8	1	11	0
Metal Work[c]	0	100	0	0	0	0
Go to Non-agricultural Work Invitation	0	70	20	0	10	0
Commerce[a,b]	1	63	3	2	26	2

Predominantly Female Activities

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Fetch Water	0	3	0	11	77	6
Fetch Wood[b]	0	26	0	5	65	2
Meal Preparation	0	1	0	10	80	7
Pottery Work[a,c]	4	3	0	8	72	10

TABLE 4.7 (cont.)

BISA DIVISION OF LABOR IN DRY SEASON (%)

Activities Undertaken By Both Men and Women

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Construct Fences[a,b]	0	39	0	3	56	0
Harvest Crops	5	40	3	5	41	4
Transport Harvest[a]	3	36	7	5	42	4
Other Domestic[a,b]	7	55	7	0	24	6
Weave Straw[a]	9	42	3	2	36	5
Spin Cotton[a,b]	1	61	0	2	33	2
Go Visiting	15	34	5	11	29	3

[a]Activity classified in a different category as compared to Mossi dry season.

[b]Activity classified in a different category as compared to Bisa wet season.

[c]Activity not practiced in wet season.

Rows may sum to less than 100 because of rounding error.

TABLE 4.8

SUMMARY OF DIVISION OF LABOR BY SEX FOR MOSSI AND BISA, OVER SEASONS

Bisa Activities

Always Predominantly Male	Always Predominantly Female	Always Divided Between the Two	Changes Category Over Seasons	Performed One Season Only
Water crops	Fetch water	Harvest crops	Construct fences	Metal work
Guard Fields	Meal preparation	Go visiting	"Other" domestic work	Sow seeds
Agricultural Work Invitation		Transport harvest	Spin cotton	Spread fertilizer
Small stock work			Prepare fields	Weed
Large stock work			Fetch wood	Travel between fields
Construction			Attend meeting	Gathering wild crops
Non-agricultural work invitation			Commerce	Pottery
Poultry work				

Mossi Activities

Always Predominantly Male	Always Predominantly Female	Always Divided Between the Two	Changes Category Over Seasons	Performed One Season Only
Prepare fields	Fetch water	Travel between fields	Weed	Metal work
Water crops	Fetch wood	Harvest crops	Transport of harvest	Sow seeds
Construct fences	Meal preparation	Attend meetings	Poultry work	
Guard fields	"Other" domestic work	Go visiting	Spin cotton	
Agricultural work invitation	Commerce		Spread fertilizer	
Small stock work			Gather wild crops	
Large stock work				
Weave straw				
Construction				
Pottery				
Non-agricultural work invitation				

group males (Collinson, 1974, pp. 200-202). The justification for this is the feeling that these groups are not able to spend as many hours per day at arduous tasks as men in their prime. The alternative basis for this view is that the quality of work by these groups is less than that of prime males. However, as Collinson points out (1974, p. 201), no one has ever demonstrated this, and it runs counter to the author's subjective impressions of the research area. For these reasons, the second argument will be rejected out of hand. The question of "man-equivalents" then is a problem that is primarily of interest to studies which use census data as an estimate of labor availability. The problem is circumvented by measuring the actual number of hours spent at each task, by each person. If young girls spent less time weeding than prime adult males, it appears in the data. A fundamental assumption of this study is that differences in strength show up primarily in endurance, rather that in efficiency at a given task. This is a second best solution, given that there is no easy way to compare the productivity of an hour's labor among sex and age groups.

It is noteworthy that even the argument to the effect that men in their prime supply more farm work labor hours than other groups deserves more attention. Collinson argues that the only practical method for comparing male and female labor is "to establish relative performance on the labor-intensive operations which make an important contribution to the (labor) peaks..." (1972, p. 202). The conventional wisdom on labor peaks among sample members is that maximums are obtained during the second weeding of millet and the millet harvest. These activities correspond roughly to fortnights 6 and 14-15 in the system defined by this study. The household average, over the entire sample, of hours spent weeding by women in their prime during fortnight 6 is 173, compared to 157 for men in the same age group. When these figures are divided by the average number of prime age men and women in a household, the figures are 94 hours per man and 84 per woman.[1] The same procedure for hours spent harvesting in fortnights 14 and 15 yields the figures of 60 hours

[1]As an approximation, for heuristic purposes.

per man and 67 hours per woman in the prime age group. The conclusion is that there is very little or no basis for estimating that a female worker is worth less than a male worker in the same age group.

The argument does have some validity when applied across age groups, however, a procedure identical to the one in the previous paragraph is used for each labor category, and the combined results are listed in Table 4.9. These figures suggest that there are significant differences

TABLE 4.9

ESTIMATES OF TOTAL HOURS SPENT IN PEAK PERIODS AT PEAK TASKS BY ONE WORKER IN EACH LABOR CATEGORY

	Males			Females		
	8-14	15-60	61+	8-14	15-60	61+
Weeding (fortnight 6)	54	94	87	42	84	42
Harvesting (fortnights 14 and 15 combined)	29	60	45	24	67	32

in the hours supplied to peak labor period activities by different age groups. As a first approximation, the figures of 0.5 "man-equivalents" could be used for children and elderly women, with 0.8 being used for older men when using census data as an estimate of labor availability. However, the sensitivity of procedures such as linear programming to resource constraints dictates the use of data that is of a higher quality than census figures aggregated with "man-equivalent" conversion factors. This chapter will include below the construction of an index of labor availability for farm work, over fortnights, for Mossi-Bisa type farms, based on the actual labor allocations made by sample members to different tasks.

The Fulani Division of Labor by Age and Sex During the Wet Season

The herder division of labor is of interest primarily in order to judge if herding activities require labor of particular categories at different times of the year. Since the Fulani did not participate in the twice-weekly interviewing, a composite view of the herder division of labor was compiled from the answers of twenty households to questionnaire L_3 (Appendix C). The results are presented in Table 4.10. The major finding is that there is some substitutability of (unmarried) female herding labor for young male herding labor during the dry season. However, livestock activities appear to require men for herding purposes during the wet season. The potential availability of labor for agricultural tasks is severely restricted in Fulani households by the tradition of women not participating in field preparation or weeding.

Men and boys over the age of 14 herd the cattle during the rainy season, when the danger of damage in neighboring fields is great. This is partly because children are not trusted with the responsibility and partly because the cattle are harder to control. During the rest of the year, day-time herding activities for grazing can be left to children under 15. Watering the cattle during the hot season (April, May) is done by the men and older boys, since watering from wells is particularly arduous work. If the cattle are watered from the few remaining surface ponds, extra care must be taken in order that the first animals do not stir up the small amount of water; this would make it undrinkable for other herds.

As in the case of the peasant groups, the division of labor by sex is not inviolate. Five out of 20 households report that girls help out with the herding task, although married women never do. They gave the insufficiency of boys in the household as the reason for this. In one case, the entire herd of 40 head is cared for in the dry season by four girls under 15, their father often being away. While milking is considered women's work, 15 out of 19 households responding stated that the men "occasionally" helped the women do the milking. The reason universally given for this was that the cattle are sometimes difficult to control.[1]

With the exception of milking and fetching grasses for staked calves, in which everyone helps, livestock activities are primarily a male concern. Men also clear, plant and weed the fields. However, women will cut the ears of grain off the harvested stalks, much in the fashion of Mossi women. Women also plant and tend small patches of maize and cotton. In the category of household tasks, men confine themselves to construction and repair of houses and shade platform. Market activities are undertaken by both sexes. Livestock and grain sales and purchases are in the male domain. Usually, although not always, these latter activities are the prerogative of the head of household.

The Farmer Allocation of Labor by Sector of Activity

Four aspects of labor allocation among the Mossi and Bisa deserve particular attention. These are labor allocation by major type of activity, labor allocation by specific task, labor allocation by crop category and labor allocation by type of animal kept.

The first aspect of interest is the allocation of labor to five major categories, or "sector," based on the type of services performed. These are agricultural (crop), livestock, domestic, and nonagricultural work on the one hand, and social activity on the other. The major finding is that there is considerable variation in the kinds of work performed over the seasons, as illustrated in Figure 4.2. The curves for each sector are drawn by linking together the observations of mean (over household) labor hours devoted to the sector in question. The sum of the observations for all sectors except social activity in a fortnight gives the mean total household hours worked. Social activity, domestic and nonagricultural work activities are held to a minimum to permit peak allocation of labor to agriculture during the rainy season. Livestock work is more

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[1]Since the Fulani do not use milking stalls, this is most likely true. The cow is tied to a stake. Often the calf is tied next to its mother, to reassure the cow.

TABLE 4.10

DIVISION OF LABOR 20 FULANI HOUSEHOLDS
(x = Primarily Performed by This Group)

Task Category	Activity	Men Fifteen Years and Up	Boys Under Fifteen	Women Fifteen Years and Up	Girls Under Fifteen
Livestock Tasks	Daytime Herding	x (rainy season)	x (rest of year)		x (rest of year if not enough boys)
	Watering	x	(Dec.to March)		
	Transhumance	x			
	Veterinary Skills	x			
	Visit Cattle Proprietors	x			
	Guard at Night	x			
	Fetch Feed for Calves	x	x	x	x
	Feed Salt and Millet Bran to Dairy Cows			x	
	Milk Cows			x	x
Agricultural Tasks	Clear Fields	x			
	Plant and Weed Fields	x			
	Spread Fertilizer	x			
	Harvest: Cut Stalks	x			
	Cut Ears of Grain			x	
	Thresh	x		x	
	Pick Cotton			x	x
	Transpor' Harvest	x	x	x	x

TABLE 4.10 (cont.)

DIVISION OF LABOR 20 FULANI HOUSEHOLDS

Task Category	Activity	Men Fifteen Years and Up	Boys Under Fifteen	Women Fifteen Years and Up	Girls Under Fifteen
Household Tasks	Construction Repairs	x			
	Milling Grain			x	
	Cooking			x	x
	Cleaning			x	x
	Taking Care of Children			x (under three)	x (over three)
Market Activity	Livestock	x			
	Grain	x			
	Cotton			x	
	Milk and Butter			x	x
	Eggs	x	x		
	Jewelry			x	
	Vegetables and Oil			x	
	Clothing	x		x	

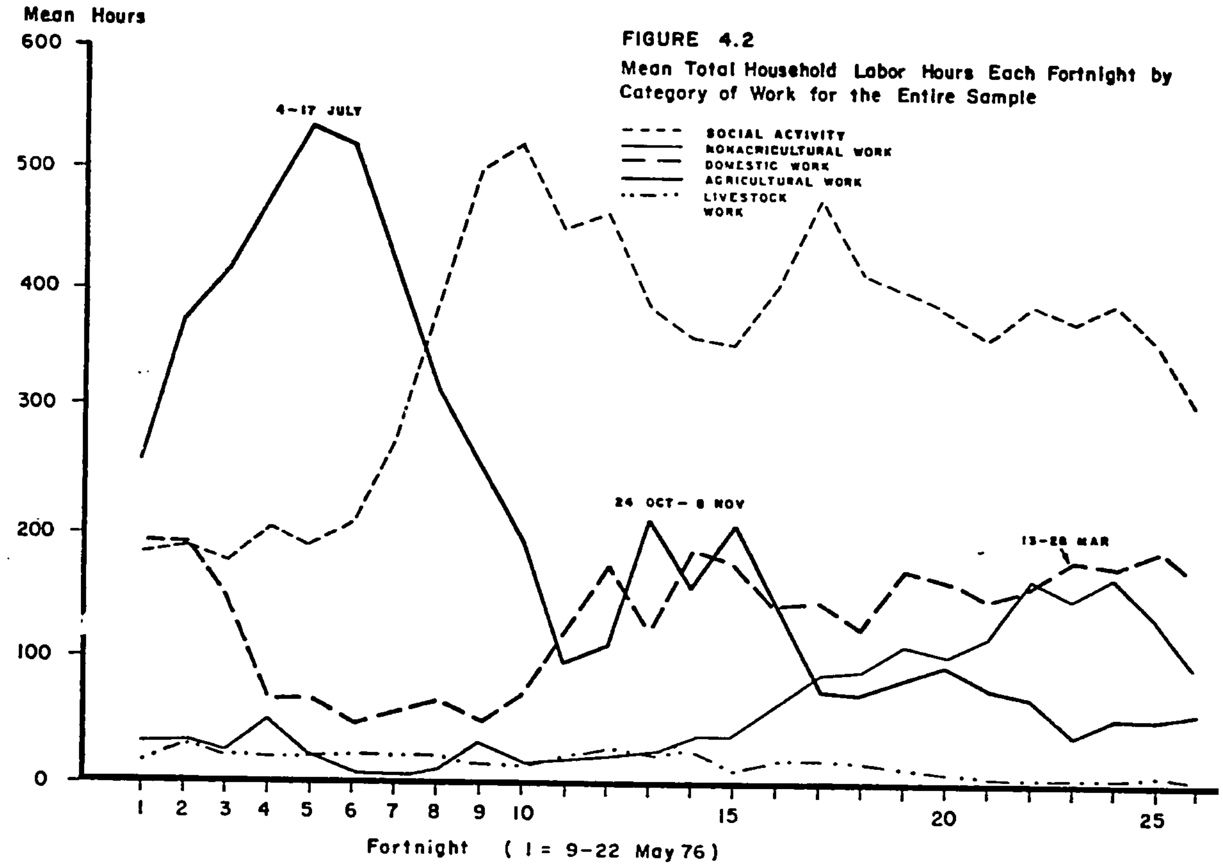

FIGURE 4.2
Mean Total Household Labor Hours Each Fortnight by Category of Work for the Entire Sample

labor intensive during the wet season than during the dry season. Each sector will be dealt with in a sub-section below.

Agricultural Work.-- Agricultural work is defined as all farm work that does not relate specifically to livestock production, which is the subject of a special category. Mean household hours devoted to agricultural tasks reach a peak in the fifth fortnight, which is also the period of peak household activity throughout the year. This is the basis of a labor bottleneck associated with the second weeding of cereals. September 26 through October 9 represents a relative slack in agricultural activity just after the sorghum harvest. Period 13 (October 24 through November 6) is another peak period of agricultural activity, during the end of the cowpea harvest and the beginning of the groundnut harvest. The end of the millet harvest in fortnight 15 (November 21 to December 4) is the last peak period of agricultural activity, as households rush to bring in the millet harvest before birds and domestic animals destroy it. The latter represent a special incentive for haste. Pigs are corral led while the crops are on the ground, sheep and goats are tied to stakes and cattle are kept outside the village. As soon as the fields are cleared, however, the animals will be released, which puts a serious penalty on households which are tardy in harvesting. Furthermore, the millet must be harvested in time to weave fences out of the stalks to protect perennial gardens and long-maturing cotton fields.

Livestock Work.-- Livestock work on peasant farms is confined to hours spent caring for pigs, sheep, goats, poultry, horses and donkeys. The care of cattle is reserved for the Fulani. Livestock work is fairly constant throughout the year, although the mean hours worked each fortnight between periods 2 and 14, which corresponds to the time crops are growing above ground, are at a consistently higher level than during the rest of the year. This is because extra care must be taken to prevent domestic animals from eating crops on the unfenced fields. Animals such as sheep and goats must have their tethers moved periodically so that they can browse. At night, they have to be led back to the compound stable by a rope. Pigs must be corralled permanently during this period, which in turn requires extra labor for gathering a thorny bush preferred for forage or the bran from millet beer brewing. Horses and donkeys are either tethered and fed forage or kept outside the village, both requiring extra labor.

Nonagricultural Work.-- Nonagricultural work in the village comprises weaving, construction, pottery and commerce, to name a few household activities, as well as labor performed outside the village. The pattern in Figure 4.2 indicates that nonagricultural activity is held to a minimum during the crop growing period (fortnights 1 to 15). After fortnight 15 (November 21 through December 4), mean household hours devoted to nonagricultural activity quickly rise to a peak from fortnights 22 to 24 (February 27 through April 9). This is a period of agricultural slack, between threshing of millet in January and February and field clearing during late April and early May. Overall household work and social activity dips after fortnight 24 because of the extreme heat during April and early May, when a good part of the daylight hours (the period recorded) is spent sleeping.[1]

Domestic Work.-- Domestic work encompasses the usual household chores of infant care, meal preparation, laundry and house cleaning, as well as fetching firewood and water for family use. Domestic activity, the catchall work category, also includes going to school and religious observances.[2] The rationale for the inclusion of the last two is that these activities reflect family roles and duties as opposed to leisure time or other forms of work. One of the most interesting aspects of Figure 4.2 is the marked dip in mean household hours devoted to domestic work between fortnights 4 and 10 (June 20 through September 25). Part of the reason for this is that, during the rainy season, water is easily obtainable from in-village wells and firewood in bush is too wet to burn. However, this is equally true of fortnight 2, and water is available close to living areas at least through fortnight 17 (January 1, 1977). The explanation must also be in the ability of households to compress the hours devoted to domestic work during the peak agricultural season.

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[1]The enumerators recorded resting while awake as a conscious social activity. Sleeping during the day was not recorded.

[2]Only a handful of sample households had children in school.

Small children, who are left to crawl around the compound other times of the year, are strapped to their mothers' backs while they weed. People stockpile firewood in advance. Meals are hurried and made with less labor consuming methods (i.e. millet ground at the mill instead of being pounded with mortar and pestle). Finally, ritual observances such as animist "funerals" are put off until periods of less frantic activity.[1]

The important point to note is that the ability to compress these domestic labor requirements is temporary and conditional upon it being confined to a fraction of the year. The same is true of a good part of nonagricultural work as well. The head of household can put off tool and house repair for just so long, but eventually it must be done.

Social Activity.-- Social activity in this context includes visiting with friends and relatives, drinking millet beer at "dolo" shops, and travel away from the village to see relatives. This study treats this behavior as the result of a choice rather than as a residual left over after work. The reasoning is that leisure time can always be converted to labor, if the marginal utility of income from the latter excedes the marginal utility of the former.

Figure 4.2 indicates that sample members usually choose to undertake these casual activities outside the periods of peak agricultural labor use. This suggests, *a priori*, that people choose periods of low opportunity cost of labor to engage in this form of activity. However, it is not correct to infer from this that the creation of a well-remunerated alternative use of time will necessarily provide a reallocation of labor away from these pursuits. There are two basic arguments supporting the view that the labor supply is not as elastic during the agricultural slack season as might be supposed. First, people can put off certain tasks and obligations to different parts of the year, but they must be accomplished at some time. A prime example of this is visits to relatives living in other areas, particularly in marriages between partners from different villages. Second, the value of leisure after the arduous agricultural

[1]"Funeral" in this sense connotes a rather joyous celebration, some years after the burial of an important family member. It celebrates the deeds of the departed member and assures a link between the spirit of the ancestors and those of the living.

season might be quite high. The term "slack season" is defined in relation to a season of great exertion. The former may be necessitated by the latter in order to give people a chance to rest up for the next year. The slack season is also the hot season, with noon temperatures in excess of 100° Fahrenheit the norm. Extra labor at this time makes extra demands upon the worker.

The Farmer Allocation of Labor by Work Category

This section shows that the peak period of agricultural labor use, which corresponds to the peak period of prime adult labor use in July, is attributable primarily to weeding labor. No other single work activity of sample members occupies as much of their time for any given fortnight. The lesser agricultural peak period in November corresponds to the harvesting of crops.

The Bisa and Mossi farm management survey breaks down labor allocations into thirty-four different work categories, derived from the eighty-five codes used for the twice-weekly interview (Chapter 3, p.50). Table 4.11 lists the work categories and their relationships to the sectors of the previous section. The numbers at the right refer to the activity codes used with the twice-weekly interview that correspond to the work category in question. Appendix B lists mean household labor hours contributed by each category of labor each fortnight to each work category, averaged over the combined forty-one households of the Bisa and Mossi sample and summed over all products. For brevity, the analysis in this section will concentrate upon the mean household labor hours allocated each fortnight to the three main sets of operations in African crop production under traditional methods: preparation of the seedbed, weeding and transplanting, and harvesting and processing (Collinson, 1972, p. 219).

The total mean household hours devoted to the preparation of the seedbed are obtained by summing together for each fortnight the mean household hours devoted to the first three work categories in Table 4.11. The total mean household hours devoted to weeding and transplanting are given directly by the figures for the fourth work category. The appropriate numbers for harvesting and processing labor come from summing the mean total household hours attributable to the two work categories bearing those labels in Table 4.11. The observations for each fortnight of each of these three series are reproduced in Table 4.12 and plotted as curves in Figure 4.3. Figure 4.3 shows that the maximum period of labor use is in the sixth fortnight, the second half of July. This is the period for weeding millet and sorghum and making mounds around the millet stalks, to cover the roots and support the stems during the heavy rains of August. The second labor peak in fortnight 15 is clearly attributable to harvestin labor allocated to the millet harvest.

The Mean Farm Allocation of Labor Per Hectare of Each Major Crop Category by Fortnight

This section examines the relative labor intensity of different crops expressed in hours per hectare. The food staples of millet, sorghum and cowpeas are the least labor intensive of all crops. High value products such as cotton, tobacco, fruit and vegetables are more than twice as labor intensive per unit of land. The major crops for the Tenkodogo area - millet, sorghum, groundnuts and rice - all require peak labor input at approximately the same times of year, in July and November.

The total number of hours allocated by each household to each major crop category was calculated by fortnight. The figures for each household were divided by the total household land area in hectares devoted to the crop in question. The ratio obtained for each fortnight, household and crop category was averaged over households to give the mean total household hours allocated to each major crop category by fortnight. The aggregate results are displayed in Table 4.13 and Figure 4.4 and discussed in the following sub-sections dealing with each crop category.

Millet and Sorghum.-- Over three quarters of the 295 Mossi and Bisa food grain fields and nine-tenths of the area planted with millet and sorghum are attributable to two crop mixtures. These are red sorghum, millet and cowpeas, planted in proximity to the farm dwelling, and millet and cowpeas, planted further away from the compound and on bush fields. A comparison of the mean household hours per hectare spent on each major

TABLE 4.11

LIST OF PRINCIPAL WORK CATEGORIES ANALYZED BY THE FARM MANAGEMENT STUDY

Sector	Work Category	Activity Codes
Agricultural Sector	Field Preparation	1, 2, 3, 4, 6, 12
	Spreading Fertilizer	7, 14, 46
	Sowing	8
	Weeding and Transplanting	5, 9, 10, 11
	Watering	13, 81
	Fencing	15
	Guarding Fields	16
	Travel between Fields	80
	Time Spent on an Agricultural Work Invitation	22
	Harvesting	17, 18
	Processing of Harvest	19, 20, 23, 47, 48, 83, 84
	Gathering	40 → 43
Livestock Sector	Poultry Production	24 → 28
	Small Stock Production	29 → 32
	Large Stock Production	33 → 37
	Milking	38
	Veterinary Care	39
Domestic Sector	Fetching Water	50, 59, 75
	Fetching Wood	51
	Meal Preparation	52 → 56
	Attending Meeting, Religious Rites or School	77 → 79
	Being Ill	58
	Other Domestic Work	57
Nonagricultural Sector	Straw Weaving	60 → 62
	House Construction & Repair	63, 69
	Metal Work	44, 45, 64

TABLE 4.11 (cont.)

Sector	Work Category	Activity Codes
Nonagricultural Sector (cont.)	Pottery Work	65
	Repair to Machinery	66
	Fabric and Spinning Work	49, 85
	Nonagricultural Work Invitation	72
	Commercial Activity	21, 67, 68, 70, 73, 74
	Nonagricultural Work Outside the Village	71
Social Activity	Travel Away from Village of a Social Nature	82
	Visiting with Friends, Drinking Millet Beer, etc.	76

TABLE 4.12

MEAN HOUSEHOLD HOURS ALLOCATED TO EACH MAJOR AGRICULTURAL OPERATION, BY FORTNIGHT

Fortnight No.	Calendar Date	Seedbed Preparation	Weeding and Transplanting	Harvesting & Processing
1	May 9-22, 1976	180	58	2
2	May 23 - June 5	201	159	1
3	June 6-19	130	268	0
4	June 20 - July 3	103	347	0
5	July 4-17	55	435	0
6	July 18-31	26	455	0
7	Aug. 1-14	4	397	0
8	Aug. 15-28	1	290	1
9	Aug. 29 - Sept. 11	14	188	10
10	Sept. 12-25	7	53	101
11	Sept. 26 - Oct. 9	5	26	32
12	Oct. 10 - Oct. 23	3	17	54
13	Oct. 24 - Nov. 6	4	11	168
14	Nov. 7-20	1	2	131
15	Nov. 21 - Dec. 4	0	2	178
16	Dec. 5-18	0	2	105
17	Dec. 19 - Jan. 1, 1977	0	0	20
18	Jan. 2-15	0	1	14
19	Jan. 16-29	0	1	24
20	Jan. 30 - Feb. 12	3	0	29
21	Feb. 13-26	3	1	10
22	Feb. 27 - Mar. 12	3	0	10
23	Mar. 13-26	5	0	3
24	Mar. 27 - Apr. 9	14	0	8
25	Apr. 10-23	13	0	12
26	Apr. 24 - May 7	39	0	8

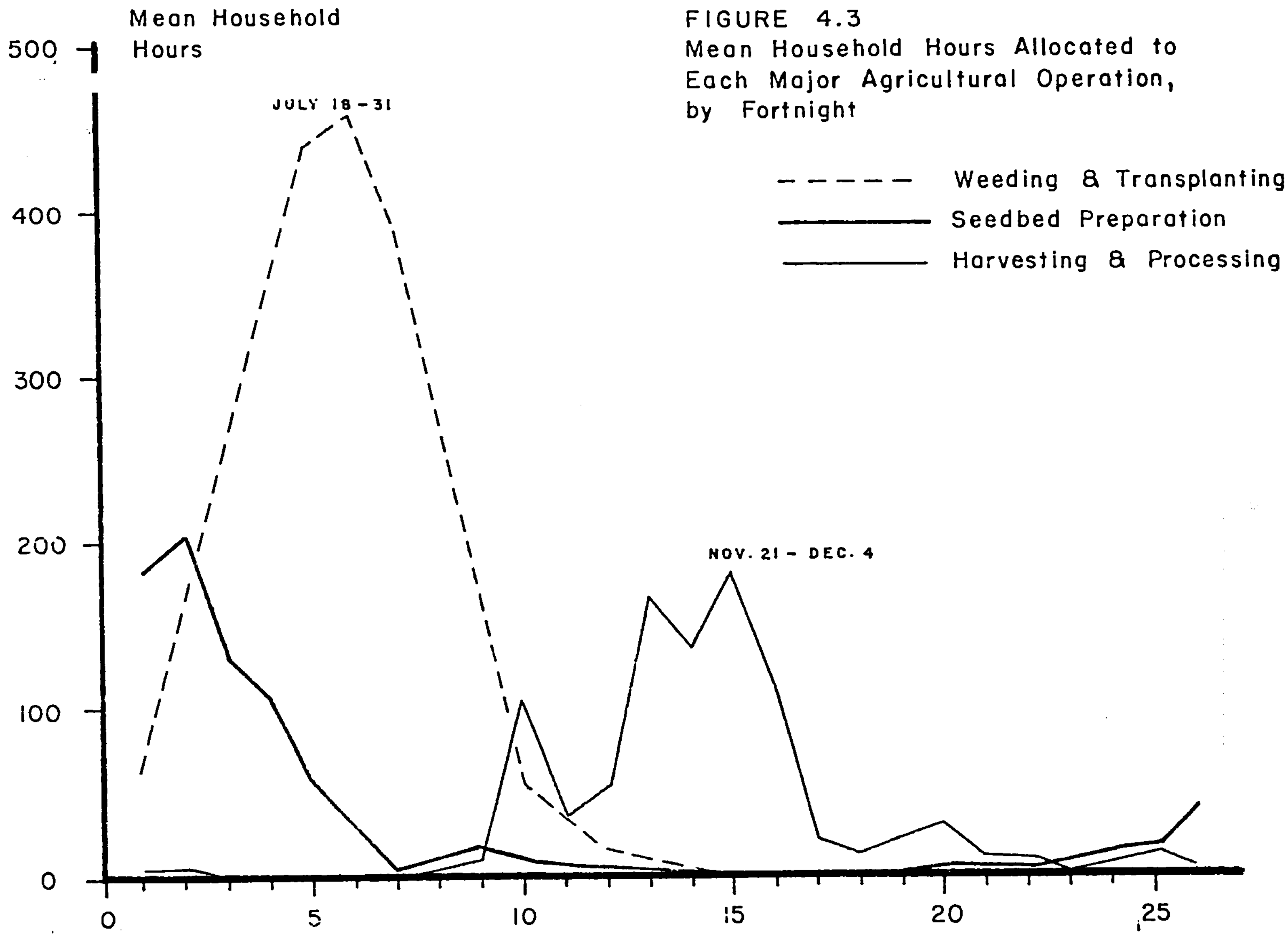

FIGURE 4.3
Mean Household Hours Allocated to Each Major Agricultural Operation, by Fortnight

agricultural operation for the two crop mixtures indicates that there is not sufficient evidence to conclude that one is more labor intensive than the other. The mean hours per hectare devoted to each operation were computed for each crop, and the resulting values compared in a test for differences in the means. The test, based on the t-distribution, follows the assumptions and methodology given on page 77.

Table 4.14 lists the results of the comparison. The figures show that there is a high degree of variability in labor allocation to each task. A two-sided test for differences in the means for each crop mixture uniformly fails to reject the null hypothesis of equal means at the ten percent level of significance. The results have most force with respect to seedbed preparation and weeding. A one-sided test for the superiority of mean hours spent harvesting and processing the mixture including sorghum succeeds in rejecting the null hypothesis of equality at the ten percent level. This suggests that, on average, more time may be needed to harvest millet and sorghum, as opposed to millet alone. This is not surprising, since the two crops ripen at different times. On the other hand, the evidence clearly does not support the view that the total number of hours per hectare spent on each crop mixture are different, on the average.

For expediency, the labor inputs per hectare to the two crop mixtures were pooled into a unified series built with data for all mixtures containing sorghum and millet as the primary crop. Extra labor input required for harvesting sorghum, as opposed to millet, comes at fortnight 10, a period of relative slack in the overall work allocations portrayed in Figure 4.1, p. 52. Thus, ignoring small amounts of extra labor required for sorghum mixed with millet, as opposed to millet alone, is not likely to affect an analysis of the labor constraints on producing food grains.

Red sorghum is by far the most important cash crop of the Tenkodogo area, by both weight and value although, in an average year, only 15% of the crop in the region is estimated to be sold (Garey and Storm, 1972, p. 39). The retained portion of the harvest is made into the ubiquitous local beer ("dolo"). The food staple, millet, is second only to sorghum in weight and value of sales, making the Tenkodogo sub-prefecture a net exporter of food grains (Ibid.). Cowpeas are nitrogen-fixing legumes of benefit to

TABLE 4.13

MEAN TOTAL HOUSEHOLD HOURS SPENT PER HECTARE OF EACH CROP CATEGORY

Fortnight	Millet and/or Sorghum with Cowpeas	Groundnuts	Maize	Rice	Root Crops	Cotton and Tobacco	Fruit and Vegetables
1	134	0	0	2	1	0	0
2	170	115	280	204	26	0	0
3	159	174	549	264	0	0	0
4	172	109	119	327	10	0	0
5	146	216	589	380	16	67	53
6	157	293	392	355	91	6	6
7	105	142	200	283	259	293	231
8	86	102	38	171	256	1100	875
9	85	29	74	31	42	88	88
10	27	17	0	40	66	10	277
11	5	22	0	45	300	264	235
12	28	106	0	127	313	88	201
13	32	265	0	114	175	792	109
14	176	329	0	194	101	378	78
15	94	38	0	31	106	110	104
16	8	3	0	4	98	1144	174
17	0	0	0	0	215	440	398
18	0	0	0	0	118	220	454
19	0	0	0	0	62	0	450
20	0	0	0	0	30	0	335
21	0	0	0	0	53	0	391
22	0	0	0	0	20	0	416
23	1	0	0	0	4	0	303
24	3	0	0	0	0	0	386
25	8	0	71	0	0	0	391
26	21	0	69	0	0	0	37
Σ1-26	1617	1960	2256	2592	2067	5000	5892

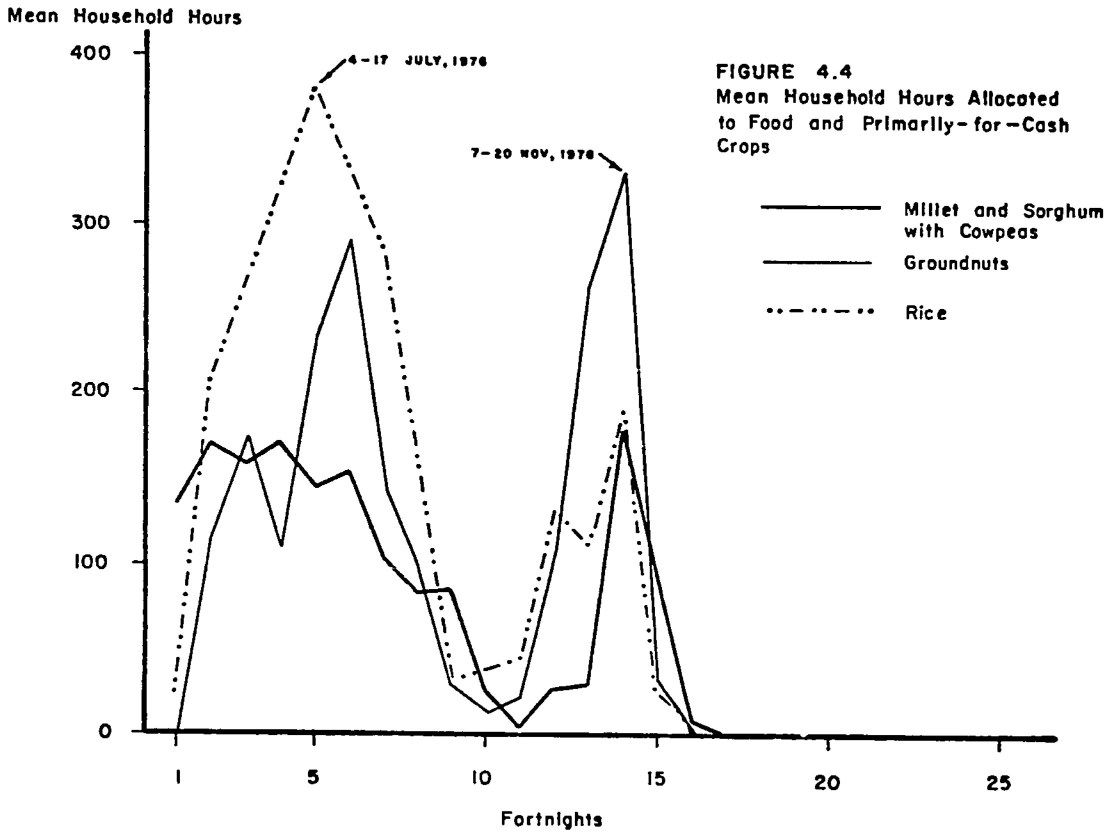

FIGURE 4.4
Mean Household Hours Allocated to Food and Primarily-for-Cash Crops

TABLE 4.14

COMPARISON OF MEAN HOUSEHOLD HOURS SPENT PER HECTARE ON SORGHUM AND ON MILLET CROP MIXTURES PER MAJOR AGRICULTURAL OPERATION

Operation	Red Sorghum, Millet and Cowpeas N=83		Millet and Cowpeas N=101		t-Statistic For[a] Testing the Difference in Mean Labor Input Per Crop Mixture
	Mean hrs/ha	(S.D.)	Mean hrs/ha	(S.D.)	
Mean Hours in Seedbed Preparation	334	(709)	266	(389)	0.825
Mean Hours in Weeding and Transplanting	1300	(1461)	1153	(1237)	0.739
Mean Hours in Harvesting and Processing	652	(1067)	471	(411)	1.570
Mean Total Labor Hours	1662	(1376)	1632	(1580)	0.168

Methodology - Each line was averaged separately, using the totals for each household.

[a]Null hypothesis: $M_1 = M_2$, reject at 10% significance level (two-sided test) if $t > 1.645$. Methodology and assumptions of the test follow those laid out in Chapter 4, p.

the grain crops. The seeds are used as a food staple, but rarely sold. The stalks and leaves are used as fodder for sheep and goats.

Sorghum is planted as soon as possible after the first major rainfall. If early rainfall is not sustained, the crop is often planted several times on the same plot. During the first month after sorghum planting, the fields must be weeded to allow the shoots to develop. Millet is then planted in the spaces where the sorghum fails to germinate. Cowpeas are planted from one month to six weeks after the sorghum, in the spaces between the millet. The month of July witnesses the peak labor use period, with the second weeding of sorghum, which also constitutes the first weeding of millet. Cowpeas are planted in the empty spaces on sorghum and millet fields. Late July and early August (principally fortnight 6) is the time for the third (final) weeding of sorghum and the constriction of mounds of earth around the millet stalks, to protect the roots and support the plants during the heavy rainfall of August. The sorghum is harvested in the middle of September (fortnight 9 and 10). Labor input then tapers off until the cowpea harvest begins in the middle of October. The peak of labor input to millet occurs next, with the harvest of that crop from the middle of November to early December (fortnights 14 and 15).

Groundnuts.-- The general term groundnuts is used in preference to peanuts since the latter are often intercropped with an indigenous plant having edible tuberous roots, usually referred to as "pois de terre."[1] The latter are boiled in the shell and eaten with salt and oil. It is difficult to separate out the labor specifically devoted to peanuts. Analysis (using the methodology of the previous section) of several single stands of peanuts compared with the mixture fails to indicate a clear difference in the mean amount of labor per hectare attributable to single as opposed to mixed stands. For expediency, the figures here relate to labor allocations per hectare to both the mixture and peanuts alone.

Both peanuts and the indigenous crop are sold for cash and consumed as food. In the 1976-1977 campaign, peanuts were by far the most important

[1] The scientific name for this plant is Voandzeia Subterranea. Webster's Seventh New Collegiate Dictionary defines a groundnut as any of several plant having edible tuberous roots (1965, p. 368).

cash crop collected by the field office of the O.R.D., although overall sales on the open market of sorghum most likely exceeded the value of peanut sales.[1]

Groundnuts are planted during the third fortnight after sorghum planting, or the early part of June. The peak labor requirement is during the latter half of July (fortnight 6), as weeds stimulated by heavy rainfall in July begin to choke off plants on untended plots. As such, groundnuts compete for labor at the same time as the food staples and revenue earners, millet and sorghum. The harvest of groundnuts is relatively very labor intensive and conflicts with the labor required for harvesting millet in November (fortnight 14). Figure 4.4 above depicts the pattern of labor allocation to millet and sorghum, the staple, next to peanuts and rice, the primarily-for-cash-crops.

Maize.-- Maize is planted in very small stands around the perimeter of the compound. Labor inputs relative to the size of the plots are very high. Sowing takes place as soon as the advent of the rainy season permits. The crop is often harvested a few ears at a time, as needed for meals. Ripe ears not required for immediate consumption are husked, with the adhering leaves woven into a chain which is hung to dry out of the reach of animals. Maize requires the most fertile ground available, but is attractive because it is the first food crop to mature. This provides nourishment in late August and early September when it is most needed, during the hungry period before the millet harvest. Sixty day varieties of red sorghum mature earlier, but are less preferred.

Rice.-- Rice is grown in low-lying areas and requires a considerable amount of labor input for weeding and transplanting according to traditional methods, particularly during the month of July (fortnights 4-6). Rice is cultivated primarily for cash. Garey and Storm (1972, p. 39) estimate that, in an average year, 70% of the Tenkodogo rice harvest is sold. Casual empiricism in Oueguedo and Loanga suggest that this considerably understates the amount traded. Sample members stated that the usual practice

[1]In a year of well-distributed rainfall, which was not the case in 1976, sample members claim that they obtain cash income by selling millet and rice.

is to eat one meal of rice after the harvest and sell the rest. A larger amount is saved if participation in an important ceremonial occasion is anticipated for the coming year, as in the case of "funeral" celebrations for a close relative. Rice is often served to the most honored guests at these gatherings. Like millet and groundnuts, rice must be harvested after the rains have stopped, while the crop is ripe and at the desired state of dryness, but before domestic animals are released to browse at will. The peak observed labor input into rice was in the middle of November, during fortnight 14.

Root Crops.-- The two root crops grown by sample members, usually in single stands, are cassava and sweet potatoes. In Tenkodogo, these crops require access to lowland, which tends to be in relatively short supply. Strong labor is required for constructing the ridges of heavy soil that plants grow on. Although these crops require a relatively high amount of labor input using this technology, they present the advantage that the periods of peak labor input can be scheduled away from conflicts with other crops. The peak input into root crops by sample members occurred during fortnights 11 and 12, which are times of relative slack with respect to cereals cultivation.

Cotton and Tobacco.-- Cotton and tobacco are occasionally intercropped on sample farms on very small plots, in the immediate vicinity of the compound. Production is very labor intensive, although the figures in Table 4.13 should be interpreted in light of the small size of the area grown. The product is used either for family use or, in some cases, cultivated as a personal plot by one of the household members in order to gain a small independent revenue. The sandy upland soils in the Tenkodogo area tend to contain insufficient organic material to support cotton on a large scale.[1]

Fruits and Vegetables.-- Fruits and vegetables are cropped throughout the year. The principal varieties are mangoes, guavas, tomatoes, okra, onions, and red peppers. Small plots of vegetables close to the compound

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[1]A view expressed by the local O.R.D. officials, seconded by an expatriate agronomist living in Tenkodogo, and confirmed by the author's measurements of yields per hectare inferior to 200 kg.

are usually maintained by each married woman in the household, for use in cooking. They often sell surplus production during market days in Tenkodogo or within the village. Men occasionally maintain plots of vegetables on well-irrigated lowland during the dry season. The principal fruit harvest concerns mangoes and occurs in March. The figures in Table 4.13 relate to at least two separate crops. One is the wet season crop, from fortnights 1 to 13, and one is the dry season crop, from 14 to 26. This division of time periods in somewhat arbitrary, but takes into account the distribution of labor input over the year, reaching a mid-year low in fortnight 14, or the beginning of the dry season.

The Mean Farm Allocation of Labor Per Animal Kept

In addition to subsistence and cash crop enterprises, Mossi and Bisa farmers in the research area keep farm animals for on-farm consumption and sale. Chapter six discusses the division of output between those two ends. This section discusses mean household labor allocation each fortnight to each category of livestock activity (in the broad sense). Farmers keep poultry, sheep and goats, pigs, donkeys, and horses. The mean household labor allocation to each enterprise, with the exception of poultry, is calculated by summing the hours allocated each fortnight by each household to that enterprise and dividing by the number of animals kept at the time of the herd inventory in February 1977. The fortnightly totals are then averaged over households. This procedure yields an estimate of per animal, fortnightly mean household labor allocations. The resulting figures are meaningful primarily for herds the size of the mean household herd, to the extent that there are labor economies of scale in stockraising which diminish per animal labor requirements as herd size increases.

Not one of the 41 Bisa and Mossi household sampled kept cattle on-farm during the interviewing period. The following section derives estimates of labor allocations to cattle for different herd sizes based on Fulani herding practices as observed among the twenty Fulani sample households. This is a second-best procedure, in view of the absence of information on the flow of labor to different activities for the Fulani.[1] The results, however, tie in well with those for other animals, in view of the increased labor input to livestock activities during the agricultural season, particularly during the periods of peak agricultural labor use.

Poultry.-- The figures for labor allocations to fowl are totals per fortnight. The high annual turnover of birds and the relatively small monetary value of each animal preclude giving figures on a per animal basis. The average household flock contains from 5 to 20 birds, composed of guinea fowl and chickens. When rounded to the nearest hour, the mean household time spent on poultry is five hours apiece during the first two fortnights (May) and 2 hours during fortnights 15 and 16 (late November-early December). Otherwise, virtually no time is spent on chicken raising. The figures reflect the care that must be exercised right after sowing, until the seeds sprout so as to be unattractive to the birds as food. During the millet harvest, the flock must be kept away from the ears of grain drying on the ground.

Sheep and Goats.-- The mean household labor input per fortnight to each of the major livestock categories, per animal, is given in Table 4.15. A Mossi-Bisa sample household possesses between 7 and 8 sheep and goats, on average. The surprisingly high labor input to small ruminants during the rainy season reaches a peak during the maize harvest, at the end of August. Sheep and goats are tethered to stakes during the rainy season and guarded by boys. As the wet season progresses, the animals must be tethered further away from the compound. After the maize harvest, green stalks and leaves are available as forage, reducing the required labor input. The distribution of labor inputs to small ruminants over fortnights remains valid whatever the herd size. The absolute magnitude of figures for per animal labor in Table 4.15 must be interpreted with caution since the figures advanced are valid only for a small household

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[1]The information presented here is based on casual conversation and approximately six interviews of each Fulani household in the sample. A repeated-interview labor survey of the same Fulani sample members was performed by the author's staff during the 1977 rainy season. Results will be forthcoming in a report to REDSO-WA/USAID in July 1978.

TABLE 4.15

MEAN HOUSEHOLD LABOR INPUTS PER ANIMAL TO EACH
OF THE MAJOR LIVESTOCK CATEGORIES ON PEASANT FARMS

Fortnight	Sheep & Goats	Donkeys & Horses	Pigs
1	15	35	3
2	15	41	2
3	16	42	4
4	21	56	9
5	21	73	12
6	23	84	6
7	26	94	7
8	27	92	6
9	24	66	10
10	19	52	8
11	17	43	2
12	17	52	11
13	19	55	9
14	19	54	13
15	18	52	6
16	17	47	8
17	17	51	14
18	16	51	9
19	16	47	9
20	15	45	7
21	14	45	7
22	15	47	9
23	16	47	6
24	16	50	2
25	15	47	8
26	13	42	4

SOURCE: Twice-weekly interviews, as explained in the text.

herd, and relate to labor supplied, for the most part, by children. Chapter eight discusses alternative formulations of labor requirements for farm animals in view of these considerations, in the context of the construction of a farm model.

Donkeys and Horses.-- Sixteen out of forty-one peasant sample members kept one or two donkeys and horses in 1976. The average fortnightly labor allocation per animal for each of these households is also given in Table 4.15. A sharp peak in labor input occurs during August (fortnights 7 and 8). Donkeys and horses are kept outside the village during the entire growing season. They are entrusted either to Fulani herdsmen or to relatives living at the periphery of the in-village fields. The animals are intensively grazed during August, a period when the agricultural peak of July is wearing off, yet natural forage still abounds. Every effort is made to fatten the animals as quickly as possible before the dry season. The animals are returned to their owners in the central village after the millet harvest, in December, at which time they are kept tethered to wooden stakes. The patterns over time of the per animal labor inputs for sheep, goats, donkeys and horses are given in Figure 4.5. The same disclaimers concerning magnitudes, as opposed to the distribution of inputs over time, applies to large stock as to small stock, for the reasons expressed in the subsection.

Pigs.-- Pigs were kept by only four Mossi and Bisa households, and on a very small scale. In each case, the farmer concerned had access through family ties to the bran generated from millet beer production. This diet was supplemented by an indigenous thorn bush found in remote areas. Given the low availability of organic kitchen wastes from households in the area and the absence of suitable by-products from industrial processing, swine must be maintained through gathering or growing a suitable forage crop. This form of feeding entails considerable labor, a long distance from the house. Perhaps the best alternatives for forage crops are red sorghum or peanuts. However, the prevailing prices for these products make this solution uneconomic.[1] The figures for labor inputs to swine

[1]A two to three year old animal yielding forty kilograms of usable meat will fetch 6,000 CFA during the dry season, which is equivalent to three 100 kg. sacks of sorghum at harvest time prices, or roughly 150 kg. of shell peanuts. Clearly, the weight of crops consumed during the weaned life-time of the animal surpasses 300 kg. of sorghum or 150 kg. of peanuts, making this form of fattening a dubious proposition.

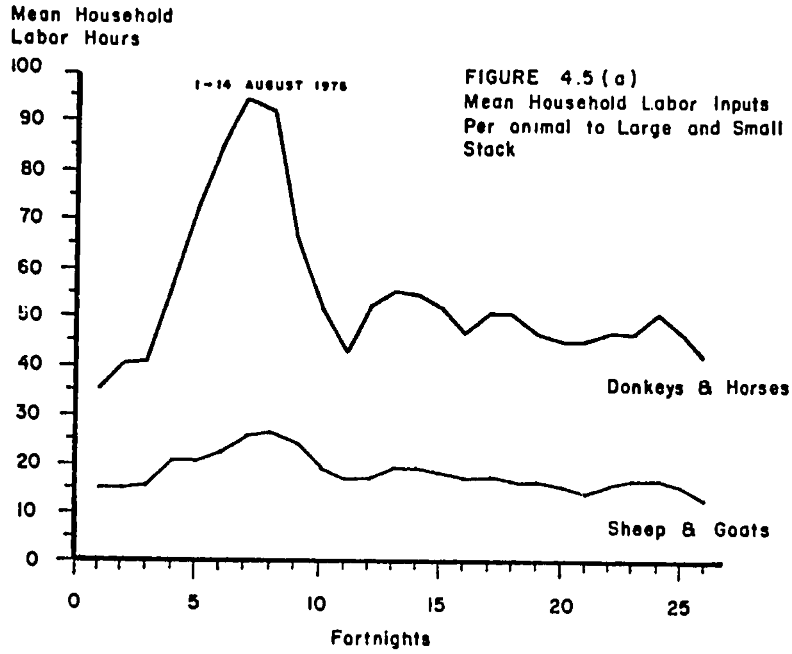

FIGURE 4.5 (a)
Mean Household Labor Inputs Per animal to Large and Small Stock

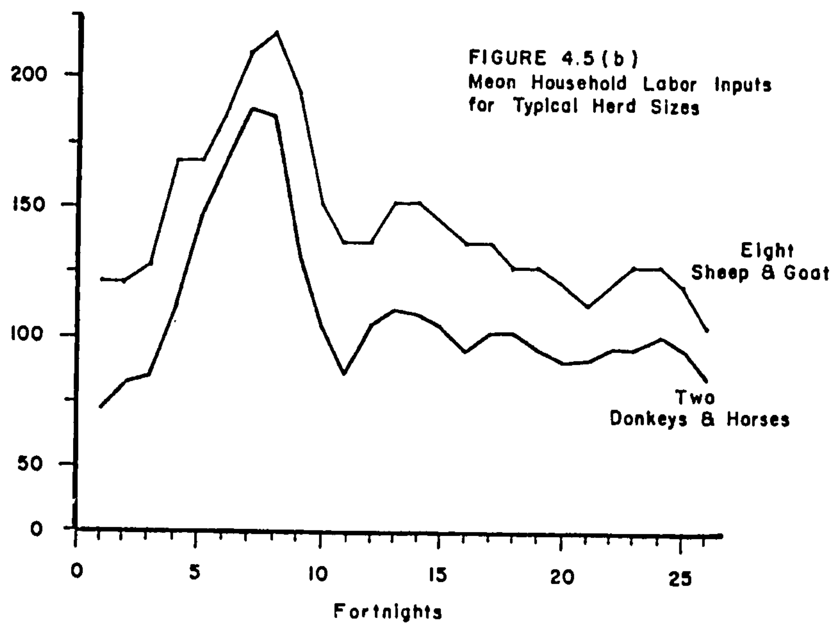

FIGURE 4.5 (b)
Mean Household Labor Inputs for Typical Herd Sizes

in Table 4.15 depict a highly irregular pattern over fortnights which is difficult to interpret. Given the small sample of four families, with unrepresentative access to feedstuffs, great caution should be exercised in drawing conclusions from these results.

Deriving Labor Requirements per Animal for Cattle from the Fulani Sample

The twenty Fulani families sampled in Oueguedo are subject to many of the environmental constraints familiar to their Mossi neighbors, notably high population density, a long dry season, and poor soils. The absence of cattle raising by peasants necessitates observing Fulani labor inputs to cattle as a guide to the requirements applicable to Mossi (and Bisa) stockraising. Since peak labor use occurs during the crop growing season, it is the period of May through December which is of greatest interest when defining necessary labor inputs to cattle enterprises. It is during this period that labor use conflicts are likely to occur between crops and livestock. The major conclusion of this section is that cattle enterprises require a great deal of supervisory labor during the crop growing season.

The Fulani Evidence for Range-Fed Cattle.-- A composite account of Fulani labor requirements for a herd of thirty head pastured during the rainy season is given in Delgado (1977, pp. 59-61), and the essence of it reproduced in Table 4.16. This overview was compiled from answers to questionnaire L Appendix C) and more casual interviews conducted by the author between March and May 1977.

It can be seen from Table 4.16 that looking after a herd of 30 animals in the rainy season largely occupies the time of two males over 15 years of age. Smaller children cannot be used to herd the cattle at this time, according to sample members, since greater strength, experience, and endurance are required to keep them away from crops. Greater maturity is also required of herders at this time, since an error of judgement can result in a very costly damage suit. Children have duties gathering forage for calves and a leaf that will drive off insects when burned at night. Women go to markets to sell excess butter and milk, which are plentiful in the rainy season.

TABLE 4.16

A FULANI ACCOUNT OF LABOR REQUIREMENTS FOR
A HERD OF THIRTY HEAD IN THE RAINY SEASON
(Not Including Transhumance)

A.

Daily Activities	Place	Time	Type of Labor
Grazing and Watering Adult Herd	Bush away from Fields	6:30 a.m. to 6 p.m. daily	1-2 Males Over 15 Years Old
Watering Claves	Near Home or Corral	1-2 p.m.	Boys or Girls
Veterinary Check by Herder for Parasites and Disease	Corral	6 p.m. to 6:30 p.m. Daily	Head of Household
Gather Special Leaves in Bush for Medicinal Smoke to Drive Off Insects from Corral at Night, also Gathering Forage for Calves	Bush	2-3 Hours During the Day, Daily	Boys
Removing Ticks	Corral	1/2 Hour Daily in Evening	Males Over 15
Milking	Corral	1/2 Hour in Morning and in Evening	All Females

B.

Occasional Activities	Place	Frequency	Type of Labor
Give Salt Licks	Corral	Several Days During Rainy Season	Boys and Men
Moving Corral	Corral	Every Seven to Ten Days	Everyone
Taking an Animal to Veterinarian in Tenkodogo	Tenkodogo	?	Head of Household
Delivering an Animal to a Buyer	Up to 70 km Away	?	Young Male, Usually Not Head of Household
Buying and Selling Animals	Up to 15 km Away	?	Head of Household

SOURCE: Delgado (1977) p. 61.

The major labor requirement for stockraising in the savannah is feeding the cattle, particularly when they are surrounded by crops. The majority of Fulani sample members saw pasture and not water as the critical dry season constraint. If a suitable forage crop were available, the labor requirements for a small number of animals would be much less than those for a large number. The feeding labor input would be principally that of cultivating, preparing, storing, and serving the forage. However, it is not clear that a suitable crop exists for the Tenkodogo area, given the seven month dry season. This is north of the area suitable for stylosanthes and most other planted forage grasses (Serres, Hübl, and Roider, 1975, I, p. 51). Even if this were not the case, it would still require the labor to cultivate and protect nearly a hectare of land to feed even a few animals.[1] The labor input for this would come during the rainy season, when labor use is at its peak, aggravating labor conflicts with crop activities.

It seems realistic to assume that cattle in the Tenkodogo area will have to be fed on natural pastures, within the foreseeable future. The implication is that substantial time must be spent herding the animals, particularly during the crop growing season. The closer the animals are kept to in-village fields, the more time must be spent herding them. The labor requirements for herding two animals may not be that much less than that required for eight. Problems faced by small herds are not unlike those of large herds. To compound the problem, Fulani experience in Oueguedo indicates that the labor required to do this during the rainy season is young adult male labor, which has a high opportunity cost in terms of crop production.

Besides herding labor inputs, keeping animals on-farm requires the veterinary care and corral maintenance labor currently performed for the peasants by the Fulani. The labor requirements for these tasks occur primarily during the rainy season because of a higher incidence of insects and parasites.

[1]For the much more humid Bouake area in Ivory Coast, Ruthenberg (1974) estimates the carrying capacity of one hectare of stylosanthes at 3.5 animals weighing 250 kilograms each.

In addition to wet season labor inputs, substantial labor is required to graze range-fed cattle during the end of the dry season, when pasture near the village is scarce. The Fulani typically solve this problem by leaving the village area on a three month migration in late April, returning in early July. The animals are taken to the more humid river beds, rarely more than sixty kilometers away (Delgado, 1977, pp.62-64). A peasant family with special access to labor, such as that of the village chief, and little competition from neighbors for the small amount of in-village pasture near river beds, could conceivably gather feed closer to home. However, this model reflects externalities not available to everyone should they (simultaneously) decide to keep cattle.

The Derivations of an Optimistic Set of Fortnightly Labor Requirements for Two Steers.-- Given a pessimistic view of the possibilities for a suitable forage crop in an area with a seven month dry season, a set of labor requirements is derived taking account of range pasturing. The fortnightly totals are for a two steer activity, such as would apply to a peasant household purchasing two young bullocks for animal traction-*cum*-fattening purposes. The results are displayed in Table 4.17. These figures are *optimistic* in the sense that they hypothesize little in the way of labor input, relative to the amount of labor requirements for a herd of thirty head given in the previous section. They follow approximately the same pattern of seasonal variation suggested above. The numbers are based on a minimum estimate of 7 1/2 hours daily household labor needed to water, feed, and generally maintain the two animals in the crop growing season, when strict supervision must be exercised during grazing to prevent crop damage. This figure may be compared with the overall average figure of nine hours daily care for two donkeys or horses, during fortnights 3 to 14.[1]

The nongrowing season labor estimates for cattle in Table 4.17 are based on a distinction between the period when cattle can graze on crop

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[1]For the 16 sample households with donkeys or horses, the mean herd size was two animals. Thus, the per animal labor figures in Table 4.15 were calculated on the basis of family herds of approximately this size. In this sense, it is more accurate to speak of 9 hours a day for two animals, as opposed to 4 1/2 hours for one, given the existence of economies of scale in grazing supervision.

TABLE 4.17

AN OPTIMISTIC ESTIMATE OF FORTNIGHTLY
LABOR REQUIREMENTS TO MAINTAIN TWO STEERS
(In Hours)

Fortnight	Season	Fortnightly Total	Daily Total
1	Planting, Sprouts	84	6
2	Not Above Surface	84	6
3	Growing Season	105	7 1/2
4		105	7 1/2
5		105	7 1/2
6		105	7 1/2
7		105	7 1/2
8		105	7 1/2
9		105	7 1/2
10		105	7 1/2
11		105	7 1/2
12		105	7 1/2
13		105	7 1/2
14		105	7 1/2
15		105	7 1/2
16		105	7 1/2
17	Post-Harvest Dry Season	35	2 1/2
18		35	2 1/2
19		35	2 1/2
20		35	2 1/2
21		35	2 1/2
22		35	2 1/2
23	End of Dry Season, Range	84	6
24	Forage is Scarce	84	6
25		84	6
26		84	6

stubble and in-village pastures near dry water courses, and the period when animals must be led further afield to browse. The latter case occurs approximately from the middle of March until the new grasses come in at the beginning of June. This period covers fortnights 1, 2, and 23 to 26 in Table 4.17. The hypothesis is that it requires half a day to graze and water stock at this time, whether by gathering and transporting fodder to the corral, or by herding in bush areas. Again, the Fulani experience indicates that this estimate is, if anything, optimistic in terms of a low labor requirement.

Labor Peaks and Conflicts Between Crops and Livestock: A Graphical Analysis

The evidence accumulated in this chapter indicates the existence of conflicts in fortnightly labor use as between cash and subsistence crops, and livestock. Chapters seven and eight will explicitly analyze these conflicts in a linear programming context. This section provides a visual indication of the problem by superimposing the labor requirements for a herd of eight sheep and goats, and for two steers, on those for crops portrayed in Figure 4.4. The livestock figures are extrapolated from Table 4.17 above. The results are presented in Figure 4.6.

The figure of eight sheep and goats represents the mean household herd size actually kept. The peak figure in fortnight eight implies that two boys are kept occupied for seven hours a day caring for the animals at this time. This estimate appears to be high. A modification of fortnightly labor requirements for sheep and goats is discussed in chapter seven. This involves deriving a set of requirements by a method similar to the one used in the previous section. The net effect is to lower the per animal labor requirement, keeping the same percentage distribution of total labor input over fortnights. The justification for this is that young boys can supervise staked sheep and goats, whereas they cannot supervise cattle in this manner during the rainy season. It is likely that a boy who watches over goats for seven hours would be unable to weed millet for the same number of hours, the latter being much more arduous work. Thus, for the purposes of comparing labor inputs between different activities, the actual allocations in hours to sheep and goats should be revised downward in relation

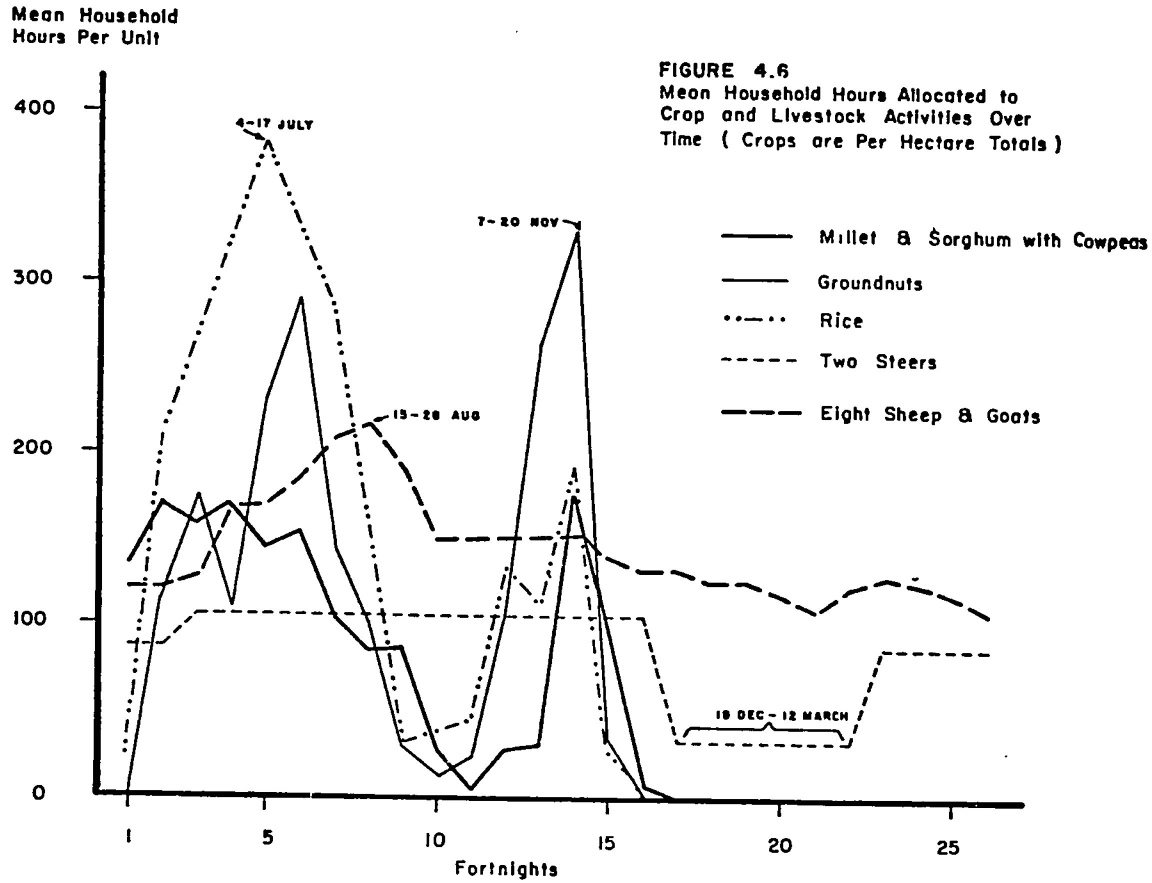

FIGURE 4.6
Mean Household Hours Allocated to Crop and Livestock Activities Over Time (Crops are Per Hectare Totals)

to cattle and crop production, because labor hours spent supervising small stock are not fully transferable to the more demanding tasks of supervising large stock or weeding crops.

The magnitude of overall labor input to livestock activities is sensitive to assumptions concerning the size of the herd kept and the value of child labor in alternate uses. However, the percentage distribution of labor inputs remains relatively unaffected by these considerations.[1] The shape of the curves in Figure 4.6 clearly indicates that labor allocations to livestock, as for crops, are higher during the wet season. This suggests that labor during critical periods in July and November may well be the binding constraint that determines the level and composition of the optimal production mix of livestock and crops.

[1]Conceivably the labor requirement for steers could be decreased in the dry season, since children can do the work. This only serves to accentuate the relative labor peak in the wet season.

CHAPTER 5

LAND

This chapter discusses the availability and use of land by households in the sample, practices involved with the maintenance of soil fertility, and the allocation of land to different enterprises. Since all livestock are grazed on communal, natural pasture, questions of land allocation are approached from the standpoint of crop farming, with livestock raising entering as a residual activity. The typical peasant farm is composed of many small fields of irregular shapes, spread over a large area. The Mossi and Bisa cultivate substantially greater areas per household than the Fulani. There is a great deal of variation, however, in the amount of land cultivated per agricultural worker in both the farming and herding groups. This is interpreted as the manifestation of an uneven distribution of wealth in the research area. A minimum of two-thirds of the land area cultivated by all three ethnic groups is planted with crop mixtures involving millet. The average amount of household land devoted to millet and sorghum excedes four-fifths of the total cultivated area. Land close to the village is very scarce, encouraging the expansion of peasant bush fields into traditional grazing areas. Since cattle are closest to bush fields during the growing season, the staple food grain is involved in most instances of crop damage. This serves to accentuate the competition between livestock and food grains for the same resources.

Types of Land and Soils in the Research Villages

Following Norman, a basic distinction can be made between "lowland" and "upland" resources (1973a, pp. 5-6). Lowland is usually centered around wet season watercourses or swampy areas with poor drainage in July and August. It supports relatively high value, labor intensive crops. Tubers and fruit grow year-round. Vegetables are cropped with irrigation during the dry season, and rice is planted during the wet period. Lowland soils tend to be composed of a high proportion of sedimentary material and clay, mixed with sand. As such, they are compact and relatively difficult to work with hand tools.

Upland is divided into three types, depending on its proximity to human habitation. The most fertile upland is referred to here as "house land." This is the area within a circle of fifty meters radius around the compound walls. It is composed, like most upland areas, of leached tropical ferruginous soils. Because of its location, however, it receives all of the organic garbage of the household, including night soil and goat droppings. House land can support red sorghum during the wet season, in addition to the usual upland crop mixture of millet and cowpeas, because of this manuring. Maize, cotton, tobacco, and vegetables will grow on the most fertile ground nearest to the compound walls. The second form of upland is referred to here as "in-village land." The soil is also composed of leached tropical ferruginous material over granite or laterite crust. Since this area is conveniently close to the compound, most households have farmed their portions continuously for many years. Unfortunately, it is not close enough to the dwellings for convenient night soil manuring. Thus, the fertility of in-village fields is lower than that of house fields and quite possibly declining over time. Only millet, cowpeas, and groundnuts will grow during the wet season. During the dry season, the interior of the village is a barren area of denuded hummocks. The third form of upland, "bush land," is clearly outside the zone of human habitation. As a practical matter, any field over three kilometers away from the compound of the farmer who cultivates it is defined as a bush field in this study. Bush land is similar in characteristics to in-village land, except that its use for cultivation is a more recent practice. Thus, the soil retains more of its original fertility because much of the bush field area was only recently cleared of its original cover.

Table 5.1 contains the results of a granulometric analysis of soil samples taken from Loanga village by the author, courtesy of the laboratory of physical geography of O.R.S.T.O.M., Ouagadougou.

TABLE 5.1

MAJOR COMPONENTS OF LOANGA SOIL SAMPLES

Type of Land	Crop Grown in Wet Season of 1976	% of Clay and Organic Alluvia	% of Large Sand 0.2-2 mm	% of Small Sand 0.05-0.2 mm
Sample from Bed of Dry Water Course		82.2	3.8	14.0
Wet Lowland	Mangoes and Bananas	61	23.6	15.4
Lowland	Sweet Potatoes	43.9	37.2	18.9
House Field	Red Sorghum + Millet + Cowpeas	33.7	47.3	19.0
In-Village Field	Millet + Cowpeas	24.2	47.1	28.7

SOURCE: Analysis performed by the staff of the laboratory of physical geography of O.R.S.T.O.M., Ouagadougou. Thanks are due to the director of the laboratory, M. Avenard.

The results suggest that the compactness and organic content of village soils increases with proximity to wet season watercourses and thus with decreasing elevation. However, the house field sample was found to contain a higher percentage of clay and organic material than a less elevated in-village field, which may be a result of long-term manuring. The complexity and length of methods required to analyze the samples precluded further sampling, thus the results here are presented solely as indications for further research.

Use of Cattle Manure as a Soil Improver

In addition to the use of night soil and goat dung on house fields, the Mossi and Bisa occasionally use cattle dung obtained from Fulani corrals as field fertilizer. Enumerators made every effort to record all instances of this practice during the twice-weekly visits to Mossi and Bisa families. Applications were summed for each field and converted from local measurements of volume into rough estimates of weight in kilograms. Totals were divided by field areas to get data in kilograms per hectare. Summaries for each type of field appear in Table 5.2.

TABLE 5.2

USE OF CATTLE DUNG AS MANURE BY MOSSI AND BISA SAMPLE MEMBERS, BY TYPE OF FIELD (All Recorded Instances Out of 768 Fields in the Sample)

	Mean Total Application in kg/ha	Standard Deviation	Maximum	Minimum
All Fields N = 46	92	173	780	1/2
House Fields N = 22	151	228	780	8
Bush Fields N = 3	5	1	5	3
In-Village Fields N = 14	44	81	300	1/2
Lowland Fields N = 7	37	44	120	5

The results indicate that applications are greatest per hectare to house fields intended for growing small plots of maize, sorghum, cotton, tobacco, and vegetables.

The dung is obtained from cooperating herdsmen in return for ceremonial gifts of kola nuts at the time of the transaction. The herdsman thus acquires a claim of obligation over the peasant, who often, in reciprocation, sends him ceremonial (kg) gifts of millet after the harvest. All of the twenty Fulani sample members acknowledged receiving requests for cattle dung from peasant families. Only four said that they always refused these requests and spread all of the dung from their corrals on their own fields.

Another method of fertilizing fields is for a Mossi or Bisa peasant to invite a Fulani herdsman to paddock his herd on the peasant's fields for a number of nights during the dry season, thus benefiting from the animal droppings. This practice was studied in Oueguedo, where four out of the twenty Fulani sample members participated in such invitations during 1976. The author has written elsewhere (Delgado, 1977, pp. 46-50) of the Fulani reluctance to participate in night-paddocking invitations. The reticence is based primarily on the extra labor required to guard the animals at night, away from the home corral and is compounded by the loss of the benefit of the cattle manure, which is only partially compensated for by the free food received while on the farmer's fields.

The Fulani sample members all appear to be well aware of the yield-increasing benefits of animal dung. All twenty households claimed that they spread the dung from their corrals over the entire field area that they cultivate. The dry season corral is moved to at least two different locations within the field area between January and April. This provides especially fertile ground for next year's maize and cotton crop.

Total Land Available Versus Total Land Cultivated

Leaving land fallow for long periods of time provides another means of regenerating soil fertility in the Mossi areas of Upper Volta (De Wilde, 1967, II, p. 372). Bush fields are typically left fallow for many years after a comparatively short period of cultivation (Ibid.). Farmers often leave a portion of the small lowland area available to them unplanted. Other land within the village, however, is virtually never without a crop. This tends to aggravate a situation of declining fertility on those fields used to produce staple food grains. The net result is to place a premium on cattle manure as a soil improver and to force the expansion of bush field areas for staple food grain production.

There is strong evidence to the effect that house fields are almost continuously planted. Only a very small proportion of in-village fields are left fallow. A survey of 161 Mossi and Bisa fields, conducted with questionnaire J (Appendix C), estimated that the mean number of years of continuous cultivation of all fields is 39 (S.D. = 32). However, when only fields bearing millet-sorghums or legumes are considered, the figure is close to 60. In this context, this finding can be interpreted as saying that these fields have been continuously cultivated within living memory. Sample members could remember only six cases of an in-village or house field, which was cultivated in 1976, having been left fallow. Table 5.3 presents a summary of information on these findings.

TABLE 5.3

SUMMARY OF ALL RECORDED INSTANCES OF A FIELD BEING LEFT FALLOW
(From 161 Field Histories)

Type of Crop	Land Type	No. of Fields Concerned	Average Field Area	Average Value For Last Year Left Fallow
Millet & Cowpeas	In-Village	5	.53 ha	1969
Millet, Sorghum & Cowpeas	In-Village	1	2.23 ha	1971

[a]Within 3 km. of the compound and cultivated in 1976.

Sample members reported only four instances of leaving a lowland field fallow. Upon investigation, these turned out to be cases where the entire holding was not cropped. In practice, farmers usually cultivate only one-third of the lowland available to them, rotating each year. This may be because the crops grown with high labor input on lowland areas -- rice, root crops, and vegetables -- are quite sensitive to the fertility of the soils. While lowland areas may be cropped to their maximum sustainable level under current practices, it seems likely that cattle dung and mineral fertilizers may provide a means of expanding cropped lowland areas by lessening fallow requirements in the future.

It is very difficult, on the other hand, to obtain new parcels of in-village- or house land since most of it is already occupied. Lowland close to the village and suitable for cropping is virtually all claimed by one family or another, even if two-thirds of the area is fallow during a given season. Bush land, on the other hand, is easier to obtain. The aspiring cultivator needs only to ascertain that no one else has planted upon the site within the last few years. He then asks the village chief concerned for permission to plant. The chief is under considerable pressure to concede to the request, since bush field grants also serve as a safety-valve for relieving the pressure on in-village land resources.

The Fulani, who already live in the bush areas being claimed as new peasant fields, also grow crops during the rainy season. The twenty households interviewed all planted fields of millet, sorghum, and maize, situated in concentric circles around the compound. The Fulani cultivate their fields (which are almost all house fields) continuously over the years. Occasionally, a young man living in his father's compound will plant a "bush field" (any field away from the living area) of millet and cowpeas, but this is rare, according to Fulani elders interviewed. In any event, none of the sample members maintained this form of field.

The Fulani do not cultivate lowland. The most likely explanation for this is that their labor is fully employed drawing well water for cattle during the dry season, as opposed to drawing water for crops. It is also likely that lowland gardens in Fulani areas during the dry season would be destroyed by the herds congregating at the watering points. During the wet season, the Fulani are fully employed, by their own account, looking after their cattle and working the house fields which provide staple foods.

Total Land Cultivated Per Houshold by Ethnic Group

The farm management survey of the Mossi and Bisa farms measured the area of all 768 fields cultivated by the 41 sample households, according to the methods set forth in Chapter 3. The fields of 6 Fulani households were also measured.[1] This section presents the justification for pooling Mossi and Bisa data on land areas, but not including the Fulani data. The major finding is the highly fragmented nature of the land holdings of a typical Mossi or Bisa household. Tables 5.4 and 5.5 summarize the total

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[1]Field measures of the remaining fourteen Fulani households in the sample are not yet available.

area of each kind of land farmed and the percentage of total holdings represented by each kind of land for Bisa and Mossi households respectively. Table 5.6 gives information of a comparable nature for six Fulani households.

A one-sided test for the equality of the means of total area cultivated by Bisa and Mossi households, assuming that the (unknown) variance is the same in both cases, fails to reject the null hypothesis that the means are equal, at the 10% level of significance.[1] The implication is that there is not sufficient evidence to conclude that there is a difference in the means, even with a decision rule that permits making the wrong decision ten percent of the time. The same finding holds true for inter-village comparisons of each of the mean areas across households of house fields, bush fields, and lowland when a two-sided test is performed. A one-sided test of the alternative hypothesis, that the mean amount of in-village land farmed by Mossi households is greater than that of the Bisa households, fails to indicate rejection of the null hypothesis of equality, at the 10% level of significance.

The Fulani, on the other hand, clearly farm a smaller amount of land per household than their Mossi and Bisa neighbors. The close similarity of results for the two farming groups, as shown in Tables 5.4 and 5.5, encourage the pooling of land data for the two groups. The combination of information for the Mossi and Bisa increases the number of observations to 41 households, and thus permits greater confidence in statistical results, provided one believes the households to be drawn from the same population with respect to land use practices. Table 5.7 contains the same variables for the pooled Mossi and Bisa stratum as Tables 5.4 and 5.5 do for the groups separately.

The average peasant land-holding is fragmented into 17 separate fields, of varying dimension. Table 5.8 lists the average number of fields per household and per land type, and the average size of fields on different varieties of land. The mean size of each field is quite small, at .22 hectares. As can be seen in Table 5.8, the average size of a bush field is relatively large at .61 hectares. However, the other 16 plots farmed by

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[1] The methodology is the same as that on page 77, Chapter 4.

TABLE 5.4

SUMMARY OF AREAS AND PROPORTIONS OF EACH TYPE OF LAND FARMED BY BISA HOUSEHOLDS

Area = Area in Hectares

% = Percentage of Total Household Area Cultivated in 1976

Type of Land		Mean of 15 Households	Deviation	Maximum	Minimum
House Fields	Area	.74	.55	1.51	.03
	%	34[a]	23	58	1
Bush Fields	Area	1.09	3.47	13.58	0
	%	14[a]	24	84	0
In-Village Fields	Area	1.18	.88	3.19	.18
	%	42	24	96	12
Lowland Fields	Area	.23	.18	.76	.05
	%	10	6	19	1
Total Area Cultivated		3.24	3.68	16.80	1.01

[a]METHODOLOGY: Areas are computed for each household with the mean taken over households. Percentages are also computed for each household, with the mean taken over households. Therefore, the mean percentage of land in house fields is not necessarily the same as the percentage calculated by dividing the mean area of house fields by the mean area of total household fields. The large discrepancy arises here because only a few Bisa households had bush fields, and they were quite large.

TABLE 5.5

SUMMARY OF AREAS AND PROPORTIONS OF EACH TYPE
OF LAND FARMED BY MOSSI HOUSEHOLDS

Area = Area in Hectares

% = Percentage of Total Household Area
Cultivated in 1976

Type of Land		Mean of 15 Households	Standard Deviation	Maximum	Minimum
House Fields	Area	.76	1.03	4.00	.01
	%	18	21	73	.2
Bush Fields	Area	1.10	1.15	3.73	0
	%	26	24	76	0
In-Village Fields	Area	2.02	1.53	6.29	0
	%	49	30	96	0
Lowland Fields	Area	.33	.18	.77	.5
	%	8	3	13	2
Total Area Cultivated		4.22	2.04	10.64	1.56

METHODOLOGY: Same as in Table 5.4.

TABLE 5.6

SUMMARY OF FULANI FIELD AREAS IN HECTARES

All Fields are House Fields:	
Mean Area Cultivated (N=6):	2.40
Standard Deviation:	.85
Maximum	3.65
Minimum	1.58

5% Confidence Interval for Mean Fulani Field Area is (3.36 ha, 1.44 ha.)

This may be compared with a sample mean (N=11) of 1.51 ha. for 11 Fulani households in Western Upper Volta (Quêant and Rouville, 1969, Vol. 1, p. 224).

The joint mean of the two estimates is 1.82 ha. (N=17).

TABLE 5.7

SUMMARY OF AREAS AND PROPORTIONS OF EACH TYPE OF LAND FARMED BY MOSSI AND BISA HOUSEHOLDS COMBINED

Area = Area in Hectares

% = Percentage of Total Household Area Cultivated

Type of Land		Mean of 41 Households	Standard Deviation	Maximum	Minimum
House Field	Area	.75	.88	4.00	0.01
	%	24	23	73	0
Bush Field	Area	1.10	2.25	13.58	0
	%	21	25	84	0
In-Village Fields	Area	1.71	1.38	6.29	0
	%	46	28	96	0
Lowland Fields	Area	.29	.19	.77	0.05
	%	9	4	19	1
Total Area Cultivated		3.85	2.75	16.18	1.01

METHODOLOGY: Same as in Table 5.5.

TABLE 5.8

AVERAGE NUMBER AND SIZE OF FIELDS FARMED BY
PEASANT HOUSEHOLDS ON DIFFERENT TYPES OF LAND (N = 41)
(S.D. of the Mean in Brackets)

Type of Land	Number of Fields Per Household	Average Size of Each Field, in Hectares
House Land	4 (2)	.22 (.31)
Bush Land	1 (1)	.61 (.86)
In-Village Land	6 (3)	.26 (.17)
Lowland	6 (3)	.05 (.03)
Total	17 (6)	.22 (.10)

METHODOLOGY: The mean number of fields per household was calculated by counting the number of fields in each category for each household, and taking the mean over the combined Mossi and Bisa households. Similarly, the average size of a field in each category was computed for each household, with the mean taken over households.

the average household represent more than four-fifths of the total area planted. The mean size of an in-village or house field is approximately one-quarter of a hectare, while lowland fields are in fact small garden plots of one-twentieth of a hectare.

Furthermore, the 17 plots cultivated by the average peasant household are distributed over a wide area. By definition, bush fields are situated over 3 kilometers away from the farm house. Lowland fields are of necessity in watercourse areas, while the compound and house fields are on the more salubrious high ground, away from the malaria-infested swamp zones. In-village fields are distributed anywhere with a circle of 3 kilometers radius. Often, they are at opposite sides of the village. This is because of a complex system of access to land through family lineage and redistribution by the village chiefs.

Land Cultivated per Agricultural Worker by Ethnic Group

It is instructive to calculate the amount of land farmed per active agricultural worker for both peasants and herdsmen. The variability of results among the peasant farmers elucidates the distribution of wealth within these groups. The labor-land ratio also gives an indication of the labor intensity of cultivation, provided that farmers are fully employed in crop production. For herdsmen, the same ratio indicates the extent to which these groups have abandoned specialization in livestock enterprises. In the absence of accurate labor input data for herdsmen, the labor to field area ratio can be used in conjunction with yield and manure data in forming a judgement about the quality of herder labor input to crop activities.

The Mossi and Bisa Land to Labor Ratio.-- The average area and number of fields planted and maintained by Mossi and Bisa households in 1976 is given in Table 5.9.

TABLE 5.9

SUMMARY OF AREAS AND PLOTS CULTIVATED PER AGRICULTURAL WORKER
(Mossi and Bisa Combined)
(in hectares and %)

	Mean	Standard Deviation	Maximum	Minimum
Total Area Cultivated per Agricultural Worker	.79	.38	1.79	.19
Number of Plots per Agricultural Worker	3.7	1.5	7.5	1.9
Total Area of Bush Fields per Male Worker 15-60 Years Old	.59	.91	4.52	0
Number of Bush Fields per Male Worker 15-60	.7	.8	3	0
Total Area of Bush Fields per Agricultural Worker	.19	.29	1.50	0

METHODOLOGY: The appropriate values were calculated for each of the 41 households in the sample and the means computed over households.

The results suggest that there is considerable variation in the amount of household land controlled per agricultural worker. The maximum figure is 1.79 hectare, compared to a minimum figure of .19 hectares. A 95% confidence interval for the total amount of land cultivated per agricultural worker is: .67, .91 hectares. This suggests that there are considerable income disparities on a per person basis between different families, since the vast majority of income in the sample villages comes from crop cultivation. The inequality of Mossi and Bisa land holdings over farms and persons is consistent with the evidence for a village in northern Nigeria studied by Norman (1973a).

It is likely that increases in the amount of land farmed per agricultural worker could occur only by an expansion in the amount of bush area cleared for fields. The results in Table 5.9 show a large variability over households in the surface area of bush fields planted per worker and per prime age males. A major finding is that the area of bush fields per household increases with farm size and decreases with access to in-village fields according to a linear relationship. This assertion is formalized by the following regression run on data for all 41 Mossi and Bisa households:

$$ABF_i = - .861 + .007\ TAF_i - .21\ \frac{AIVF_i}{LAB_i}$$

t - statistics: (- 2.361) (10.573) (- 3.330) $R^2 = .752$

where:
ABF = Area of Bush Fields
TAF = Total Area of Fields
AIVF = Area of In-Village Fields
LAB = Labor Force on Farm

and the subscripts relate to household i. A Chow Test (Chow, 1960, pp. 591-605) failed to indicate the inclusion of dummy variables for Bisa and Mossi households.[1] This is interpreted as further evidence of structural similarities between the Mossi and Bisa farming systems. The results also serve to emphasize that pressure on in-village fields is associated with the expansion of peasant farms into bush areas.

The Fulani Land to Labor Ratio.-- The amount of land per agricultural worker is harder to calculate in the case of the Fulani. Women work on small plots of maize and cotton, but tend not to work on the other crops. Treating female workers as potential agricultural labor, the total area cultivated by each household is divided by the number of persons over eight years of age in each household, we arrive at the figures summarized in Table 5.10.

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[1]This involves running the regression with zero-one dummy variables for Mossi and Bisa households with the constant term suppressed. The same specification is re-run in "restricted" form, where the constant term represents the sum of the dummy variables. An F test is then performed on the restriction. In this case, the test failed at the ten percent level of significance to indicate rejection of the null hypothesis, to the effect that the same relationship exists for Mossi and Bisa households. For an exposition of the methodology, see Johnston, 1972, p. 207.

TABLE 5.10

SUMMARY OF AREA CULTIVATED PER
FULANI WORKER PRESENT IN HOUSEHOLD

Mean Land Cultivated per Worker in Hectares	.43
Standard Deviation	.21
Maximum	.73
Minimum	.23

METHODOLOGY: The means are taken over households.

Not surprisingly, Table 5.10 shows that Fulani households as a whole cultivate a smaller area of fields than do their farming neighbors. However, the herdsmen are more heavily engaged in crop activities than a pastoral vocation would suggest. The average acreage of millet and sorghum grown by Fulani households per male worker (only men work on food grains) yields an area slightly larger than that farmed per Mossi and Bisa person over 8 years of age. The Fulani sample members claim that their participation in crop activities is a relatively recent phenomenon.[1]

The Farm Allocation of Land to Each Crop Category in 1976

The allocation of land to different crop activities is perhaps the single most significant issue in farm economics. This section examines the actual behavior of farmers during the 1976 growing season. Besides the intrinsic interest in the question for agricultural planning, these results indicate conscious choices on the part of the farmers. It will be particularly instructive to compare the actual allocations portrayed here

[1]It cannot be too recent, since they also claim that their grandfathers raised crops.

with the "optimal" allocations suggested by the linear programming exercise in chapters eight and nine.

Household Land Area Allocated to Each Crop Category.-- Household areas planted are divided into seven major crop categories. These are millet and sorghum with cowpeas, maize, rice, groundnuts, root crops, vegetables and fruit, and cotton and tobacco. These categories represent the most aggregated form of a complete description of household cropping patterns. Very small amounts of other crops are also cultivated by a few households, such as single stands of red sorghum. These have simply been incorporated into the labor category of millet and sorghum intercropped with cowpeas because of the small amounts of labor involved. The basic criteria for including a crop or mixture in one of these categories are twofold. First, the mixture to be incorporated must be constituted solely, or almost entirely, of the crops named in the category. Second, if the composition of the mixtures differ, as in the case of millet, and cowpeas (without the sorghum), the labor allocations to the new mixture per hectare and over fortnights must be similar in size and distribution to those prevailing within the category.

The total area planted in 1976 under each one of the crop categories is given for the combined Mossi and Bisa sample in Table 5.11.

TABLE 5.11

MEAN HOUSEHOLD LAND AREA UNDER EACH CROP CATEGORY
(Mossi and Bisa Households)
(in Hectares)

Crop Category	Mean Household Area	Standard Deviation	Maximum	Minimum
Millet, Sorghum, and Cowpeas	3.27	2.58	14.85	.81
Maize	.02	.027	.13	0
Rice	.19	.15	.71	.03
Groundnuts	.27	.33	1.35	0
Root Crops	.06	.02	.10	0
Vegetables & Fruits	.01	.01	.06	0
Cotton & Tobacco	.002	.01	.06	0

The totals are calculated by summing the areas of all fields under each crop category, for each household. The mean is then taken over households. The results indicate the overwhelming importance of millet, red sorghum, and cowpeas in the cropping mixture. To pursue the point further, the next subsection examines the percentage of household land devoted to each crop category.

The Percentage of Household Land Devoted to Each Crop Category.--

The acreage devoted to each crop category by each household is divided by the total field area of the household in question, to obtain the percentage distribution of land to each crop category, for each household. The household values are averaged over farms to get the summary statistics presented in Table 5.12.

TABLE 5.12

THE MEAN PERCENTAGE OF HOUSEHOLD LAND ALLOCATED TO EACH CROP CATEGORY (in %)

Crop Category	Mean Household Percentage	Standard Deviation	Maximum	Minimum
Millet and Sorghum with Cowpeas	82.9	16.7	98.2	37.8
Maize	.5	.5	2.5	0
Rice	5.7	3.6	17.5	1.1
Groundnuts	7.6	9.3	48.4	0
Root Crops	2.0	2.3	9.9	0
Vegetables & Fruits	1.1	1.1	5.5	0
Cotton & Tobacco	.2	1.0	6.3	0

Millet and/or sorghum intercropped with cowpeas is by far the greatest user of household land, occupying just under 83%, on average, of household field areas. Groundnuts and rice, grown primarily for cash, occupy just over 13% of household holdings. The only mixture planted by the entire sample without exception is millet intercropped with cowpeas.

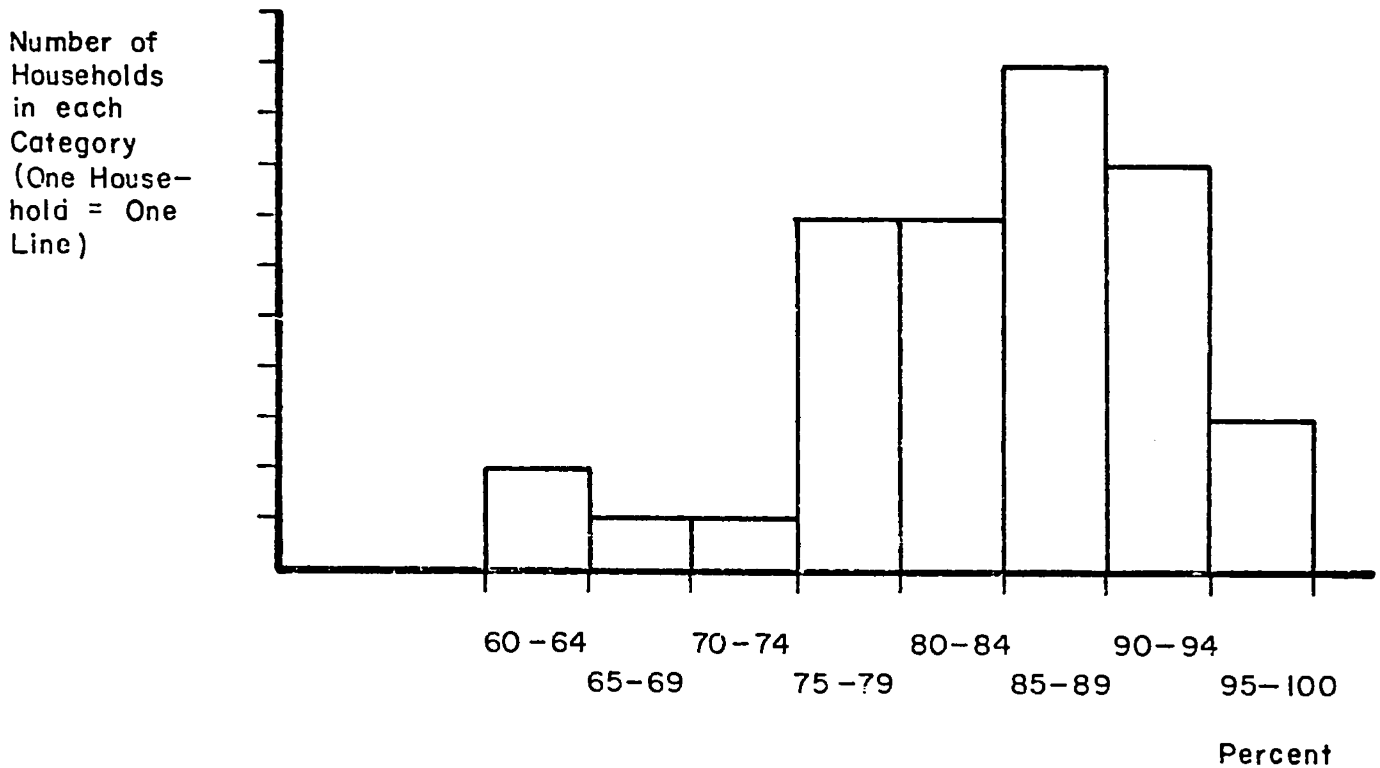
The high proportion of land put into millet and cowpeas, with or without red sorghum, appears to reflect a concern with assuring an on-farm supply of staple foods. Figure 5.1 charts the distribution across households of the proportion of land under millet-sorghums. Thirty-eight percent is the smallest amount of total household land devoted to this crop category. This outlier is not at all representative of the distribution suggested by Figure 5.1, with a mode falling in the 85 to 89 percent range. The household concerned is atypical, in that it controls a relatively very large section of lowland (15% of holdings, on which cassava, sweet potatoes, fruit, and vegetables, and rice are grown. The farm in question is also exceptional in that only one-third of a hectare of land is cultivated per agricultural worker. This is not surprising, since lowland crops are more labor intensive than upland crops. Excluding the atypical case, the next lowest percentage of household land under millet-sorghums is sixty-three percent, which is in the lower tail of the distribution suggested by Figure 5.1. In subsequent work, this figure will be used to represent the minimum proportion of land that Mossi and Bisa households are willing to plant with the staple food grains. Chapters eight and nine will show that a constraint requiring that a large proportion of household land be put into staple food crops has serious implications for the composition of the optimal farm output mix. This is particularly true as regards the decision to produce fattened cattle.

Land Use and Conflict Between Crops and Livestock

Cattle graze throughout the year on natural pastures of the sort described by Benoit (1974). These consist primarily of seasonal grasses that grow up to a yard high. The edges of watercourses and other lowland areas often contain andropogon guyanus, highly prized by the Fulani for forage. During the dry season, crop enterprises are on the whole complimentary to stockraising, since cattle can browse on crop stubble. The exceptions to the rule are dry season irrigated gardens, which are progressively crowding livestock away from the much-prized lowland areas. The indigenous fences made of woven millet stalks are not always

FIGURE 5.1

HISTOGRAM of the PERCENTAGE of MOSSI and BISA HOUSEHOLD LAND HOLDINGS PLANTED with MILLET-SORGHUMS



(One Outlier Not Shown = 38 %)

sufficient to keep large stock, such as cattle, away from the plants.

During the wet season, crop and livestock activities are in direct opposition to each other with respect to land use. An unsupervised herd of thirty hungry animals can wipe out half a hectare of grain in a matter of minutes. Naturally, feelings run high in such cases, after the peasant has worked hard to coax the crop out of the infertile ground. In 1976, one peasant in the central Oueguedo shot six sheep belonging to the Mossi canton chief that had slipped their tethers to invade his house garden. In hierarchical Mossi society, this might be thought a tremendous affront to the chief, yet public opinion in Oueguedo was on the farmer's side.

The fields most often involved are the bush fields cleared and planted, in many cases, after the Fulani have installed themselves nearby. The density of habitation and population growth in the Tenkodogo area are such as to continually push the frontier of village fields outward, as in many parts of the arable savannah. In many cases, the Fulani are forced to move further away from the center. In addition, land that has been occupied by the Fulani for any period of time is coveted for its agricultural potential, due to manure fertilization.[1] This may encourage settlement close to Fulani-living areas. Figure 5.2 shows bush fields belonging to Mossi sample members sandwiched between Fulani sample households. The instances of crop damage from livestock inevitably increase as peasant fields expand into Fulani areas. Five out of a total of 62 Mossi and Bisa families interviewed by the author in the Tenkodogo area reported at least one instance of substantial damage to bush fields from cattle in the 1976 growing season.[2] Often the aggrieved peasant cannot find the herdsman who is responsible for the ravages, although he will

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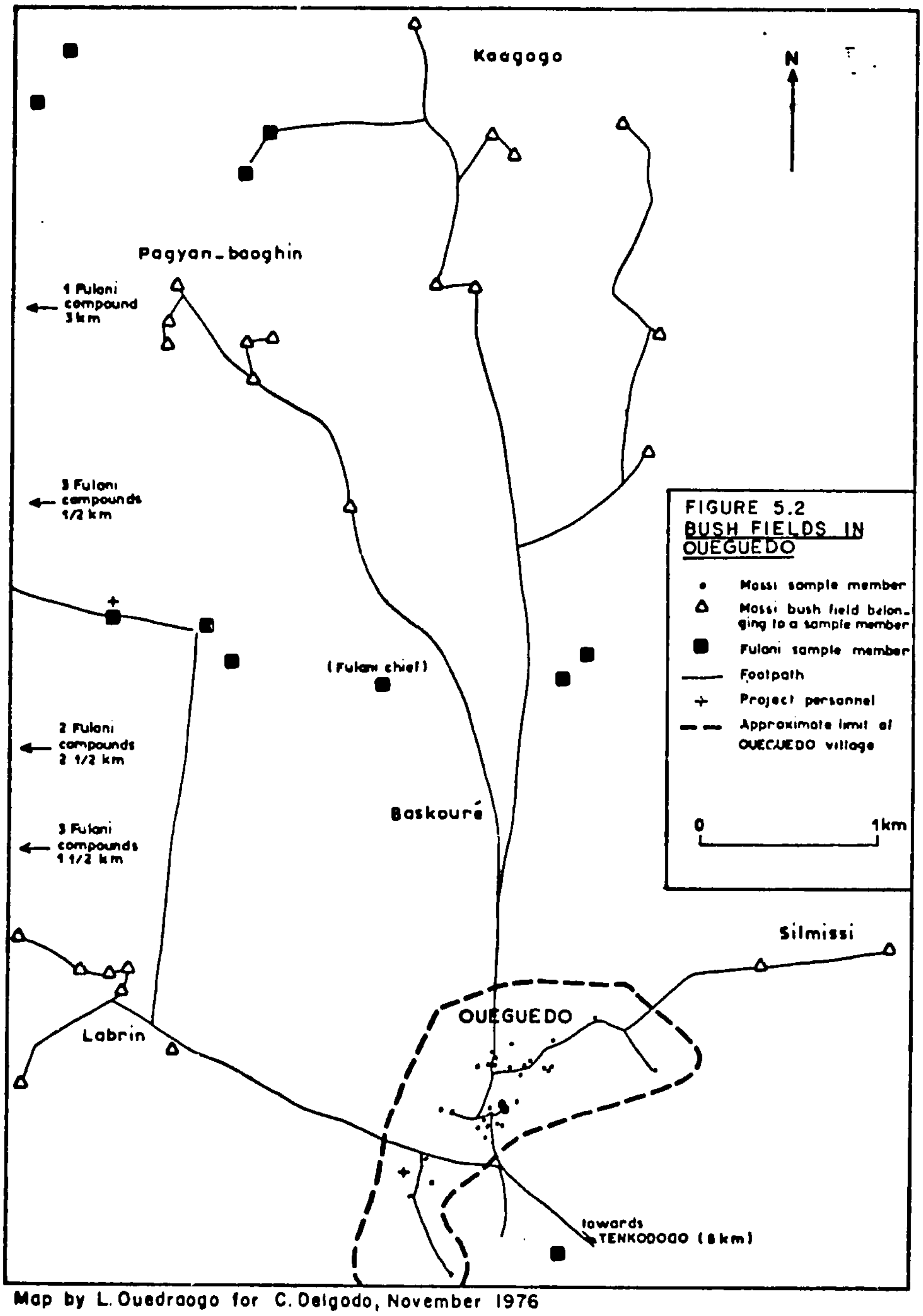
[1] I am not aware of overt cases of Fulani being thrown off their land in Oueguedo in recent times in order to plant. However, I have personally seen several instances of Fulani families being driven off the land thirty kilometers to the south, the household burned over and cleared for planting, all in a space of two weeks.

[2] It was not possible to ascertain how many incidents the Fulani sample had been involved in during 1976.



Map by L. Ouedraogo for C. Delgado, November 1976 ask to find out who was nearby at the time of the occurrence. If he is unsuccessful. the damaged portion of the field is a net loss.

When the offending herd is identified, the peasant makes an appeal for redress of grievances to his village chief in the first instance, and then to the canton chief. The canton chief sends for the Fulani chief in charge of herders in the area concerned and briefs him. The latter is responsible for producing the offender. In the case of substantial damage, the case is submitted to the tribunal of the first degree in Tenkodogo. This court is composed of a middle-level civil servant and two elders of the ethnic groups concerned. In cattle questions, the advisors would usually be a Fulani and a representative of the peasant group concerned. The court requests an assessment of damages from the local representative of the O.R.D.,[1] who sends an agent to note the area involved and the degree of damage. The tribunal disposes of the case based on the O.R.D. findings and the principles of customary law of the ethnic groups concerned. The defendant has thirty days to appeal the decision.

If the defendant chooses to appeal, the verdict is handed down by the tribunal of the second degree. This consists of a court held by the Sub-Prefect or Deputy Prefect of Tenkodogo.[2] In theory, a decision may be appealed to the regional magistrate in Fada N'Gourma (136 kilometers by road) and thence to the Supreme Court in Ouagadougou.

During the 1976 growing season, numerous cases were handled by the canton chiefs. The author was able to locate the minutes of seven cattle damage trials in the tribunal of the first degree.[3] "Several" cases were heard before the tribunal of the second degree, although the officials concerned could not remember the exact numbers nearly a year later. No one at the Tenkodogo administrative headquarters could remember a cattle damage case ever being appealed to the magistrate in Fada N'Gourma.[4]

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[1] Organisme Régionale de Developpement or regional development authority.

[2] Sous-Prēfêt and Secrétaire-Génèrale du Département, respectively.

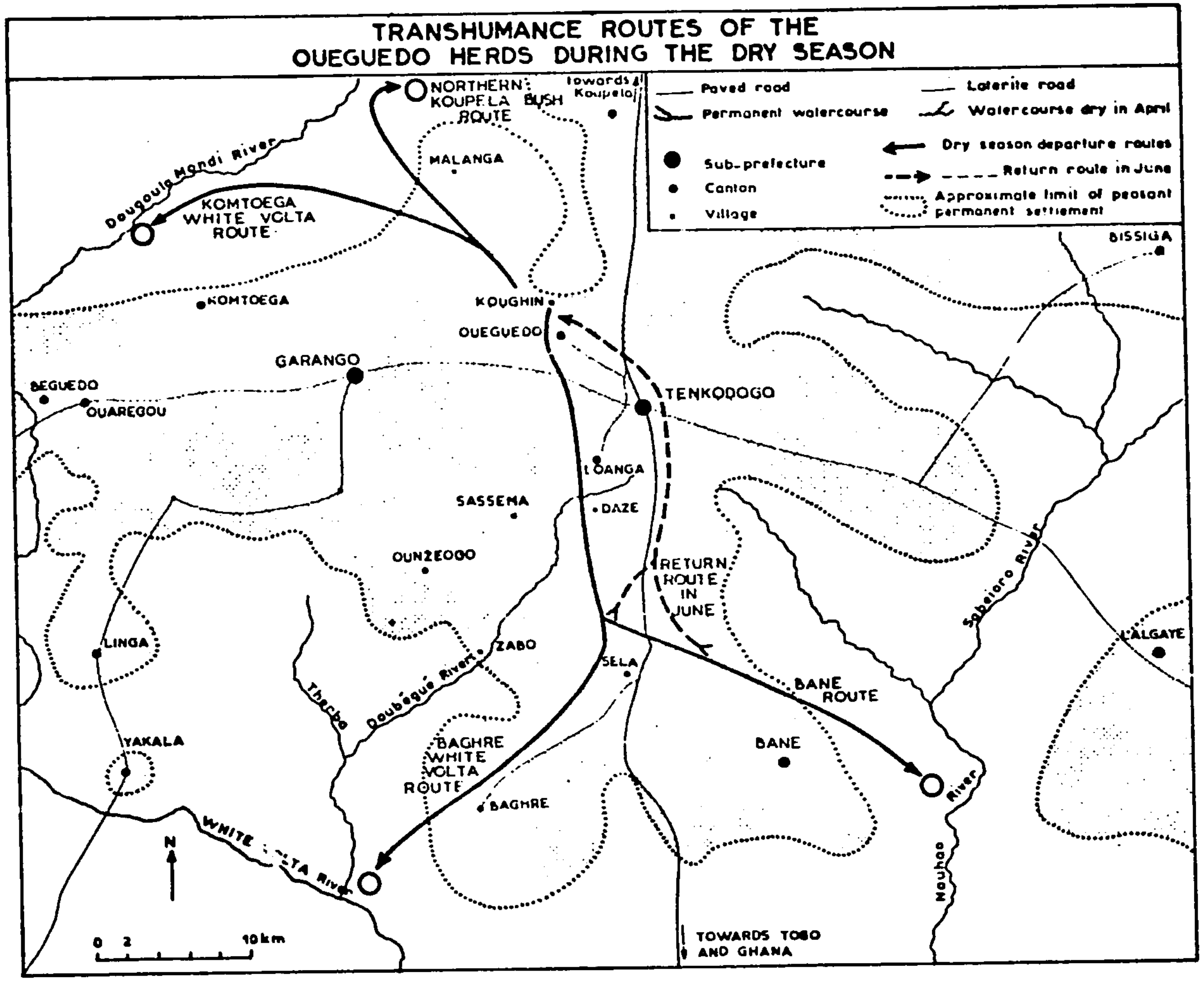
[3] There may have been more.

[4] This procedure is usually adopted only if long prison sentences are possible, such as in the case of cattle theft on a grand scale.

Where clear evidence of damage by the accused is established, which was usually the rule in cases going to the prefecture, fines and compensatory damages are levied. These might run from forty to several hundred dollars, a considerable expense for a herdsman. If a convicted herdsman pleads inability to pay, he is kept in jail until his relatives pay for him.

The penalties for being held responsible in a crop damage case are sufficiently severe to ensure great care by the herdsmen during the seasonal migration, or "transhumance." When animals leave during the dry season, they can take the most direct routes through the villages to get to the river valleys, as shown in Figure 5.3. The return trip takes place when the grain sprouts are knee-high. At this time, herdsmen are very careful to remain on the government-sanctioned cattle trails, often not sleeping for the two to three days it takes to move the herds back to the rainy season pastures, according to Fulani sample members.

FIGURE 5.3


TRANSHUMANCE ROUTES OF THE
OUEGUEDO HERDS DURING THE DRY SEASON
Paved road
Laterite road
Permanent watercourse
Watercourse dry in April
Sub-prefecture
Canton
Village
Dry season departure routes
Return route in June
Approximate limit of peasant permanent settlement
NORTHERN KOUPELA BUSH ROUTE
Towards Koupela
MALANGA
KOMTOEGA WHITE VOLTA ROUTE
Dougoula Mondi River
KOMTOEGA
KOUGHIN
OUEGUEDO
GARANGO
BEGUEDO
OUAREGOU
TENKODOGO
LOANGA
DAZE
SASSEMA
OUNZEOGO
RETURN ROUTE IN JUNE
LINGA
ZABO
Doubégué River
Thecho
SELA
BANE ROUTE
BANE
YAKALA
BAGHRE WHITE VOLTA ROUTE
BAGHRE
WHITE VOLTA River
N
0 2 10km
TOWARDS TOGO AND GHANA
Nouhao River
Sabatoro River
BISSIGA
LALGAYE

CHAPTER 6

CAPITAL AND LIVESTOCK

This chapter has three objectives. First, it explores the level of physical and financial capital and purchased inputs available on a typical peasant farm, as a guide to smallholder investment capacity. Second, it examines cattle, either kept on the farm or entrusted to Fulani herdsmen, as an investment alternative for farmers. Third, it surveys the livestock holding practices of sample farmers and Fulani pastoralists. There are five major results. First, there is little use of purchased inputs in the sample area, although there is some evidence of a small amount of discretionary purchasing power. Second, cattle are a good investment alternative, consistent with the usual assumption of a twenty percent opportunity cost of capital. Third, when the opportunity cost of keeping animals inside the village is taken into consideration, standard discounted cash flow analysis indicates that farmers do better to entrust their cattle to Fulani herdsmen. Fourth, the evidence suggests that up to one peasant farm in three owns cattle, with an average holding of four animals for each household owning cattle. The animals are entrusted to Fulani herdsmen in every case. Somewhat inconclusive data suggest a preference for younger, primarily female, cattle. Fifth, over half of the animals in Fulani herds belong to peasant proprietors. There is a marked preponderance of older female cattle.

The On-Farm Supply of Physical Capital and Purchase Inputs

The peasant farmers sampled use little in the way of purchased inputs for crop production. This is true for implements, seeds, and dressings. Agricultural equipment is limited to low productivity hand tools of traditional design. Seeds are obtained from the harvest. Mineral fertilizer and insecticides are not used in the sample area. There is little observable difference in the average amount of agricultural physical capital on

Mossi, as opposed to Bisa, farms.[1]

Purchased inputs available to farmers in the Tenkodogo area are sold by the field office of the O.R.D. These include plows, hoes, and carts for both ox and donkey traction, improved rice and peanut seeds, insecticides, and seed dressings. In theory, a compound mineral fertilizer is available through the O.R.D.; however, there is very little demand for it.

No one in either the Mossi or Bisa samples possessed a donkey cart.[2] One (Mossi) farmer had a donkey plow, even though fifteen households had donkeys for transportation of bulky items. Every household denied intending to purchase improved seeds from the O.R.D. for the 1977 planting.[3] The author was unable to discover any instance of the use of mineral fertilizer, insecticide, or seed dressing in either Oueguedo or Loanga. In any event, none of the above were used by sample members.

The traditional implements used by sample members consist primarily of short-handled hoes ("daba"), machetes, hatchets, and sickles. The heads are made locally out of beaten iron. Summaries of the inventories of agricultural implements and silos found on Mossi, Bisa, and Fulani farms are given in Tables B.32 and B.33 of Appendix B.

Seeds are selected from among the most promising products of the previous harvest, which helps assure an on-going process of genetic adaptation and selection. Table 6.1 gives the average weight of seeds retained on peasant farms during the 1976 harvest for sowing the following year. The figures, given in kilograms, can be interpreted as the amount of seed required by an average farm of less than four hectares. Sample members indicated a substantial interest in obtaining seeds for vegetable crops, which they could not obtain through the O.R.D. Vegetable seeds were sold by private traders in Tenkodogo markets, but were often spoiled.

[1] Summary statistics of agricultural implements and grain silos are contained in Appendix B.

[2] The answers in the section were obtained from a sample of 28 Mossi and 30 Bisa households responding to Questionnaire K, Appendix C. The results for the canton chiefs were excluded as being unrepresentative of the population as a whole.

[3] The varieties offered were peanuts, cotton and soy beans, none of which do well in Tenkodogo.

Farm Access to Financial Capital

Farms in the research area have little access to credit for investment purposes. Consumption credit can be obtained for food supplies, against the pledge of next year's harvest. Despite the paucity of credit resources, peasant farmers do have a small amount of discretionary purchasing power each year. Evidence of this can be found in the research area by the existence of radios, bicycles, and mopeds. The remittances of household members recently returned from work migrations account for approximately one third of an average annual cash income per household in excess of US $100.

TABLE 6.1

MEAN WEIGHT OF SEED RETAINED PER HOUSEHOLD
FOR SOWING IN 1977
(in kilograms)

Variety	Millet[a]	Red Sorghum[a]	White Sorghum[a]	Peanuts[b]	Rice[b]	Cowpeas[b]
Bisa Farms N=30	20 (S.D.=17)	13	2	6	10	6
Mossi Farms N=28	23[c] (S.D.=11)	14[c]	10	6	10	8
Bisa & Mossi Combined N=58	21[d]	14[d]	6	6	10	7

[a]in grain form

[b]in shell form

[c]N = 13 only

[d]N = 43 only

METHODOLOGY: Answers were given in "plats," a local volume of grain measure roughly corresponding to a half-gallon enamel bowl. Conversion weights in kilograms were supplied by the O.R.D. field office in Tenkodogo, as follows: Millet 2.38; Sorghum 2.75; Peanuts 1.3; Rice 2; Cowpeas 1.6.

Farm Access to Credit.-- By and large the possibilities for obtaining credit for agricultural innovation are bleak for most peasants in the Tenkodogo area. Successful individuals need to rely upon help from neighbors or family members, either within or outside the village. Unlike large areas of Asia, there is no established moneylending caste in Upper Volta. In rural Tenkodogo, this role is filled by richer peasants who serve as grain brokers. Under a typical arrangement, a farmer borrows a sack of millet during the "hungry" season before the harvest. The lender then collects up to two to three sacks of millet from the borrower at harvest time and sells them to private collectors with trucks. Another, less common, practice is for a farmer to borrow cash against the produce of a given area of field. This form of arrangement only occurs when the crop is well advanced.

Bank credit was not available in rural Tenkodogo as of 1976, although a branch bank did open in town in late 1977. In view of the paperwork and guarantees necessary for loan approval, it seems unlikely that the typical smallholder will benefit from this development in the foreseeable future. The O.R.D. extends credit for the purchase of animal traction equipment, which few individuals desire. It is not possible to obtain credit from the O.R.D. for donkey carts, yet every farmer to whom the author spoke expressed a desire to own one.[1] Despite the difficulty in obtaining credit, there is evidence that the average Mossi or Bisa farm family has a small amount of cash discretionary purchasing power potentially available for investment. This hypothesis will be explcred further in the next two subsections.

Data from the Tenkodogo Sample.-- The information on sample member cash incomes obtained in 1976 is too unreliable to be of direct use in this context, although the next chapter includes an estimate of the value of overall farm output.[2] To skirt this problem, a survey was taken

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[1]The somewhat obscure rationale for the credit policy was that carts are clearly profitable, therefore individuals should be able to find their own source of financing for them.

[2]It is hard to differentiate what is sold from what is consumed on-farm.

of the three major consumer durables likely to be present on peasant farms: radios, bicycles, and mopeds. These three items represent a significant amount of discretionary purchasing power. As such, they indicate the presence of a cash surplus which could have been invested, in theory at least, in other uses.[1]

Figure 6.1 shows the distribution over 58 Bisa and Mossi households of the purchasing power represented by the three major consumer durables. This exercise is intended solely to demonstrate the fallacy of assuming that, within subsistence agriculture, people do not invest in farm tools or fertilizer because they have no money. The evidence clearly shows that small but non-negligible cash surpluses can be mustered on some occasions. It is not intended as a statement to the effect that ten percent of the sample have either an annual revenue or a stock of saleable consumer goods worth more than 50,000 CFAF. The former inference is clearly untrue and the latter is questionable, since the items surveyed were evaluated according to a fixed schedule, regardless of quality.

Data from the O.R.S.T.O.M. (1975) Migration Study.[2]-- The O.R.S.T.O.M. survey was conducted in three regions of the Mossi Plateau during 1973. A total of 106 households were interviewed in this zone, in addition to a companion study of 97 farms outside the Mossi area. Twenty-six of the Mossi households were in the Zorgho region, only forty-five kilometers to the northwest of Oueguedo village. The Zorgho data are representative of the research area. The information was gathered during a drought period and thus underrepresents the cash income available to households following a crop season with normal rainfall. Thus, the results should be interpreted as representing the minimum cash income available on farm.

The Zorgho survey estimated a mean household net cash income per annum of 28,324 CFAF.[3] One third of the sum comes from remittances sent or carried home by migrants working in areas away from the village. The

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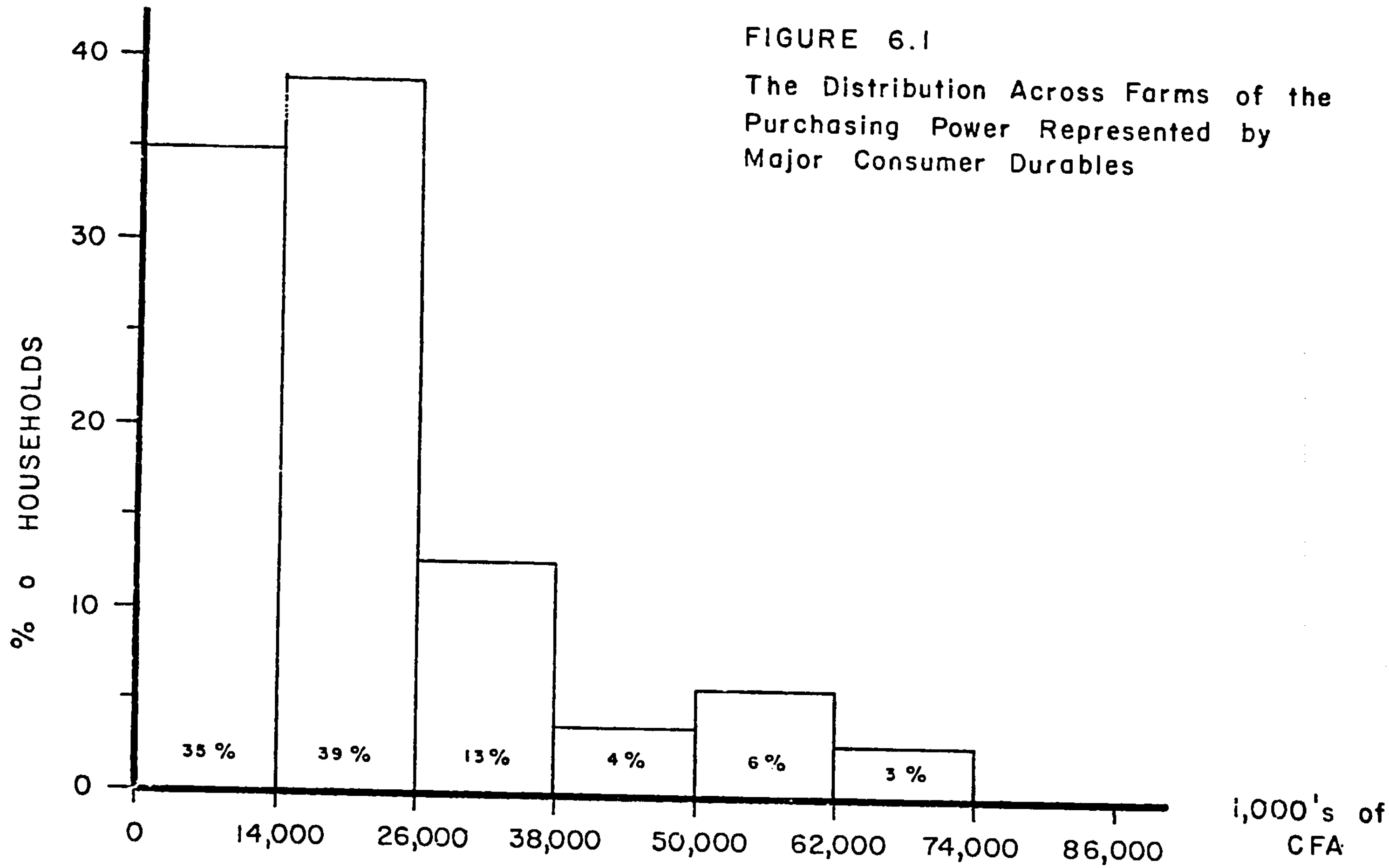
[1]It is at least arguable that bicycles are an essential production tool as well as a consumption item.

[2]The work used in this subsection comes from pages 71 to 90 of Volume III, by G. Ancey.

[3]Approximately US $110 in 1973.

FIGURE 6.1

The Distribution Across Farms of the Purchasing Power Represented by Major Consumer Durables



Methodology : A survey of radios, bicycles and Mopeds was performed among 58 Bissa and Mossi households. The items are weighted according to the following purchasing power weights: radios: 4,000 CFA ; bicycles: 16,000 CFA ; mopeds: 40,000 CFA. (1976: approximately 240 CFA = one U.S. dollar.)

comparable figure averaged over the entire Mossi sample is 35,843 CFA ,[1] of which twenty-nine percent was attributable to cash flows from migration. The conclusion is that a small, but non-negligible amount of cash revenue is available to farm households from on-farm family sources, one third of which is independent of the sale of farm products. The absence of investment in crop production does not necessarily indicate that farmers had no cash revenue to invest in livestock.[2]

Livestock as an Investment Alternative for Farmers

The first two sections of this chapter expressed the view that farm in the research area typically do not invest in purchased agricultural inputs, even though there is evidence that they have a small amount of discretionary purchasing power. This section examines the possible uses of farm savings as an investment in cattle. The major finding is that cattle provide an investment alternative with internal rates of return consistent with a twenty percent opportunity cost of capital. At first approach, there appear to be higher returns to cattle kept on-farm as opposed to those entrusted to Fulani herdsmen. However, this turns out to be an unjustified conclusion based on the sole use of expected cash returns to livestock, without considering the cash value of the opportunity cost of resources required to maintain cattle within the village. When the latter is incorporated, discounted cash flow analysis indicates that farmers do better to entrust cattle to the Fulani, thus liberating their own time for crop cultivation.

Assumptions and Methodology.-- The following calculations are rough estimates which depend upon a number of important assumptions. In addition to making these explicit, this subsection will introduce a bias favorable to keeping cattle on-farm throughout the year; the operational assumption made here works to maximize the returns to keeping cattle

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[1] Approximately US $140 in 1973.

[2] Besides necessary outlays on clothing, medicine, and other purchases, farmers had a tax liability in 1976 of 650 CFA per adult household member and small charges for cattle (200 CFA/head) and swine (100 CFA/head).

within the village. This is done in order to present the argument in favor of peasant livestock production in the most favorable light. Additional assumptions concerning the resources required to maintain cattle on the farm will be made further on. The implicit assumption for the immediate purpose is that (allegedly) otherwise unoccupied child labor is sufficient for caring for cattle on-farm, thus labor costs are zero. Entrusted cattle incur no labor cost for the owner since the herdsmen do all the work.

The first major assumption is that cattle kept on the farm permit the farmer to benefit from the by-products of milk and manure which would otherwise go to the herdsmen. Milk is valued at 25 CFA per litre, the prevailing market price in 1976 for milk delivered to Tenkodogo.[1] A fifty percent calving rate is assumed for cows between the ages of four and nine years (Peretti, I, 1977, p. 76). Each lactation is assumed to produce 150 kg. of saleable milk, with a value of 3,750 CFA . The annual expected value of milk revenue from a cow between the ages of four and nine years, <u>ceteris paribus</u>, is then 1,875 CFA . An adult animal is assumed to produce one metric ton of dry usable manure per year, with night paddocking (McCalla, 1975, p. 83). Manure is valued at what it will produce in terms of extra crops. This is taken as being 67 kg. of sorghum per ton of manure (I.R.A.T., 1969, p. 284). At an average harvest time price of 20 CFA /kg. for sorghum in Tenkodogo during 1976, this puts the annual revenue from manure at roughly 1,300 CFA .

The second major assumption is that the cost of veterinary care and the adult mortality rate are constant, whether the animals are kept by the owner or by a Fulani herdman. The cash cost of veterinary care is assumed to be 600 CFA per annum (Letenneur, 1973, p. 275). The adult mortality rate is fixed at the rather low six percent per annum.[2]

The third major assumption concerns the price structure for cattle in rural Tenkodogo. Table 6.2 gives the price structure used in this

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[1]An exchange rate of 245 CFA = $1.00 will be used for the rest of this chapter.

[2]Figure used by the 1975 I.B.R.D. livestock mission to Upper Volta.

section. It is derived from an initial response to Questionnaire L (Appendix C) which was refined in conversation with Fulani informants.

TABLE 6.2

PRICE STRUCTURE FOR HEALTHY CATTLE
IN RURAL TENKODOGO
(Data are for 1977 in CFA)

Age	Males	Females
2	15,000	18,000
3	20,000	22,000
4	25,000	25,000
5	30,000	30,000
6	35,000	35,000
7	35,000	32,000
8	33,000	30,000
9 and above	32,500	25,000

Note: These values are approximations. It is difficult to establish in conversation with a herdsman the difference between a 5 and a 6 year-old

The methodology used to evaluate the returns to capital invested in livestock is an adaptation of the standard discounted cash flow analysis, using internal rates of return.[1] It takes into account the stream of cash benefits of different sizes expected each year, the purchase price, and the selling price which is part of the expected cash flow for the last period. The expected cash flow in a given period is the average benefit to an animal in the appropriate age and sex category multiplied by the probability that the animal will be alive at that age. The probability that the animal will be alive n years from now is given by:

$$m^n = (1 - M)^n$$

where m^n is the probability that the animal will be alive in year n and M is the annual mortality rate for cattle.

[1]For the standard use of internal rates of return in investment evaluation, see United Nations, Industrial Development Organization (1972) pp. 167-68.

Then the internal rate of return (r) for investment in one animal is found by solving the following formula:

$$0 = - PP + \frac{m^1(CF_1)}{(1 + r)^1} + \frac{m^2(CF_2)}{(1 + r)^2} + \cdots + \frac{m^n(CF_n)}{(1 + r)^n}$$

where:

PP = purchase price of the animal in CFA

CF_1 = cash receipts in year one of ownership in CFA

m^1 = probability that the animal will still be alive at the end of year one

n = year the animal is sold (CF_n includes the sale value of the animal)

The Returns to Investment in Male Cattle.-- This subsection investigates the returns to investing in a two year old male animal, to be fed on natural pasture. The expected benefits are yield increases from manure and the increased sale price of an older, heavier animal. Cattle entrusted to the Fulani are assumed to provide no manure to peasant farms. This formulation also does not take into account possible animal traction benefits. Table 6.3 presents calculated rates of return for animals kept at different periods of time, based on the assumptions of the previous subsection.

Table 6.3 shows that in the absence of opportunities for animal traction, a farmer maximizes his returns by selling the animal bought at age two within the first year thereafter, whether he keeps it himself or entrusts it to a Fulani herdsman. The rate of return is quite high, even allowing for a six percent annual mortality rate for cattle. Given the sensitivity of results to the price structure, the figures are consistent with the usual rule-of-thumb of an opportunity cost of capital of twenty percent.

The Returns to Investment in Female Cattle.-- This subsection investigates the returns to investing in a four year old female animal, to be fed on natural pasture. Milk and manure accrue to the owner if he keeps the animal on his farm, otherwise those benefits go to the herdsman. Milk and manure are evaluated as explained above. An additional benefit to keeping female cattle, whether they are on-farm or entursted to a herdsman, is the possibility of obtaining newborn calves. In the Tenkodogo region, cows are assumed to be fertile between the ages of four and nine years.[1]

TABLE 6.3

INTERNAL RATES OF RETURN FOR MALE CATTLE
(one animal, purchased at age 2)

Age at Sale	Number of Years Kept	Probability That Animal will be Alive After n Periods	Internal Rate of Return (%)	
			On-Farm	Entrusted
3	1	.94	29.0	21.0
4	2	.88	25.0	19.2
5	3	.83	22.0	16.2
6	4	.78	19.5	13.9
7	5	.73	14.5	8.9
8	6	.69	10.5	4.8

Assumptions: -annual mortality rate of 6%
-sale values given in Table 6.2
-manure benefits for on-farm animals only, amounting to 1,300 CFA
-veterinary cost for all animals are 600 CFA per head
-internal rates of return are calculated according to the formula in the preceding section

To evaluate the stream of benefits from calf breeding, it is assumed that calves are raised until maturity at age four, at which point they are sold. For each one of the six years between ages four and nine, the cow is assumed to have an equal (independent) probability of having a calf:

$$P_{HC_n} = P_{CBA_n} \times C_n$$

[1]Some animals produce calves past age twelve, but this is rare, according to the Fulani.

where:

P_{HC_n} = Probability of having a calf in year n

P_{CBA_n} = Probability of cow being alive in year n = $(1 - M)^n = m^n$

C_n = Calving rate in year n (this is assumed to be constant = C)

The expected revenue from sale at age k for a calf born in any given year is assumed to be determined by the following relationship:

$$E(R_k) = (1 - d)\ (1 - M)^{k-1} \cdot P_k$$

where:

$E(R_k)$ is the expected revenue from the sale of a calf at age k

d is the mortality rate for calves in their first year (assumed to be 25%)

M is the mortality rate for animals after the first year

P_k is the average sale price of an animal which is k years old.

Each year the cow is alive adds an expected cash flow from calf breeding equal to the probability that the cow will be alive in the year in question, multiplied by the expected revenue from a calf sold k years later:

$$E(V_{nk}) = P_{HC_n} \cdot (1 - d)\ (1 - M)^{k-1} \cdot P_k$$

or:

$$E(V_{nk}) = C_n\ (1 - M)^n \cdot (1 - d)\ (1 - M)^{k-1} \cdot P_k$$

$$= C_n\ (1 - d)\ (1 - M)^{n+k-1}\ P_k$$

Assuming that all calves are sold when they reach four years of age, k is set to four. Table 6.4 calculates the flow of cash benefits expected from calf breeding each year, using the above formula. Interestingly enough, the sum of the expected annual flows from the sale of calves alone exceeds the purchase price of the cow.

TABLE 6.4

COMPUTATION OF THE EXPECTED STREAM OF REVENUE FROM CALF BREEDING

Year	Age of Cow	Probability of Having a Calf	Expected Revenue from Sales of Calves at Age 4 (CFA)	Expected Value of Sale of Calf Born in Year n at Age 4 (CFA)
n	n+3	$C_n(1-M)^n$	$(1-d)(1-M)^3P_4$	$E(V_{n4})$
1	4	.47	15,573	7,319
2	5	.44	15,573	6,852
3	6	.42	15,573	6,541
4	7	.39	15,573	6,073
5	8	.37	15,573	5,762
6	9	.35	15,573	5,451

Total: Sum of expected benefits $\sum_n E(V_{n4})$ = 37,998

Assumptions: The calving rate (C_n) is constant at 50%
The adult mortality rate (M) is 6%
The calf mortality rate (d) is 25%
The average sale price for four year olds (P_4) is 25,000 CFA

Cattle entrusted to herdsmen do not permit the owner to benefit from the by-products of milk and manure. However, the proprietor pays for veterinary expenses and owns the progeny of female cattle, whether he keeps the cattle on-farm or not. The flow of cash benefits from calf breeding is read from the last column of Table 6.4. Constant annual costs and receipts from milk and manure are added to these figures after discounting for the possibility of annual mortality, to derive estimates of the internal rate of return to investing in female cattle. The results are displayed in Table 6.5.

The internal rate of return to female cattle is substantially above that for male cattle, because of expected receipts from calf breeding.

TABLE 6.5

COMPUTATION OF THE INTERNAL RATE OF RETURN
TO KEEPING ONE COW ON AND OFF THE FARM

(a) Age of Cow	(b) Year of Ownership (n)	(c) Probability That Animal Will be Alive at End of the Year	(d) Expected Cash Costs	(e) Expected Flow of Benefits from Calves and Final Sale	(f) Net Expected Cash Receipts for Each Year Entrusted Cattle	(g) Expected Cash Value of Benefits from Milk and Manure	(h) Net Expected Cash Receipts each Year for On-Farm Cattle
4	0	1.0	25,000	0	0	0	0
5	1	.94	564	7,319	6,755	2,985	9,740
6	2	.88	528	6,852	6,324	2,805	9,129
7	3	.83	498	6,541	6,043	2,637	8,680
8	4	.78	468	6,073	5,605	2,479	8,084
9	5	.73	439	5,762	5,323	2,330	7,653
	6	.69	414	22,701	22,287	2,190	24,477

(i) Internal rate of return to entrusted cow, from (f): 21.11%
(j) Internal rate of return to on-farm cow, from (h): 33.03%

SOURCES: (a), (b) Assume that animal is purchased at age 4 and sold at 9, to reap maximum benefit from calving.
(c) Probability that an animal will be alive = (1 - Mortality Rate)^n.
(d) Includes 600 CFAF p.a. for veterinary care X (c), but excludes 200 CFAF/head taxes.
e) From the last column of Table 6.4, (expected value of the final sale = probability animal will be alive X average rate value for a 9 year old added to returns in year 6).
f) = (e) - (d).
g) See text: (1,300 CFAF for manure + 1,875[f] for milk) X (c). These calculations exclude manure from calves.
h) = (f) + (g).
i), (j) IRR's calculated according to the formula in the text above.

The calculated rate for a cow kept on-farm is thirty-three percent, an outstanding return on invested capital. The comparable rate for a cow entrusted to a Fulani herdsman in over twenty-one percent. The similarity in prices between males and females in the four to six year old age bracket reported in Table 6.2 above may come from the fact that these animals are traded in different markets. Most sales of animals in the four to six year age bracket consist of sturdy males, destined for export by trekking. The few females traded in this age category are either emaciated or somehow undesirable animals, sold locally.

Keeping Cattle on the Farm Versus Entrusting to a Herdsman.-- The preceding two subsections present an idealized account of the returns to keep cattle on the farm, as opposed to entrusting it to a herder. In the case of male cattle, the internal rate of return (IRR) was six percent higher in the on-farm case. The differential was twelve percent in the case of the female cattle. At first glance, it would appear that farmers should look after their own stock. However, this is an unjustified conclusion, since it ignores three major problems associated with keeping animals on the farm.

First, and foremost, comparison of the rates of return ignores the extra (opportunity) cost of looking after the cattle -- it implicitly assumes that there is no extra cost to the farmer in looking after cattle himself. This is because no cash value is put upon foregone production. This question is analyzed more thoroughly in subsequent chapters, using linear programming. A quick calculation illustrates the point in the immediate context. The author has argued elsewhere that the work requirement for keeping five head of cattle on-farm during the rainy season is the labor of one adult male, full-time. (Delgado, 1977, pp. 69-70). This is also consistent with the labor estimates for cattle contained in chapter 4 above. Given an average area cultivated per worker of four fifths of a hectare, this implies that approximately 800 kilograms of grain are lost in an average year (Ibid.). If one animal incurs only one fifth of this cost in foregone grain production, then the cost of keeping an animal in-village is 160 kilograms of millet and sorghum.[1] At the rock bottom

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[1] This probably understates the cost because of economies of scale in herding.

harvest price of 20 CFA a kilogram, this leads to an expected animal cash cost $E(CC_N)$ in year N equal to:

$$E(CC_N) = 3{,}200 \text{ CFA} \times \text{Probability that animal will be alive throughout year N}$$

$$= 3{,}200\ (1-M)^N \text{ CFA}$$

This formula is used in Table 6.6 to calculate the expected opportunity cost of keeping an animal on the farm. The internal rates of return taking account of this new cost factor is computed in Table 6.6.

The results are striking. The internal rate of return for female cattle kept in the village is now the same as that for entrusted female cattle. In the case of male animals, the new internal rate of return for cattle kept on-farm is substantially below that for entrusted animals.

The second major problem with the initial comparison of cash receipts is that keeping cattle on-farm entails a substantial risk of damaging a neighbor's field. It is undoubtedly convenient to have an outsider to blame for these "anti-social" outcomes in a West African communal society (Delgado, 1977, p. 78). Furthermore, whoever herds the cattle is financially responsible for damage. The extra risk for the farmer of keeping his own animals does not enter into the calculations.

The third major problem with the original comparison is that the entrusting system is a highly discrete way of saving. Cattle kept on the farm are a blatant indication of wealth in a society known for the obligation of its members to share wealth with relatives. The Fulani fulfill the role of rural "Swiss Bankers" in this respect (Delgado, 1977, p. 73). The value of this service is not taken into account in cash comparisons.

Conclusion.-- Even though cattle remain an attractive investment opportunity, adding a cash value for the opportunity cost of labor required to maintain the animals on-farm indicates that farmers do better to entrust the animals to Fulani herdsmen. This position is the result of a comparison, on purely economic grounds, of internal rates of return to cattle under different assumptions. When the social benefits of the peasant-herder relationship are also considered, such as the convenience

TABLE 6.6

THE INTERNAL RATE OF RETURN TO CATTLE ON AND OFF FARM
INCLUDING THE OPPORTUNITY COST OF RESOURCES
(in CFAF)

Year	On-Farm Cattle: Annual Expected Cash Flows without Opportunity Cost		On-Farm Cattle: Annual Expected Cash Flows with Opportunity Cost		Entrusted Cattle: Annual Expected Cash Flows	
	(a)	(b)	(c)	(d)	(e)	(f)
(N)	Male	Female	Male	Female	Male	Female
0	-15,000	-25,000	-15,000	-25,000	-15,000	-25,000
1	658	9,740	- 2,170	6,732	- 564	6,755
2	22,616	9,129	19,788	6,313	21,470	6,324
3		8,680		6,024		6,043
4		8,084		5,588		5,605
5		7,653		5,317		5,323
6		24,477		22,269		22,287
IRR	25%	33%	8%	21%	19%	21%

SOURCES: (a) from calculations pertaining to Table 6.3. Males are purchased at age 2 for growing out.
(b) from Table 6.5. Females are purchased at age 4 for breeding and dairy.
(c) = (a) - 3,200 $(1 - M)^n$ except for N = 0.
(d) = (b) - 3,200 $(1 - M)^n$ except for N = 0.
(e) from calculations pertaining to Table 6.3.
(f) from Table 6.5.

of having discrete outsiders performing the banking function in a highly communal society, this conclusion is reinforced. The rest of the chapter is devoted to ascertaining the actual behavior of sample farmers with respect to livestock holdings.

Bisa and Mossi Livestock Holdings

The major finding of the next two sections is that the actual behavior of peasant farmers with respect to livestock holdings is consistent with the behavior indicated by discounted cash flow analysis, when the latter includes the opportunity cost of looking after a small number of large animals within the village. Farmers entrust their cattle to the Fulani and show a marked preference for female cattle. The evidence indicates that few males are kept after they reach four years of age. Inconclusive evidence taken from direct questioning of sample farmers indicates little in the way of ownership of mature cows.[1] However, data from Fulani herds indicate a strong proportion of older females. Since the herds are owned in majority by peasant farmers, it is also possible that a substantial proportion of the mature cows in Fulani herds are owned by farmers.

No peasant farmer kept livestock on the farm in the Tenkodogo area in 1976, to the best of the author's knowledge. Yet, many farmers owned livestock which were kept for them by Fulani herdsmen.[2] This section analyzes farmer responses to interviews concerning their livestock holdings (Questionnaire H, Appendix C). The major result is that approximately one household in three owns cattle and, among households owning cattle, the average holding is four head.[3] The average farm in the sample possesses seven to eight sheep and goats which are kept in the village throughout the year. Of the forty-one Bisa-owned cattle surveyed in a sample of thirty households, nearly

[1]In this context, animals four years and older.

[2]The precise nature of the entrustment contract is discussed in detail in Delgado (1977).

[3]Or a mean of 1.37 head per household.

nine-tenths were under five years of age, suggesting a willingness to sell off older stock. A comparable survey was made of Mossi sample members in Oueguedo, with disappointing results. The census among the Bisa was conducted by an enumerator related to the village by marriage, which appears to have allayed the qualms of sample members about giving out confidential information. Subsequent interviews of the Fulani in Oueguedo, however, cast doubt on the results concerning cattle for the Mossi village. The Mossi figures are presented here only for the purpose of completeness.

Bisa Herd Inventories.-- Eleven out of thirty households possessed cattle. These farmers had an average holding of four head apiece. The thirty farms also had an average of seven to eight sheep and goats, with little in the way of donkeys, horses or swine. Table 6.7 presents summary data on livestock holdings for the enlarged Bisa sample, excluding the canton chief.

TABLE 6.7

SUMMARY OF BISA SAMPLE HOUSEHOLD LIVESTOCK HOLDINGS (N=30)[a]

(Number of Head)	Mean	Standard Deviation	Maximum	Minimum
Cattle	1.37	2.69	12	0
Sheep	4.63	3.74	17	0
Goats	2.83	3.47	15	0
Horses	.30	.70	3	0
Donkeys	.37	.72	2	0
Swine	.30	1.02	5	0

[a]Excludes the canton chief.

Age Structure of Bisa Herds.-- Two thirds of the cattle owned by the Bisa sample were female, with preponderance of them being under five years of age. Table 6.8 presents data on the age structure of the combined cattle holdings of the Bisa sample.

TABLE 6.8

AGE STRUCTURE OF THE BISA SAMPLE CATTLE HERD

	MALES				FEMALES			
Age	0-2 Years	3-4 Years	5-6 Years	Over 6 Years	0-2 Years	3-4 Years	5-6 Years	Over 6 Years
Total Head in Sample	6	7	0	0	8		15	2
Mean Household Animals	.20	.17	0	0	.27	.50	.10	.07
(Standard Deviation)	(.55)	(.53)	(0)	(0)	(.78)	(1.36)	(.40)	(.37)

The same information for the cattle owned by Bisa sample members is presented in Figure 6.2. The striking conclusion in that 89 percent of the herd consists of animals four years and younger. These findings admittedly based on a very small sample, suggest one hypothesis for further research: that peasant owners sell off the older stock for cash revenue or reinvestment. In view of the high returns to calving examined earlier, it remains puzzling that older cows are so underrepresented.

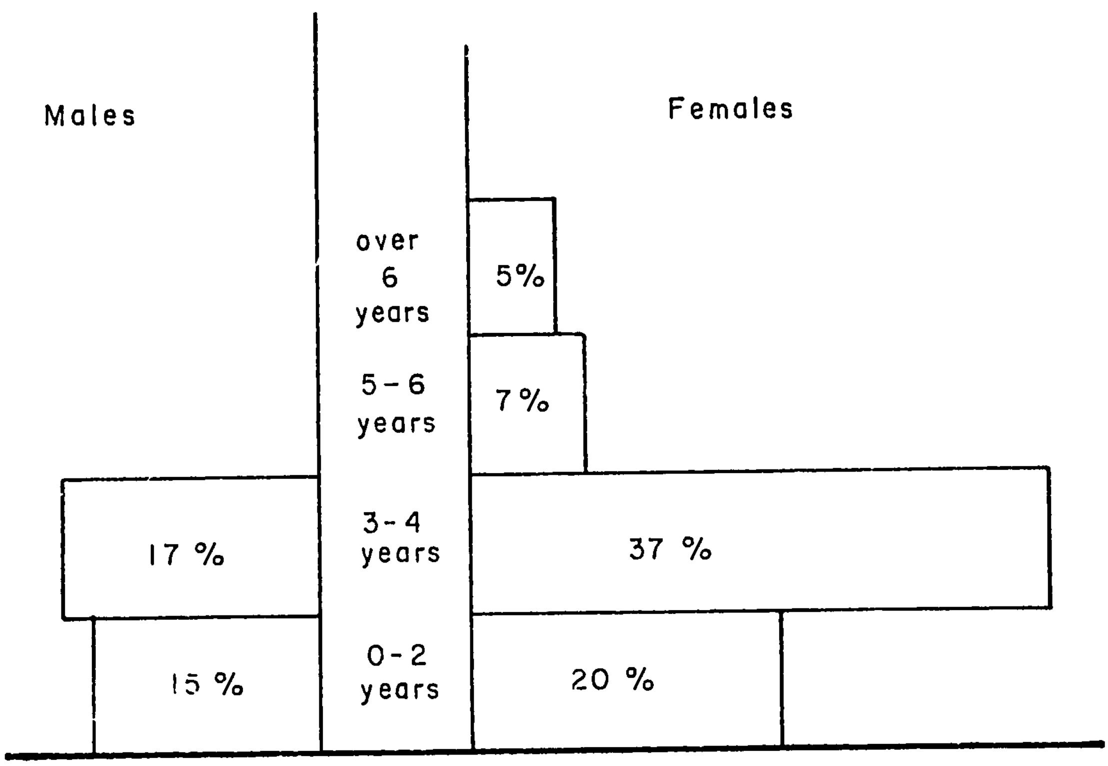
The age structure information for sheep and goats indicates that all age categories are well represented. There is a noteworthy proportion, as indicated in Table 6.9, of animals in the four year old and up category.

TABLE 6.9

AGE STRUCTURE OF THE BISA SAMPLE SHEEP AND GOAT HERD

Age	Less Than 1 Year	1-2 Years	2-3 Years	Over 3 Years
Total Head in Sample	46	67	51	50
Mean Household Head N=30	1.53	2.17	1.70	1.63
Standard Deviation	(1.76)	(2.17)	(2.23)	(2.58)

FIGURE 6.2
Age Structure of Total Herd Owned by Bisa Sample Members



% (Based on 41 animals.)

Mossi Herd Data.-- This section presents herd size information for the Mossi of Oueguedo. It is, in theory at least, comparable to the preceding data for the Bisa. However, the estimates for cattle are judged to be far too small. The basis for this judgement is that the enumerators in the Mossi village made little effort to obtain figures relating to cattle holdings, since sample members were not enthusiastic about providing such information. The data for sheep and goats appear to be acceptable. It should be borne in mind that cattle are taxed approximately 200 CFA [1] per head per annum, while sheep and goats are kept free. The Mossi data are presented in Table 6.10.

TABLE 6.10

SUMMARY OF MOSSI HOUSEHOLD LIVESTOCK HOLDINGS
(N=28)[a]

Type of Stock	Mean	Standard Deviation	Maximum	Minimum
Cattle[b]	.25	.97	5	0
Sheep	2.93	3.24	9	0
Goats	1.61	1.77	4	0
Horses	0	0	0	0
Donkeys	.39	.88	3	0
Swine	.68	2.26	11	0

[a]Excluding the canton chief and his brother.

[b]The data for cattle are highly questionable, as explained in the text. Only three households out of the twenty-eight admitted to owning livestock. The figure estimated after speaking with herdsmen in the area is eight households out of the twenty-eight.

Fulani Livestock Holdings

The size, age, and ownership of Fulani herds in the Tenkodogo area provide a valuable second perspective on the extent and type of peasant

[1]Approximately US $.80 in 1976.

livestock holdings, since virtually all Mossi and Bisa cattle are kept by the Fulani. A preliminary cattle census of twenty Fulani families was conducted in Oueguedo in 1976 and 1977.[1] A subsequent detailed study of a subset of fourteen of these herds was conducted in late 1977. The results in this section are based on the latter.[2] The major findings are that sixty percent of Fulani sample herds belong to non-Fulani proprietors. The average herd of over forty animals is composed primarily of older females, suggesting that younger males are sold off to cattle brokers for trekking to market. A further result requiring investigation is an average decrease in Fulani sheep and goat holdings of fifty percent between December 1976 and December 1977.

Fulani Herd Inventories.-- Approximately sixty percent of the cattle in the fourteen Fulani herds surveyed in 1977 belonged to sources outside the household. These consist primarily of peasant farmers in the immediate vicinity of Tenkodogo.[3] The average size of the cattle herds in 1977 was 43 animals.[4] Each household also kept an average 16 sheep and goats, with the emphasis on the former. These were all owned by the household in question. Being Muslims, the Fulani do not keep swine. Table 6.11 presents a summary of the data.

Between December 1976 and December 1977, there was a net increase in the cattle herds of Fulani sample members of four percent.[5] At the same time, there was a net decline in the herd of sheep and goats of over fifty percent. The primary explanation for this surprisingly large decrease

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[1] Reported in Delgado (1977).

[2] The research team was better known to the sample by the time of the second census. Enumerators were able to count livestock numbers personally, which boosted previous estimates of herd size.

[3] The 1976 survey of 19 Fulani herds reported in Delgado (1977) counted 120 non-Fulani proprietors of which approximately one-sixth lived outside the rural area of Tenkodogo.

[4] These results may be contrasted with the 1976 survey, which found an average herd size of 38 head, of which 30 percent were owned by the Fulani (Delgado, 1977, p. 34).

[5] Based upon herder recall in December 1977, rather than a comparison of two surveys which are not fully comparable, owing to a greater degree of access to herds in 1977.

in sales of sheep and goats to buy millet, since the 1976 harvest was particularly poor. Another possible explanation is that herdsmen are reconstituting their personal cattle herds using the sheep and goats raised immediately following the drought in 1974. Both these assertions require more data and further research for adequate analysis.

TABLE 6.11

SUMMARY OF FULANI HERD SIZES IN OUEGUEDO FOR 1977
(N=14)

Type of Stock	Mean	Standard Deviation	Maximum	Minimum
Total Cattle	43.14	19.16	90	17
Fulani-owned Cattle	17.29	14.63	50	2
Sheep	9.71	8.33	30	0
Goats	6.43	5.28	22	1
Horses	.07	.27	1	0
Donkeys	.36	.82	3	0

The Age Structure of Fulani Herds.-- Data on the age structure of the Fulani herds show that over half the animals kept are females five years and older. A surprisingly high figure of one fifth of the herd is represented by males five years and older. A top-heavy age pyramid for Fulani herds reflects in part the high mortality among younger stocks.[1] Another explanation may be a preference for older cattle who have proven their endurance and fertility; the younger stock being sold to collectors for Pouytenga cattle market.[2]

Figure 6.3 presents the data on Fulani herd structure in age pyramid form. When compared to Figure 6.2 relating to Bisa cattle holdings, a

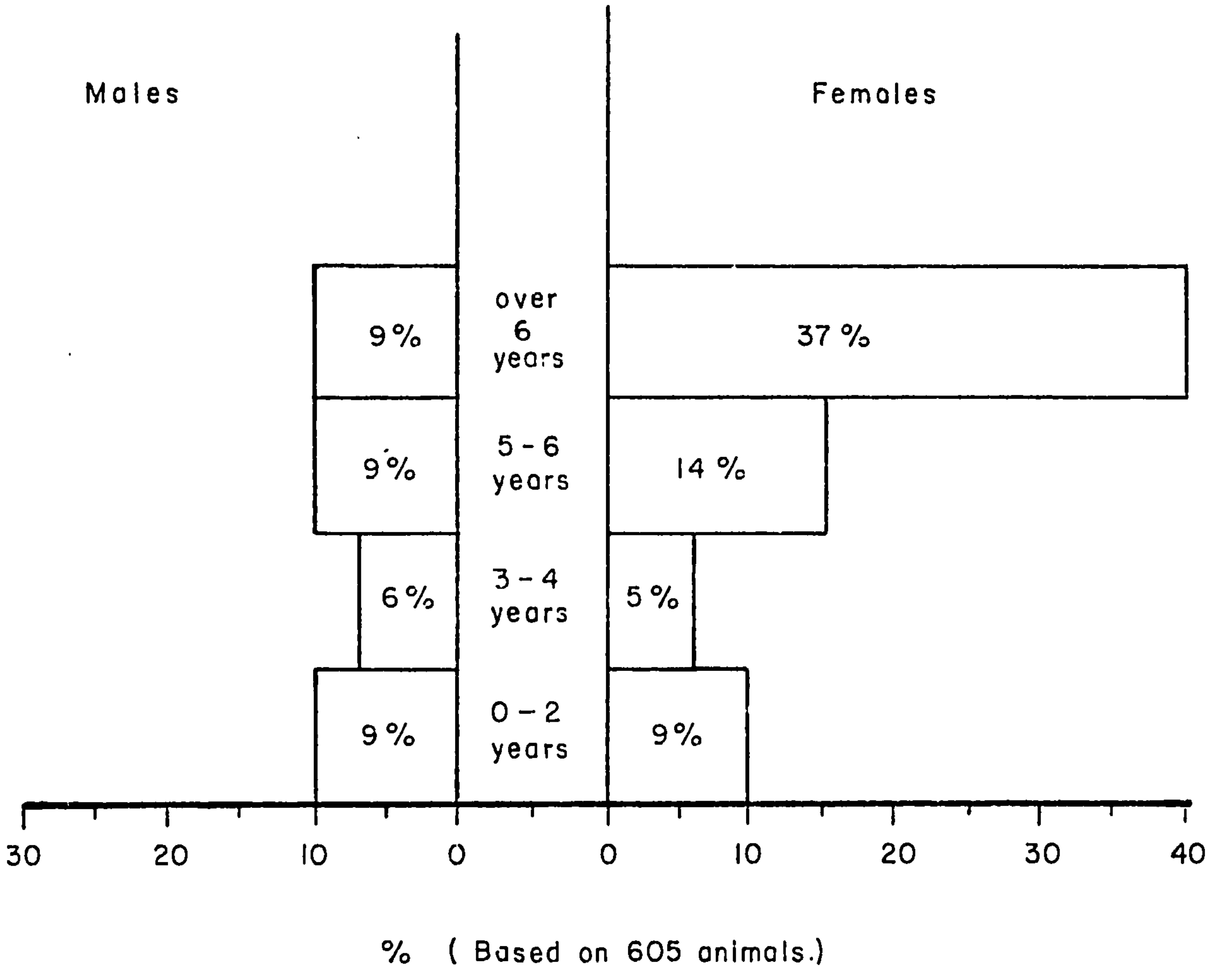
[1]Said to be from 35 to 45 percent in Upper Volta (Peretti, 1976, I, p. 63).

[2]According to sample members, Pouytenga is the destination for young animals after they are sold. This is a major collecting market and the regional starting place for cattle drives to the capital or to the coast.

further preliminary hypothesis is presented for further research. This is that the younger animals in the Fulani herds belong principally to peasant proprietors, with the Fulani-owned portion of the herd concentrated among the older animals. The answer to this question requires further research. In view of the high returns to capital invested in cows of calf-bearing age, however, it seems likely that at least some of the older animals belong to peasant farmers.

Chapters four and five analyzed the availability and allocation of labor and land in the research area. This chapter dealt with capital as both an input and an output -- in the form of livestock investment -- of the production process. The next chapter portrays the output of crop enterprises on Mossi and Bisa sample farms.

FIGURE 6.3
Age Structure of Fourteen Fulani Herds



CHAPTER 7

FARM AGRICULTURAL OUTPUT

This chapter deals with the crop output of sample farms in 1976. The evidence on nonagricultural and livestock income generated by the farm management survey is sufficiently sporadic that it was, regretfully, dropped from this analysis.[1] Data from the adjoining Zorgho area of the Mossi plateau are used in the final section to estimate that animal products account for approximately one fifth of sales of on-farm agricultural produce. An intentionally conservative set of prices is chosen to evaluate crop production. The Tenkodogo data show that the average value of 1976 household crop production is approximately 112,159 CFA. Comparative figures on crop sales for Zorgho suggest that roughly one tenth of crop output is sold. Detailed data on yields indicate that food grains such as millet did poorly, while legumes such as cowpeas did very well in 1976. This can be attributed to a large extent to the very sunny weather in August. An analysis of the determinants of crop output indicates that food grain yields are subject to a number of environmental influences which are hard to control for within the cross-sectional data set. In any event, regression analysis of the effects of July weeding labor on food grain yields gave poor results. Part of this is due to a number of thorny estimation problems and part to the dry August which precluded (after the fact) the necessity of July ridging.

Crop Yields in Tenkodogo in 1976

This section presents data on the mean yield of each crop grown on sample member farms. The objective is to derive figures for yields per

[1]The conclusion drawn from this by the author is that, given limited resources and a desire to avoid over-imposing on the sample, a researcher must choose between a good household budget survey or a good labor use and production survey.

hectare of major crop categories. These will be used in the construction of the objective functions of the linear programming models in later chapters. The 1976 harvest in Tenkodogo was below average, by all accounts. Millet, sorghum, and rice suffered because of an abnormally dry August. Heavy rainfall in September and October compounded the situation by interfering with the granulation of the millet ears. Ground crops such as peanuts, cowpeas and voandzeia subterranea looked promising initially, but were heavily rotted by the late rains. The low figures for 1976 are appropriate for an exercise designed to show that extra crops are more profitable than livestock for a farmer who is primarily a crop raiser. To the extent that yields are low, the opportunity cost of labor time is low in terms of crops. Conclusions from this exercise favorable to crop activity are therefore all the more valid for years of average and high yields.

The Yields of the Major Crops.-- The yields of the principal crops grown in the research area are measured using two separate methods.[1] The first set of estimates stem from farmers' recall of the amount of each crop harvested during the three days prior to each interview. The estimate given in, say, "small baskets of sorghum ears" is converted into kilograms of dry storable grain by the variant of the "Five Unit Method" discussed in chapter 3 (pp. 57-58). After summing observations for each field over time periods, total yields in kilograms are divided by the area of the field concerned in order to obtain the yield in kilograms per hectare. Fields under one fifth of a hectare are excluded from the yield calculations, since small areas are difficult to measure accurately and errors are multiplied by computations involving division by field area.[2] The remaining observations were averaged within each crop and land type to get estimates of the mean and variance of yields within that category.[3]

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[1]The principal crops are millet, sorghum, cowpeas, groundnuts, and rice.

[2]Rice fields were excluded only if their area was less than one twentieth of a hectare, since no rice field was over one fifth of a hectare.

[3]The results were pooled for the Mossi and the Bisa.

The yields on some fields are also measured by yield plots, with the tendency towards over-estimation discussed in chapter 3 (p. 57). The estimates obtained from the recall data are in many cases lower than those obtained from yield plots. The recall estimates will be used in the linear programming, given the objections to yield plots already cited (Ibid.) and the desire to avoid overestimating the returns to crop raising for the reason cited above.

The yield plot information is useful in inter-field comparison, however, such as the estimation of production functions. This is because the recall data include an extra component of (random) error stemming from the conversion of farmers' units into kilograms. Some baskets are larger than the average and some smaller. Some farmers may tend to give a figure that is too high, while others give one that is too low. The yield plot data, on the other hand, give a measure of differences among fields, even if they consistently overestimate production in each one of them. There is little measurement error involved in the amount actually taken off the yield plots, since the enumerators weighed the produce directly. This use of yield plot data will be explored more thoroughly in the section concerned with the determinants of yields. The results for both the yield plot and recall data techniques are contained in Tables 7.1 through 7.4.

The Yields of the Secondary Crops.-- It was not possible to measure the yields of a number of secondary crops grown in the research area for two reasons.[1] First, the areas of each plot were very small, raising the problem of accuracy cited in the previous subsection. The average stand of cotton and tobacco was 0.002 hectares, which is even smaller than the standard twenty-five square meter yield plot. Second, these crops are not harvested all at once, but over a period of weeks or months. Maize, for example, is harvested a few ears at a time, as needed in cooking. Cassava can even be left in the ground until the next year, if so desired. This makes farmer recall methods highly inaccurate and yield plot methods impossible.

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[1]The secondary crops are cassava, sweet potatoes, maize, fruit, garden vegetables, cotton, and tobacco.

Instead, estimates of yields per hectare were obtained from two outside sources (F.A.O., 1977, and République Francaise, Ministére de la Coopération, 1974). Subjective estimates were made on the basis of these figures, first hand experience, and conversations with sample members and O.R.D. officials. The latter numbers are mostly in the lower range of the estimates from outside sources, for three reasons. First, the published data is heavily influenced by results obtained under experiment station conditions. Second, 1976 was a year of poor growing conditions in Tenkodogo for some of the crops concerned, such as maize, cotton, and tobacco. This is not reflected in the general figures published for Upper Volta. Third, in linear programming, a conservative approach is indicated, given the intended use of the estimates.

For simplicity of analysis, the data are aggregated into a combined yield estimate for one hectare of each of five crop mixtures or categories. These are starchy root crops, dry season fruit and vegetables (on lowland), wet season vegetables (on house land), maize, and cotton and tobacco. The basic assumption is that each crop in a combination occupies a fraction of the land allotted to the mixture in direct proportion to the number of crops therein. Thus, a yield of 800 kg/ha for "cotton and tobacco" implies that each one has a yield of 400 kg. when intercropped with the other. The paucity of the data, the small importance these crops have in farm production strategies, and the limited ends of the exercise combine to rule out a more sophisticated approach. In another section, the same linear combinations of crops will be used for each mixture in order to calculate composite prices of output. Table 7.5 shows the composition prices of output. Table 7.5 shows the composition of each mixture, the published yield estimates for each crop, and the conservative combined estimate of yield for each crop mixture that will be used in the linear programming.

Conclusions for the Linear Programming.-- The average yields for each crop within each crop mixture, computed from recall data, are added to results from Table 7.5 into a summary statement of average yields in Table 7.6. These figures will be used in the computation of the value of mean farm production in 1976 and the linear programming exercise of chapter eight.

TABLE 7.1

YIELD MEASUREMENTS FOR RED SORGHUM INTERCROPPED WITH MILLET AND COWPEAS
(In kilograms per hectare)

Field Type:	House		In-village		Bush		All Fields	
	Mean (kg./ha)	(S.D)[a]	Mean (kg./ha)	(S.D.)[a]	Mean (kg./ha)	(S.D.)[a]	Mean (kg./ha)	(S.D.)[a]
<u>Recall Method</u>								
Number of Observations:[b]	N=22		N=12		N=3		N=37	
Red Sorghum	584	(415)	355	(312)	353	(406)	488	(389)
Millet	343	(374)	174	(136)	273	(165)	289	(319)
Cowpeas[c]	713	(546)	697	(527)	1,045	(822)	734	(552)
<u>Yield Plot Method</u>								
Number of Observations:[b]	N=18		N=15		N=0		N=33	
Red Sorghum	1,161	(831)	690	(555)			947	(747)
Millet	468	(182)	325	(144)			403	(179)
Cowpeas[c]	111	(94)	199	(107)			149	(108)

NOTES: [a]Standard deviation

[b]One observation per field, Mossi and Bisa samples combined. The recall data observations do not necessarily refer to the same fields as the yield plot data.

[c]In shell

TABLE 7.2

YIELD MEASUREMENTS FOR MILLET INTERCROPPED WITH COWPEAS
(In kilograms per hectare)

Field Type:	In-village		Bush		All Fields	
	Mean	(S.D.)[a]	Mean	(S.D.)[a]	Mean	(S.D.)[a]
Recall Method						
Number of Observations:[b]	N=36		N=22		N=58	
Millet	280	(366)	273	(379)	277	(367)
Cowpeas	672	(438)	652	(577)	665	(485)
Yield Plot Method						
Number of Observations:[b]	N=15		N=7		N=22	
Millet	415	(238)	311	(51)	382	(203)
Cowpeas	126	(102)	308	(242)	184	(177)

NOTES: [a]Standard deviation

[b]One observation per field, Mossi and Bisa samples combined. The recall data observations do not necessarily refer to the same fields as the yield plot data.

TABLE 7.3

YIELD MEASUREMENTS FOR GROUNDNUTS
(In-village fields only, in kilograms per hectare)

Field Type:	Peanuts in single stand	Peanuts intercropped with voandzeia subterranea[a]	
		Peanuts	Voandzeia[a]
Recall Method			
Number of Observations:[b]	N=8	N=9	
Mean	354	346	180[c]
Standard deviation	(473)	(208)	
Yield Plot Method			
Number of Observations:[b]	N=10	N=7	
Mean	1,126	644	n.a.
Standard deviation	(466)	(165)	

[a]An edible tuberous root with a fruit resembling a chick pea in a hard shell.

[b]One observation per field, Mossi and Bisa sample combined.

[c]Based on only two observations.

TABLE 7.4

YIELD MEASUREMENTS FOR RICE[a]

(On lowland fields only, in kilograms per hectare)

	Recall Method	Yield Plot Method
Number of Observations[b]	N=8	N=6
Mean	561	1,163
(Standard deviation)	(453)	(349)

[a]Paddy

[b]One observation per field, Mossi and Bisa sample combined

TABLE 7.5

ESTIMATES OF 1976 YIELDS OF SECONDARY CROPS IN TENKODOGO
(in kg. per hectare, unless otherwise indicated)

Crop	FAO Estimate For 1976 in Upper Volta[a]	French Estimate for West Africa[b]	Crop Category Pertinent to This Study[c]	Average Area Cultivated per Farm in Hectares[d]	Conservative Estimate for Tenkodogo, 197
Cassava	5,833	3,000-15,000	Starchy root crops	.06	3,000
Sweet Potatoes	2,667	3,000-10,000			
Cassava inter-cropped with sweet potatoes	4,464	---			
Mangoes	---	5,000-20,000[b]	Dry season fruit and vegetables	.01	8,000
Onions	---	10,700			
Tomatoes	8,667	5,000-30,000	Wet season vegetables		4,000
Pimento	---	4,000			
Okra	---	5,000			
Maize	511	1,000	Maize	.02	650
Cotton	745	500	Cotton and tobacco	.002	800
Tobacco	---	1,000-2,000			

SOURCES: [a]Production Yearbook 1976. These figures imply a precision that is not appropriate under th circumstances.

[b]République Française, Mémento de-l'Agronome, 1974. [c]For use in linear programming.

[d]From Table 5.11. [e]Assumes that the field is divided equally between crops in a mixture The same assumption will be made concerning the value of production.

[f]Assuming 100 trees per hectare.

TABLE 7.6

SUMMARY OF AVERAGE CROP YIELDS FOR TENKODOGO IN 1976

Crop Mixture	Type of Land	Individual Crop	Yield (kg./ ha.)
Red sorghum, millet and cowpeas[a]	House	Red sorghum Millet Cowpeas	584 343 713
Millet and cowpeas[b]	In-village	Millet Cowpeas	280 672
Millet and cowpeas[b]	Bush	Millet Cowpeas	273 652
Groundnuts[c]	In-village	Peanuts Voandzeia	346 180
Groundnuts[c]	Bush	Peanuts (single stand)	820
Rice[d]	Lowland	Rice	561
Maize[e]	House	Maize	650 (est.)
Wet season garden produce[e]	House	Tomatoes Pimentoes Okra	4,000 (est.)
Dry season fruit and vegetables[e]	Lowland	Mangos Onions	8,000 (est.)
Starchy root crops[e]	Lowland	Cassava Sweet potatoes	3,000 (est.)
Cotton and tobacco[e]	House	Cotton Tobacco	800 (est.)

SOURCES: [a]Table 7.1
[b]Table 7.2
[c]Table 7.3
[d]Table 7.4
[e]Table 7.5

The Determinants of Millet Yields[1]

This section attempts to capitalize on the very detailed land area and labor flow data available to support the view that July weeding labor is crucial to the output of food grains, principally millet. However, the available literature indicates that a number of factors which remain unquantified, such as rainfall distribution and soil fertility, also affect yields in a major way. It is highly likely that these phenomena vary over the fields in the sample, raising a number of problems for ordinary least squares estimation. A subsection will show that OLS estimators are biased under these conditions, with the weeding coefficients quite possibly biased towards zero. Problems with the included data in terms of multicollinearity and measurement error also serve to render OLS estimation imprecise and biased. In view of these considerations, results of the OLS estimation exercise should be interpreted with caution. The actual results lend very weak support to the view that July labor contributes significantly to output. This is seen primarily as a manifestation of the estimation problems present, since the conventional agronomic wisdom indicates just the opposite. The 1976 weather, however, may have also operated to reduce the actual effectiveness of July labor on output, because of an absence of rainfall in August.

The Secondary Evidence from the Literature.-- In his well-known survey of tropical farming systems, Ruthenberg states that "weeds are probably the most important yield-depressing factor in fallow systems..." (1976, p. 80). The latter include the set of farming practices in the research area. Furthermore, the timing of labor effort is essential since "no other factor is as much to blame for poor yields as late weeding." (*Ibid*. p. 99). Thus one would expect, *ceteris paribus*, that the labor supplied to a given field during the weeding period in July is instrumental in determining yields. A practical problem, however, arises when attempting to support this proposition with production

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[1]This section (pp.194-207) may be skipped by readers interested primarily in the larger question of the opportunity cost of in-village livestock production.

function analysis for millet: this is that yields of these crops also depend to a high degree on a number of other factors. The latter are often so location specific as to differ among fields within the same village and are not easy to measure.

The standard agronomic text for Francophone West Africa gives four factors which usually affect millet and sorghum yields, in addition to seedbed preparation, weeding, and harvesting labor (République Française, Ministère de la Coopération, 1974, pp. 498-502, pp. 539-548). These are the amount and distribution of rainfall; the drainage of field areas; the organic content, aeration, and fertility of soils; and finally the presence of plant parasites. The effect on yields and the variability of each one of these factors among fields are discussed in turn.

The poor distribution of rainfall in 1976 depressed crop yields generally, however some fields suffered more than others. Rainfall occurs in highly localized squalls during much of the wet season. Part of the village may receive rain while another part may not. Since typical upland soils have a low clay content and contain a high proportion of sand, water retention on most millet and sorghum fields is low (chapter 5, p. 135). This implies that land which does not receive water for a period as short as a week during critical periods--such as just after the flowering of sorghum--will have greatly reduced yields (République Française, Ministère de la Coopération, 1974, p. 542). The result is a significant variation in yields obtained on fields with otherwise similar inputs and characteristics.

Both millet and sorghum require well-drained soils, since excess moisture will rot the roots (Ibid. p. 500 and p. 542). Drainage depends upon soil composition, relative altitude, and surface inclination, among other factors. These are likely to vary among fields which are fairly close to each other. The ability of soil to produce crops also depends on a large number of other elements.[1] Many of these are likely to change from field to field. Three to sixteen soil samples per hectare are recommended when compiling data for a detailed map of village soils

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[1]Depth, acidity, salinity, mineral composition, porosity, erodability, to name a few. See République Française, Ministère de la Coopération, (1974) p. 107.

(Ibid. p. 109).

Perhaps more than any other single factor, plant parasites can severely reduce millet and sorghum output. The principal among these is striga hermonthica, a weed with purple flowers often to be seen in the research area. Simple weeding is not enough to destroy this plant, which has severe consequences for an infested millet or sorghum field (Ibid. pp. 501-02 and pp. 546-47). To the extent that striga is unevenly distributed over the village, yields on different food grain fields will tend to differ, other elements being equal.

In conclusion, the secondary evidence suggests that there is likely to be a large amount of variation in the total yields of different food grain fields, even after the influence of field size, labor flows in different periods, and recorded manure use is accounted for. This presents a problem for the estimation of production functions for food grains from data pertaining to a cross-section of plots in the research area.

Problems in the Estimation of Production Functions for Food Grains from a Cross-Section of Tenkodogo Farms.-- The availability of data on labor flows by task and time period suggests performing experiments to test the influence of July weeding labor on yields across fields. In theory this would provide a relatively costless comparison to the linear programming results in chapter nine concerning the opportunity cost of July labor. The surface appeal of this approach should, however, be tempered by this caveat from the definitive work on agricultural production functions (Heady and Dillon, 1961, p. 255):

> The use of estimated production functions as a guide to the economic allocation of resources is fraught with problems. The conditions under which a fitted function will serve as an error-free guide are extremely severe.

This subsection examines three such problems which indicate the necessity for caution in interpreting the results that might be forthcoming from production functions estimated from the data of one single year. The areas of concern are estimation bias from omitted variables, bias from measurement error in the explanatory variables, and multicollinearity between the independent variables. Besides the likelihood of obtaining incorrect estimates under these conditions, there is the difficulty of making permissible inferences when the underlying statistical assumptions are violated.

The problem of omitted variables arises from the difficulty in quantifying some of the factors that are likely to account for a high degree of yield variation among fields--rainfall distribution, drainage, soil fertility and plant parasites. The farm management survey did not gather observations usable in inter-field regressions on these phenomena. The result is that data do not exist for a number of important variables which agronomic theory indicates belong in the estimation equations. There are two negative consequences of this state of affairs.

First, one would expect that crop yields would exhibit a good deal of variation "unexplained" be a fitted regression plane. That is, the sum of squared residuals between actual yields and those predicted by the estimated equation would tend to be large.[1] In itself, this would not be a problem, since it is only the coefficient of July weeding labor which is of interest.[2] However, a second problem arises. This is the well-known result that omitting variables that belong in the true specification from the estimating equation can bias the estimators of the included variables.[3] This will in fact be the case if the omitted variables are correlated with included variables. Following Johnston (1972, p. 169), the bias in any estimated coefficient can be obtained as the summation in the right hand side of:

$$E(\bar{b}_i) = \beta_i + \sum_{k=1}^{L} r_{i,k}\, \beta_k$$

[1]As evidenced by a low R^2.

[2]Therefore, it would be sufficient in the context to be satisfied that the estimator of this coefficient is best linear unbiased.

[3]This point and the demonstration in the rest of the paragraph follow the exposition in Theil (1957) pp.41-51. Also see Griliches (1957).

where:

β_i is the coefficient of the i^{th} variable in the true relationship,

$\bar{b}_i$ is the estimated coefficient of the i^{th} variable which is included in the specification.

$r_{i,k}$ is the regression coefficient of the k^{th} excluded variable obtained by regressing the i^{th} included variable on all L excluded variables.

β_k is the coefficient of the k^{th} variable, which is in the true specification but omitted from the estimating equation.

The conclusion is that the greater the correlation of the excluded variables with an included variable, and the greater the importance of the excluded variable in determining crop yields (as evidenced by the relative size of β_k), the greater is the contribution to the bias of the estimated coefficient of the i^{th} variable.[1]

Agricultural economics theory suggests that the labor input to three major sets of operations are crucial in the African context to the total output of storable grain off a given field (Collinson, 1972, pp. 219-223). These are labor flows to seedbed preparation, weeding, and harvesting and processing. These data are available from the farm management survey, therefore the proposed specification for the estimating equation is:

$$Y_{ij} = f\ (X_1,\ X_2,\ X_3,\ X_4)$$

where:

Y_{ij} is the output of the i^{th} crop in the j^{th} crop mixture on a given field;

X_1 represents the labor hours devoted to seedbed preparation on the field in question;

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[1] If the included variables are also collinear, it follows that estimated coefficients of all the included variables are biased by the exclusion of a relevant variable correlated with one of them.

X_2 represents the labor hours devoted to weeding;

X_3 represents the labor hours devoted to harvesting and processing;

X_4 is the area of the field.

A glance shows that the included variables are likely to be correlated with the excluded variables suggested by the section on secondary evidence. In particular, weeding labor input is likely to be highly positively correlated with soil fertility, the presence in the area of plant parasites (which are weeds), and a desirable distribution of rainfall. This implies that the $r_{i,k}$ in the bias expression developed above are positive and relatively large. The β_k in the same expression, which represent the influence of the excluded variables on crop yields, are of mixed sign. As soil fertility and an index representing a favorable distribution of rainfall increase, so do crop yields. But yields decrease with an increased presence of plant parasites, thus the β in this case is negative. It follows that in two cases the products of r and β are positive and in the third, it is negative. The summation of the products, which represents the bias in the estimator for the weeding coefficient, is of indeterminate sign. To the extent that the correlation between weeding labor and the presence of <u>striga</u> is very high ($r_{ik} >> 0$) and that <u>striga</u> reduces yields very significantly ($\beta_k << 0$), it is quite possible that the net bias introduced on the weeding coefficient by omitted variables is downwards.

Another problem in the estimation of a production function for millet is that of measurement error in the explanatory variables. To the extent that error is present in any of the right variables, the ordinary least squares (OLS) estimators are biased and inconsistent. Johnston (1972, pp. 281-83) shows that the asymptotic bias of OLS estimators under these conditions is given by:

$$\text{plim } \hat{\beta} - \beta = - \text{plim } \left(\frac{1}{N} X'X\right)^{-1} \cdot \text{plim } \left(\frac{1}{N} V'V\right) \beta$$

where:

$\hat{\beta}$ is a k x 1 vector of OLS coefficients;

β is the vector of true coefficients;

X is the data set used;

V is the matrix of measurement errors included in X;

U is the vector of well-behaved disturbance terms present in the model without measurement error and plim $(\frac{1}{N} X' U) = 0$.

The result is even stronger in the two variable case, where the probability limit of $\hat{\beta}$ can be written (Johnston, 1972, p. 282):

$$\text{plim } \hat{\beta} = \frac{\beta}{1 + \theta^2_v / \theta^2_z}$$

where:

θ^2_v is the variance of the measurement error;

θ^2_z is the variance of the correctly measured variables and $E\ (uv^1) = 0$

The : plication is that if:

$$\beta > 0 \quad \text{then plim } \hat{\beta} < \beta$$

and

$$\beta < 0 \quad \text{then plim } \hat{\beta} > \beta$$

Thus, in the two variable case, the result of measurement error is to bias the estimated coefficient towards zero.

A further problem in the estimation of a production function for food grains in Tenkodogo is that the included explanatory variables are highly collinear among themselves. A high amount of seedbed preparation labor is likely to be associated with a high amount of weeding labor. This is likely to be the case even after allowances are made for the fact that large fields require more of each kind of labor than small fields. If the farmer is willing to spend a longer time preparing a seedbed, it is likely that he will weed it carefully. If theory is correct, a high labor input to weeding will result in a larger harvest, thus increasing the amount of labor required for harvesting and processing. Correlation coefficients of the order of .5 were found between the three labor variables when undeflated by field size. After dividing the data by the size of the field concerned to compensate for scale effects, the correlation coefficients were of the order of .35.

The existence of multicollinearity within the independent variables greatly reduces the precision of estimation (Johnston, 1972, p. 160). More specifically, the sampling variances of the coefficients will be quite large, leading to difficulties in making statistical inferences about the estimates. Moreover, the estimates themselves may be quite erroneous, for the same reason.

The conclusion of this subsection is that there are serious problems in using production function analysis in this context to support the hypothesis that July weeding is a crucial determinant of crop yields. For the sake of completeness, the usual production function exercise will be briefly presented in the next two subsections. These results should be carefully interpreted in the light of the discussion above.

Specification of the Estimating Equations.-- This subsection discusses the major properties of the functional form used for estimation and the rationale behind the choice. The use of dummy variables in pooling Mossi and Bisa observations is also examined briefly, as is the use of yield plot data as an alternative to the farmer recall of field output.

Two simple linear specifications are selected for estimation of the production functions for millet. The use of the linear format implicitly assumes that the marginal product of each resource is constant. This specification is also characterized by constant returns to scale and a constant elasticity of substitution of one resource for another in production equal to the ratio of their marginal products.

Clearly, the marginal product of labor will decline as the amount of labor is increased relative to land. The rationale for using a simple linear function is that it is a close enough approximation to the true (nonlinear) production function over the range of resource values in the data set, which are the only values that matter for the purposes here. A further justification for the simple specification is that a priori theory does not indicate what nonlinear form would be appropriate. Experiments using a Cobb-Douglas-type multiplicative relationship yielded appreciably poorer results.[1] Finally, the objective of the exercise is sufficiently limited to preclude the effort required by a more sophisticated approach.

Two sets of regressions were run for the millet produced on Mossi and Bisa fields using the recall duty. The first specification is:

$$Y_i = d_1 + d_2 + \beta_1 X_{1_i} + \beta_2 X_{2_i} + \beta_3 X_{3_i} + \beta_4 X_{4_i} + \Sigma_i$$

where:

d_1 and d_2 are zero-one dummy variables for Bisa and Mossi fields respectively;

Y_i is the total yield of millet on the i^{th} field, expressed in kilograms of dry storable grain;

X_{1_i} are the total labor hours devoted to seedbed preparation on field i;

X_{2_i} are the total labor hours devoted to weeding and ridging field i;

X_{3_i} are the total labor hours devoted to harvesting and processing the output of field i;

X_{4_i} is the area of field i in hectares;

Σ_i is the unknown error term.

The second specification is:

$$Y_i = d_1 + d_2 + \beta_1 X_{1_i} + \beta X_{4_i} + \beta_5 X_{5_i} + \beta_6 X_{6_i} + \Sigma_i$$

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[1]With respect to the goodness-of-fit as measured by R^2 or the size of the sampling variances of the coefficients.

where:

X_5 are the total labor hours allocated to field i in fortnights 5 and 6 (4 - 13 July 1976);

X_6 are the total labor hours allocated to field i in fortnights 14 and 15 (7 November to 4 December, 1976).

Since almost the entire labor input to fields in July is weeding, and similarly for harvesting in November, X_5 and X_6 are good proxies for July weeding labor and November harvesting labor respectively.

Dummy variables were used to distinguish shift effects between Bisa and Mossi fields. Each regression was re-run using a single constant term representing the linear restriction that the two dummy variables were added together. Chow tests on the significance of the restriction (see chapter 5, page 148) indicated that the null hypothesis of no difference between Mossi and Bisa intercepts could be comfortably rejected at the 95 percent confidence level. This was true in every case.

The equations were run separately for Mossi and Bisa fields, where permitted by a large number of degrees of freedom. This produced significantly better results for the crop mixture of millet and cowpeas than was the case for millet fields intercropped with sorghum and cowpeas.[1] The most likely explanation for this is that there are inter-village differences in the influences of the unobserved variables affecting production on millet and cowpea fields in Oueguedo and Loanga. These plots are concentrated on in-village and bush land and are thus further from the center of the village than house fields. Millet, sorghum and cowpeas, however, are intercropped on the latter. The pooled data for Loanga and Oueguedo gave estimates that were little different from the separate regressions in this case.

For completeness, both specifications are re-run using yield plot data. The disadvantage of this form of yield information is the suspected upward bias of results. There are also a relatively limited number of yield plot measurements on comparable fields, leading to a restricted

[1]In terms of a noticeably higher R^2, more plausible coefficients, and reduced sampling variances of the coefficients.

number of degrees of freedom in estimation. On the other hand, the advantage of yield plot data is that a fairly uniform procedure was applied in measuring the harvest off each yield plot. Thus, even if there is a uniform upward bias in results, the variation between fields is attributable primarily to the determinants of crop yields, as opposed to varying degrees of accuracy in recalling what was harvested off the fields. As was pointed out in the first section of this chapter, a major problem with the recall data on output is that the way the data is established introduces an extra element of measurement error. Since the yield data is the dependent variable and the measurement error is random, the effect on the recall data production functions will be to increase the random error term for each observation, leading to a lower R^2 for the regression.[1] Therefore, regressions using yield plot data are likely to have a higher R^2 than those using recall data.

The Regression Results.-- The regression results were generally disappointing, which is hardly surprising given the caveats expressed in the two preceding subsections. Recall and yield plot specifications gave quite different estimates. As predicted, the recall method leads to a relatively low goodness-of-fit, as measured by R^2. The two data sets are equally equivocal about the role of weeding as a determinant of yields, which may be ascribed primarily to the specification and multicollinearity problems examined above. The use of July and November labor, as opposed to total labor spent weeding and harvesting, did not provide a noticeable improvement in results. Trials using total labor input to each field as an explanatory variable, in lieu of the separate time and task labor figures, lead to estimated equations with very poor fits (R^2 = .1). For brevity of exposition, these have not been included with the other results, which are displayed in Tables 7.7 and 7.8.

The hypothesis that weeding labor is a significant determinant of yields is best supported by the first two equations in Table 7.7 based on recall and yield plot data, respectively. If interpreted at face

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[1]Without violating the Gauss-Markov assumptions, however. Therefore, O.L.S. retains its best linear unbiased properties in the absence of other complications (Johnston, 1972, p. 281).

TABLE 7.7

PRODUCTION FUNCTION REGRESSIONS USING LABOR EXPLANATORY VARIABLES BY TASK

Equations[a]	Coefficients[b] (t-statistics in brackets)						
	$\hat{\beta}_{o\beta}$	$\hat{\beta}_{oM}$	$\hat{\beta}_1$	$\hat{\beta}_2$ (weeding)	$\hat{\beta}_3$	$\hat{\beta}_4$	R^2
$y_1 = \beta_{o\beta} + \beta_{oM} + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$	70.355	-4.624	-.306	.078	.458	-5.290	.59
N=89 t-statistics:	(5.530)	(-.390)	(-3.546)	(2.949)	(4.916)	(-.367)	
y_2= (same)	34.782	-59.151	.415	.032	.093	262.61	.93
N=24	(1.133)	(-1.644)	(2.463)	(.486)	(.482)	(7.364)	
y_3= (same)	136.70	-4.220	0.071	-.028	.546	17.300	.50
N=87	(9.605)	(-.214)	(.948)	(-1.122)	(4.337)	(2.036)	
y_4= (same)	59.548	11.625	.231	-.087	.224	274.86	.87
N=19	(1.507)	(.143)	(.976)	(-1.519)	(.491)	(3.996)	
$y_3 = \beta_{o\beta} + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$	36.020		.105	-.046	1.596	24.210	.62
N=48	(1.578)		(.473)	(-1.281)	(7.607)	(2.742)	
$y_3 = \beta_{oM} + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$		25.307	.066	.020	.042	34.448	.65
N=39		(2.202)	(1.414)	(1.036)	(.447)	(3.023)	

NOTES: [a]The y_i represent the following yields of millet in kilograms per hectare:

y_1: intercropped with sorghum and cowpeas (recall data)

y_2: intercropped with sorghum and cowpeas (yield plot data)

y_3: intercropped with cowpeas (recall data)

y_4: intercropped with cowpeas (yield plot data)

[b]The X_i represent the following variables:

$X_{o\beta}$: zero-one dummy-Bisa household=1

X_{oM}: zero-one dummy-Mossi household=1

X_1 : seed bed preparation in hours

X_2 : weeding labor in hours

X_3 : harvesting and processing labor in hours

X_4 : area of field in hectares

TABLE 7.8

PRODUCTION FUNCTION REGRESSIONS USING LABOR EXPLANATORY VARIABLES BY TIME PERIOD

Equations:[a]	Coefficients[b] (t-statistics in brackets)						
	$\hat{\beta}_{o\beta}$	$\hat{\beta}_{oM}$	$\hat{\beta}_1$	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\beta}_6$	R^2
$y_1 = \hat{\beta}_{o\beta} + \hat{\beta}_{oM} + \hat{\beta}_1 X_1 + \hat{\beta}_4 X_4 + \hat{\beta}_5 X_5 + \hat{\beta}_6 X_6$	65.753	1.671	-.119	6.201	.134	.897	.58
N=80 t-statistics:	(4.798)	(.127)	(-1.484)	(.393)	(2.160)	(5.823)	
y_2= (same) N=18	73.540	-95.327	.577	299.82	-.088	-.203	.94
	(1.816)	(-1.324)	(3.833)	(7.112)	(-.510)	(-.619)	
y_3= (same) N=53	174.98	19.986	.108	4.911	.0004	.487	.47
	(9.106)	(.746)	(1.249)	(.260)	(.007)	(2.711)	
y_4= (same) N=17	72.586	52.909	.337	225.01	-.173	.340	.87
	(1.727)	(.614)	(1.549)	(3.713)	(-1.197)	(.887)	

NOTES: [a]The y_i represent the following yields of millet in kilograms per hectare:

y_1: intercropped with sorghum and cowpeas (recall data)

y_2: intercropped with sorghum and cowpeas (yield plot data)

y_3: intercropped with cowpeas (recall data)

y_4: intercropped with cowpeas (yield plot data)

[b]The X_i represent the following variables:

$X_{o\beta}$: zero-one dummy-Bisa households = 1

X_{oM}: zero-one dummy-Mossi households = 1

X_1 : seedbed preparation in hours

X_4 : area of field in hectares

X_5 : labor supplied to field from 4 to 31 July 1976 (= fortnights 5 & 6) in hours

X_6 : labor supplied to field from 7 November to 4 December 1976 (= fortnights 14 & 15) in hours.

value, the results indicate that the marginal product of an hour's weeding is between .03 and .08 kilograms of millet grain or distressingly close to zero. Translated into cash values at harvest time prices, these figures yield a marginal value product on the order of 2 CFA per hour of work. This may be compared with an approximate rainy season wage rate of 40 CFA per hour for unskilled agricultural labor.

The first equation in Table 7.8 gives a similar result for regressions using time periods. The marginal product of an hour's extra labor in July is estimated at 0.134 kg. of millet (approximately 5 CFA per hour at harvest prices). These low figures most likely reflect the effect of the omitted variables that are collinear with included variables.

Another explanation of the low weeding and/or July labor coefficient is to be found in the 1976 weather. The construction of humps of earth about fifteen inches high around each millet stalk is an essential and time-consuming part of the weeding of cereals in late July. The operation is designed to prevent the plant from falling over during storms and to keep the protective cover of earth around the roots from being washed away by the typically heavy rains in August. The very sparse rains and sunny weather in August 1976 greatly reduced the production value of these precautions. Perhaps the most valid conclusion is that extreme caution should be exercised when interpreting the results of production functions based on one year's data from West African rainfed agriculture.

The Evaluation of Farm Crop Output

This section presents and discusses price data for crops sold on the Tenkodogo market during 1976 with a view to deriving a set of parameters for evaluating the total crop production of an average sample farm. Market harvest prices are used for this purpose because they are relatively low from a seasonal view point. It is difficult to distinguish farm gate from rural market consumer prices for items other than food grains, since farmers or their families often sell their produce in small quantities directly to the consumer in the market place. There is a distinct wholesale price for millet sold by the 100 kg. sack. The evidence points to seasonal fluctuations of between 100 and 200 percent in food grain prices, which may mean that harvest figures seriously understate the value of food grains to the farmer. The prices are deliberately chosen on the conservative (low) side in order to favor cattle in a comparison between crops and livestock. An average value for total crop production of approximately 112,000 CFA is calculated, using detailed data on average plantings and average yields. Cowpeas, surprisingly, account for forty percent of the value of crop output, with millet running second at thirty percent. This situation appears to be the result of atypical weather conditions which favored record cowpea and poor millet yields. Comparison of the value of total crop production in Tenkodogo in 1976 with adjusted estimates of the sources of farm income in 1973 for the nearby Zorgho area indicates that less than eleven percent of the average Mossi household crop output is sold. Estimates derived from the Zorgho data also indicate that animal products account for approximately one fifth the sales of on-farm agricultural produce.

The Use of Market Prices for Evaluating Crop Output.-- The purpose of putting a money value on total farm production, sold or consumed *in situ*, is to permit the comparison of different output packages. In the context of the objectives of this study, the prices chosen play a crucial role by fixing the value of crop production vis-à-vis the expected stream of benefits from livestock production. The choice is complicated by a high degree of seasonal and spatial price variation, in addition to secular inflation.

For the most part, this study will use the harvest time consumer prices prevailing in Tenkodogo market, and for four reasons. First, farmers or their wives in the area often sell their produce directly to the consumer at these rates. On the other hand, a well-established wholesale price of millet and sorghum exists in the area, and will be used for evaluating these two products which are virtually the only crops to be regularly sold in 100 kg. sacks.[1] Second, harvest-time

[1]Peanuts and cowpeas are also sold this way, but in relatively small quantities.

prices are minimum prices. As will be demonstrated below, it is not unusual for crop values to double as the new growing season gets under way and stocks from the old harvest dwindle. Any conclusions from the linear programming favorable to crop raising, as opposed to stockraising, are strengthened by having used relatively low crop prices in the analysis. Higher actual prices would only serve to confirm the results. Third, hard data exist for 1976 harvest time market prices in Tenkodogo, checked by the author. Published data on Voltaic prices are dubious. One can often find very different estimates of the same parameter in two different government reports.[1] Fourth, both sample villages have easy access to Tenkodogo market, which occurs every three days. Farmers can exchange their produce at the harvest time ratios if they so desire, making these values the appropriate standard of comparison between two crop bundles.

Tenkodogo 1976 Market Prices in Perspective.-- This subsection discusses the price data available, presents estimates of the proper 1976 harvest market prices for evaluating the crops produced by sample members, and cites evidence that there is a very high degree of variation over seasons of the price of the staple food grain, millet.

Monthly price data pertaining to Tenkodogo market are available for 1976. The figures used here were supplied by the field office of the ORD.[2] Monthly data for 1974 and 1975 were not accessible, since the original interview sheets had been destroyed and the author was not able to locate the reports containing the synthesis of information. The ORD data refer

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[1]Traders sell by units of volume rather than weight. Price variation is often manifested by a reduced volume sold for a constant price. These elements are ignored by the O.R.D. statistical services which use a constant conversion factor for units of volume to kilograms.

[2]The author collected two series from the ORD office. One was in "plats," a local unit of volume and one in "tines," supposedly equal to seven "plats." The two series gave different results when translated into kilograms using the conversion factors suggested by the field office. The most likely explanation for this is the reduction by sellers of the weight of grain per "plat." (See previous footnote). The estimates used here are from the series in "tines." The author has reasonable confidence that the estimates for the months subsequent to his arrival in April are, if anything, slightly on the low side.

only to the more important crops in the region: millet, red sorghum, cowpeas, rice, and peanuts. Estimates of the per kilogram price for secondary crops were obtained by an enumerator who weighed his own shopping and averaged the results for three markets each in April and December.[1] The mean over five years of the average annual price of each crop on Ouagadougou market was computed from figures for 1969 through 1974, for comparative purposes.[2]

The primary crops grown in the research area in 1976 were harvested from late September through November. The maximum impact of the harvest on prices occurred around December. Average prices for this month are taken as the harvest prices of primary crops. Where possible, it is desirable to take the set of harvest prices from one month since this ensures that crops can be exchanged for each other at these ratios. December is also the first time after the harvest when farmers have sufficient leisure to spend much time going to market. Table 7.9 presents estimates of the average monthly price of each crop on Tenkodogo market during 1976.

One of the striking aspects of Table 7.9 is the high seasonal variation of millet prices, which are 2 1/2 times higher in August than in January of the same year. The August 1977 price of millet in Tenkodogo was nearly three times as high as the December 1976 price of 34 CFA per kg.[3] This is not a phenomenon limited to either 1976 or Tenkodogo. Data for Ouagadougou and seventeen rural markets spread over the period 1962 to 1976 indicate a mean percentage increase of the maximum over the minimum millet price of ninety percent within a given year (C.R.E.D., 1977, II UV, p. 54). Table 7.10 presents some of this information for Ouagadougou and Tenkodogo. Figure 7.1 portrays the monthly variation of millet prices for three years in Tenkodogo.

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[1]The relative unimportance of these secondary crops in average sample farm plantings precluded devoting resources to a more regular sampling. The results obtained were consistent with the author's experience.

[2]1974 is the last year for which published information is available at the time of writing.

[3]Based on an average price of 9,500 CFA per sack reported by an enumerator still resident in Tenkodogo.

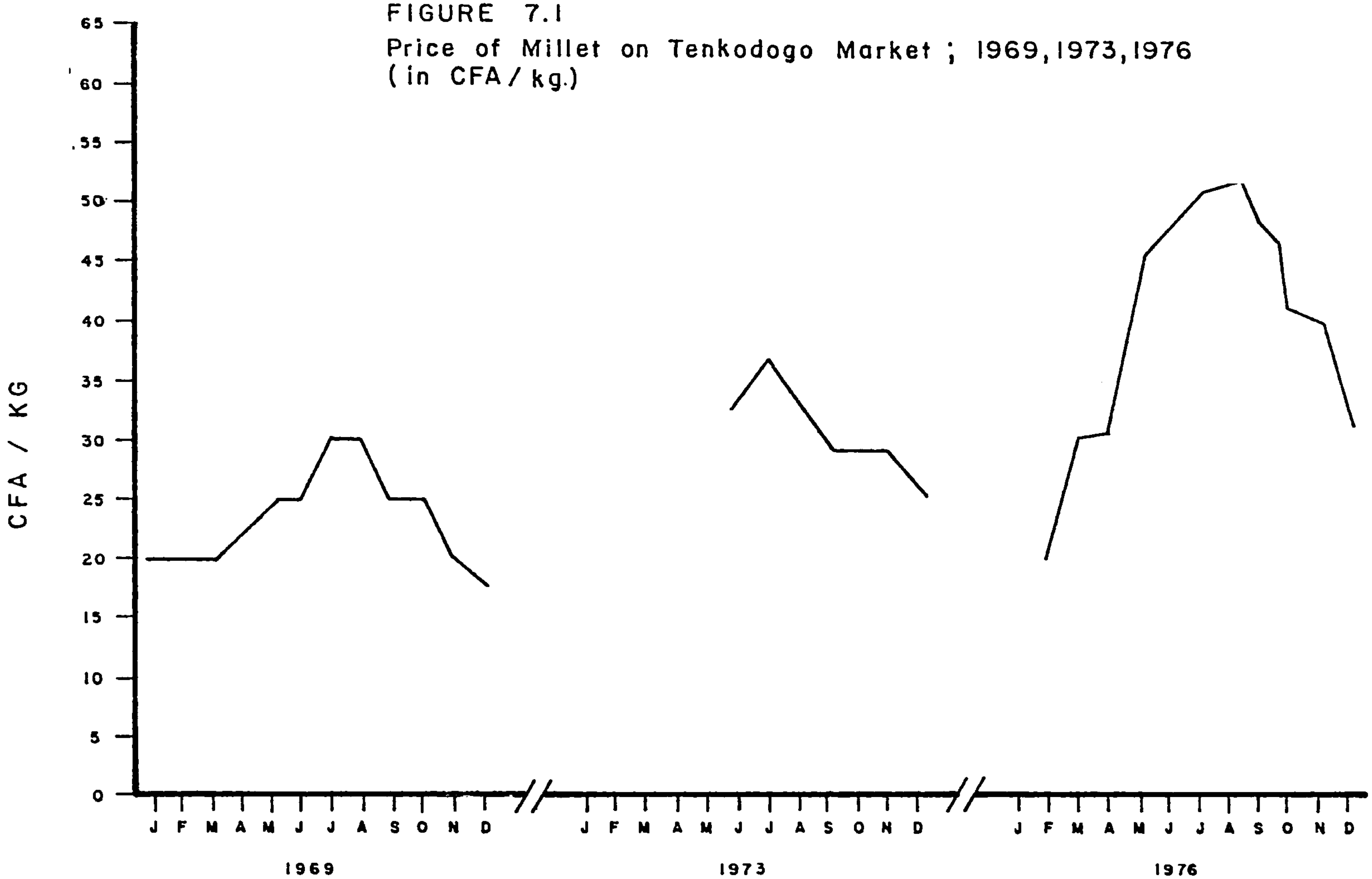
TABLE 7.9

MONTHLY PRICE OF PRIMARY CROPS IN THE TENKODOGO MARKET, 1976[a]

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.[b]	1976 Avg.	S.D.
Millet[c]	21	27	34	40	45	48	51	52	48	42	40	34	40	9.7
Red Sorghum[c]	20	27	33	40	42	41	44	49	45	31	25	19	35	10.2
Cowpeas	21	26	30	35	35	35	42	44	42	31	26	21	32	7.9
Rice, Paddy	43	45	48	50	50	50	53	55	55	50	50	50	50	3.5
Rice, Husked	71	77	83	89	89	89	97	98	98	106	98	92	91	9.9
Peanuts	45	49	53	57	57	57	61	72	53	49	47	46	54	7.7

[a] Data from the O.R.D. field office.
[b] December prices can be taken as the harvest time prices.
[c] Based on the 100 kg. wholesale sack price.
Other crops are usually sold in smaller units.

FIGURE 7.1
Price of Millet on Tenkodogo Market ; 1969, 1973, 1976
(in CFA / kg.)



Source: C.R.E.D. (1977), II UV, p. 32, 1976 figures for June — December have been amended.

TABLE 7.10

SEASONAL VARIATION IN MILLET PRICES IN PERSPECTIVE

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Mean Price of Millet in Ouagadougou within the Year[a]	27	20	28	32	40	41	60	58	44	51
(S.D.)	(3.2)	(4.0)	(5.3)	(3.5)	(6.5)	(8.0)	(13.0)	(12.6)	(11.9)	(10.3)
Maximum Price During the Year	22	16	19	26	30	27	34	36	25	36
Minimum Price During the Year	22	16	19	26	30	27	34	36	25	36
Mean Price of Millet in Tenkodogo within the Year			23				31[b]			37[c]
(S.D.)			(4.0)				(3.7)			(11.9)
Maximum Price			30				37			52
Minimum Price			18				26			21
Price Index for Traditional Foodstuffs in Ouagadougou[d]	119	111	135	142	149	149	181	209	--	--
Price Index for Gen. Consumption in Ouagadougou[d]	146	145	157	162	165	160	172	187	--	--

SOURCES: [a]C.R.E.D. (1977), II UV, p. 54
[b]for seven months June-Dec. only
[c]My data indicate that mean is 40, although it agrees with max. and min. for 1976 in source (a).
[d]from RHV, MDR, B.A.I.S.E. (1975)

Because the harvest price is usually the minimum price throughout the year, choosing the December rate as the standard value ensures that food grains are being considered at the minimum figure applicable. This is consistent with the policy adopted throughout this study, which is to make livestock as attractive as possible relative to food grains. Farmers, however, may well perceive the cost of food grains in terms of the maximum, rather than harvest time, value. This may explain cases where actual land allocation appears "uneconomic" when enterprises are evaluated solely in terms of harvest prices. This notion will be investigated further in the linear programming.

Table 7.11 gives the harvest price estimates for the secondary crops. The mean over the period 1969 to 1973 for Tenkodogo market is also given for comparative purposes. Onions and mangoes are primarily dry season crops, harvested in March and April. The estimates for the 1976 Tenkodogo harvest prices are purposely low, in keeping with the objectives of the study.

Table 7.12 summarizes the 1976 harvest price estimator for all crops grown by the sample members. Every crop for which there is distinct yield data is given an evaluating price, even if that crop is grown only in combination with other crops (such as cowpeas). Crop categories for which there are only joint yield estimates (such as wet season vegetables) are given a composite price of output, which is the simple average of the prices of crops in the mixture.[1] Price estimates exist for both paddy and husked rice, but a composite price is given. This is because sample members sell both varieties.[2] The composite price for "dry season vegetables" is one quarter of the average price per kilogram of onions and mangoes. Besides the heavy conservative bias in evaluating crop production, this is to leave a large margin for error in the judgement of yields per hectare of mangoes.

[1]This is tantamount to assuming that one third of the field space is devoted to each of the three crops grown in the category.

[2]There are small grain mills in both Ouegueda and Loanga. Otherwise, the wives thresh rice using mortar and pestle.

TABLE 7.11

HARVEST PRICES OF SECONDARY CROPS IN THE TENKODOGO MARKET, 1976
(All prices are in CFA/kg.)

Crop[a]	Month Following Harvest[b]	Tenkodogo 1976 Harvest Price[c]	1969-1973 Ouagadougou[d]	
			Avg. Price	(S.D.)
Maize	Sept.[e]	32	48	(13)
Cotton	Dec.	33	-	-
Tobacco	Dec.	200	329	(73)
Tomatoes	Dec.	45	77	(33)
Okra	Dec.	35	87	(17)
Pimento	Dec.	-	-	-
Onions	April	50	93	(13)
Mangoes	April	30	38	(7)
Cassava	Dec.	40	37	(11)
Sweet Potatoes	Dec.	50	-	-
Voandzeia S.	Dec.	20	59	(16)

SOURCES:

[a]Minor crops are defined as those which occupy less than one tenth of a hectare in the 1976 planting of the average sample farm.

[b]The month where the harvest has the maximum impact on prices.

[c]Averages for the month listed in b.

[d]For comparative purposes only, taken from RHV,MDR,B.A.I.S.E. (1975)

[e]Maize is harvested early to provide food in August through October, before the millet harvest is available.

TABLE 7.12

PRICES USED TO EVALUATE CROP PRODUCTION IN MAJOR CROP CATEGORIES, 1976

Individual Crop	Estimated Harvest Price for Tenkodogo In 1976 (CFA/kg.)[a]	Crop Category or Mixture[b]	Evaluation Price For Crop Category (CFA/kg.)[c]
Millet	34	Millet	34
Red Sorghum	19	Sorghum	19
Cowpeas	21	Cowpeas	21
Rice, paddy	50	Rice	71
Rice, husked	92		
Peanuts	46	Peanuts	46
Voandzeia S.	20	Other Groundnuts	20
Cassava	40	Starchy root crops	45
Sweet Potatoes	50		
Mangoes	30	Dry season fruit and vegetables	20[d]
Onions	50		
Tomatoes	45	Wet season vegetables	40[d]
Pimento	-		
Okra	35		
Maize	32	Maize	32
Cotton	33	Cotton	33
Tobacco	200	Tobacco	200

SOURCES:

[a]From Tables 7.9 and 7.11.

[b]These crop designations correspond to the most disaggregated categories for which separate yield data is available in Tables 7.1 through 7.5.

[c]In the case of composite crop categories, the prices are averaged except for d.

[d]See the text for explanation.

<u>The Value of Sample Farm 1976 Average Crop Output</u>.-- This subsection puts an approximate cash value on the crop output produced by an average farm. This information is of some interest, since the overall value of the production of an average farm is rarely known with accuracy. The results will be used in conjunction with the data from chapter six on cash incomes and livestock holdings to estimate total farm income, sold and unsold, in the next section. It is also useful to have a money value for crops actually produced by an average farm, in order to compare it with the "optimal" results indicated by the linear programming in the next chapter.

Crop income for 1976 is computed using the average areas of each crop cultivated from Table 5.11, the average yields from Tables 7.1 through 7.6, and the price vector given in Table 7.12. The calculations are displayed in Table 7.13. The resulting figure of 112,159 CFA is intended only for indicative purposes. It implicitly assumes that every farm obtained the average yield on each one of its fields.

The most surprising result is the high proportion of the value of crop production represented by cowpeas, which account for over forty percent. The cowpea harvest was exceptionally good in 1976, and many sample members stated that they would have to rely upon them for nourishment, given the poor performance of the more preferred millet. The latter accounts for nearly thirty percent of the value of production. The so-called cash crops of the area--peanuts, rice, cotton, and tobacco account--for a small proportion (twelve percent) of the value of output.

<u>Comparison with Estimates of Total Farm Income and Sales and Purchases</u>.-- This subsection will compare the estimate of the total value of 1976 crop output to estimates from an outside source of farm cash income and the sale and purchases of major items. Although information in these areas is inconclusive, the estimate of the total value of crop production appears to be consistent with the information from another study in the region referred to in chapter six which concentrated upon household budgets rather than production relationships (O.R.S.T.O.M., 1975, III). G. Ancy gathered expenditure and receipts data for 1973 in the Mossi areas of Upper Volta. His Zorgho subsample of twenty-six households is presumably similar to the farms found in the research area, as it is less than fifty

TABLE 7.13

COMPUTATION OF THE APPROXIMATE VALUE OF 1976 CROP OUTPUT FROM AN AVERAGE FARM IN THE SAMPLE

Individual Crop[a]	Crop Category[b]	Mean Household Area Cropped in Category[c] (ha.)	Average Yield[d] (kg./ha.)	Farm Output[e] (kg.)	Price[f] (CFA/kg.)	Value of Individual Crop in Mixture[g] (CFA)	Value of Average Field Area Under This Crop Category[h] (CFA)
Red sorghum	Sorghum, millet and cowpeas	.73[i]	584	426	19	8,094	27,514
Millet			343	250	34	8,500	
Cowpeas			713	520	21	10,920	
Millet	Millet and cowpeas	2.54	280	711	34	24,174	60,021
Cowpeas			672	1,707	21	35,847	
Rice	Rice	.19	561	107	71	7,597	7,597
Peanuts	Groundnuts	.27	346	93	46	4,278	5,258
<u>Voandzeia S.</u>			180	49	20	980	
Maize	Maize	.02	650	13	32	416	416
Cassava Sweet potatoes	Starchy root crops	.06	3,000	180	45	-	8,100
Mangoes Onions	Dry season fruit and vegetables	.01[j]	8,000	80	20	-	1,600
Tomatoes Pimento Okra	Wet season fruit and vegetables	.01[j]	4,000	40	40	-	1,600
Cotton Tobacco	Cotton and tobacco	.002	800	1.6	33	-	53
						<u>TOTAL</u>	112,159 CFA

SOURCES:

[a,b]Differences between the yields of crops grown on different types of land are dealt with by assuming that all sorghum is grown on house fields, that all millet and cowpeas without sorghum are grown on in-village and bush fields and that yield differences between the latter two are insignificant.

[c]From Table 5.11.

[d]From Tables 7.1 through 7.6.

[e] = (c) x (d)

[f]From Table 7.12.

[g] = (e) x (f)

[h] Σ(g) within crop category.

[i]Average area of house fields-average area of vegetables, maize, cotton and tobacco.

[j]Assumes same area cropped in vegetables over dry and wet seasons.

kilometers to the northwest of Oueguedo (<u>Ibid</u>. pp. 84-86).

The 1973 data are inflated into 1976 CFA using a rate of 7.4 percent annual increase in the price of agricultural commodities. This figure is obtained by calculating the annual rate of increase between 1967 and 1974 in the official index of the cost of traditional (low-income) foodstuffs in Ouagadougou market (see Table 7.10).[1] The results of this adjustment on the figures implied by Ancey's data[2] are displayed in Table 7.14.

Columns three and five contain the final expenditures on and receipts from each major item. Commercial activity, intermediate purchases, and receipts have been netted out, such that the column of final receipts (number five) indicates the value of farm-produced items sold. Intermediate purchases and commercial margins are added to column five to obtain total receipts in column one. The total in column five added to commercial margins (1,946 CFA, not shown) gives the net farm cash income in 1976 CFA (35,122 CFA).

The sum of the first three cells in column five (12,739 CFA)--sales of raw and processed non-animal foodstuffs of farm origin--can be taken as the upper limit on crop sales, since part of this figure is attributable to processing labor. This implies that less than eleven percent of farm crop output is sold, if compared with the estimate of the total value of crop production of 112,159 CFA from the previous subsection.[3] Animal products--fish, eggs, poultry, red meat, and small livestock--account for approximately one fifth of the combined receipts from the

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[1]The figure of 7.4 percent is modest compared with the author's experience of prices between 1975 and 1977.

[2]The latter are given in percentages of absolute figures expressed in 1973 CFA.

[3]This result should be interpreted carefully, since the proportion of output sold is likely to be highly sensitive to the overall quantity produced as well as the relative prices between crops and other products. The two effects, however, offset each other somewhat, since in years with relatively low crop production we would expect higher relative prices; a rise in relative crop prices encourages sales and a reduction in quantity produced is likely to damage them, as farmers strive to feed their families.

TABLE 7.14

DATA FROM ZORGHO ON MOSSI SALES AND PURCHASES 1973[a]
(Expressed in 1976 CFA per annum)[b]

Item	Total Expenditure	Total Receipts	Total Expenditure (Total-Intermediate)	% of Total Final Expenditure[c]	Final Receipts (Total-Intermediate)	% of Total Final Receipts[c]
Total	42,182	47,207	30,099	(100%)	33,176	(100%)
Raw Foodstuff Except Animal Products	9,364	12,944	3,437	(11.4)	9,077	(27.4)
Processed Foodstuffs (e.g. Millet Cakes)	10,132	6,788	9,608	(31.9)	2,315	(7.0)
Non-Food, Local Semi-Processed (e.g. Tobacco)	1,421	1,577	1,295	(4.3)	1,347	(4.1)
Non-Food, Local Manufactured (e.g. Pottery)	928	1,539	810	(2.7)	1,091	(3.3)
Animal Products	4,011	3,375	4,196	(13.9)	3,380	(10.2)
Traditional Services (e.g. Healer)	114	0	112	(0.4)	0	(0)
Kola Nut	6,370	1,298	3,798	(12.6)	0	(0)
Manufactured or Imported Food (e.g. Salt)	3,184	1,039	2,296	(7.6)	0	(0)
Manufactured or Imported Non-Food (e.g. Matches)	5,369	2,332	3,732	(12.4)	0	(0)
Monetary Transfers (e.g. Pensions, Remittances from Migrants)	1,287	16,305	1,117	(3.7)	15,954	(48.1)

SOURCES: [a]1973 data from O.R.S.T.O.M. (1975) III, pp. 84-85. The data are averages from a sample of 26 Mossi households situated less than 50 kilometers northwest of the Tenkodogo research area.

[b]Using the average annual compounded rate of increase in the price of traditional foodstuffs in Ouagadougou 1967-1974, of 7.3% (see Table 7.10).

[c]Entries may not sum to 100 because of rounding error.

sale of agricultural products. They also account for less than one quarter of the purchases of agricultural products of local origin (column 3, cells 1,2,3,5).

Chapters four and five examined the availability and allocation of the principal factors of production, labor and land on sample farms. Chapter six dealt in part with capital as a factor of production and in part with livestock as an investment alternative for capital. This chapter was addressed to problems of measuring agricultural output from the production process. Armed with the building blocks supplied by the farm management survey, the next chapter will model the typical peasant farm in Tenkodogo with a view to investigating the optimal allocation of resources among different activities under the prevailing conditions.

CHAPTER 8

MODELLING THE PEASANT FARM IN TENKODOGO

This chapter discusses the construction of a linear programming agricultural production model of the peasant farm in Tenkodogo. The purpose is to describe all the constraints and revenue considerations affecting traditional smallholder agricultural production, in a manner amenable to simultaneous consideration. The underlying theory is that the optimizing framework of linear programming can help explain why farmers typically engage in some activities more than others, given the resource constraints they face, the particular desires they may have concerning production (such as on-farm self-sufficiency in food grains), and the desire to make the most of what they have. The latter is only an operational assumption of what follows. No contention is made that farmers are always profit maximizers. The point is that a demonstrated decrease in overall revenue incurred by engaging in a given activity offers at least a plausible explanation of why farmers in fact do not engage in this enterprise.

The highlights of the issues dealt with below are the choice of a representative model, the choice of activities and objective function coefficients, how to deal with nonagricultural work and leisure, the implicit capital or special resource constraints, and formalizing the behavioral hypothesis that farmers desire to be self-sufficient in food grains. The result is a model comprising eleven crop and three livestock enterprises. Chapter seven provides conservative objective function values for crops, while very optimistic coefficients for livestock are derived below. The net extra revenue accruing to keeping two head of cattle on-farm, as opposed to entrusting them to the Fulani, is set at 14,000 CFA. Farmers are considered to be unwilling to put less than 63 percent of their land holdings under crop combinations involving millet and sorghum.

Overview of the Basic Model

This section briefly discusses the structure of a representative farm model for Mossi and Bisa peasants in the Tenkodogo area. Averages of the household values for the forty-one sample farms provide the data. The basic model is a linear function containing fourteen farm enterprises, maximized subject to thirty-eight resource and production level linear constraints. Only agricultural activities are considered directly in the maximand. This is because social activity, necessary nonagricultural work, and domestic work are treated as parameters which require a fixed amount of time at different periods of the year. The amount of labor available for allocation among agricultural activities diminishes during the dry season. The individual components of the basic model are examined in detail in the next section, including the amount of time available each period for allocation among crop and livestock activities.

Building the Representative Farm Model.-- Following Weitz (1971, p. 62), the purpose of a farm-type model is to make separate detailed planning for each unit unnecessary, which requires data pertaining to a "representative" farm. The results from the linear programming should be general enough to be applied to as many farmers as possible. In any event, the crucial characteristics of the farming system in question should be made explicit, in order to clarify exactly to whom the results apply. As Collinson points out (1972, pp. 125-33):

> Five fields are important to analysis and planning using the representative farm technique in traditional agriculture, and they center on attributes likely to vary within the area [being surveyed].

These are cropping pattern, labor supply and use, the timing of labor use, scale of operation, and output, in addition to tribal affiliations and asset structure which are less likely to vary within the survey area (Ibid.).

Thus it is valid, in this view, to build a representative model applicable to farms which have similar attributes in these domains. Presumably, results would be general enough to apply to other farms sharing the same characteristics. The preceding chapters on labor, land, capital and livestock, and output have attempted to show that there is little difference between Mossi and Bisa sample members with respect to their farming practices. Thus the problem becomes to derive a model of a representative farm from the survey data of forty-one households in Tenkodogo. The results would then be valid for other farms with the same characteristics as those described in the previous chapters. The attributes most in evidence in this context are the absence of a high value upland cash crop, such as cotton,[1] the small size and dispersion of land holdings, the absence of purchasable fodder for animals, peak labor use in July and November, a common level of access to technology, and a high population density.

The obvious way of constructing a representative farm from the forty-one sample households is to average land holdings, fortnightly labor requirements, labor availability, and yields across sample units. The problem with this procedure is that it introduces aggregation bias, as Collinson (1972, p. 134) notes with an example pertaining to labor use:

> ...Interfarm differences in timing create different peak requirements on particular farms, which are damaged (sic) when averaged - and peaks on one farm are offset by relatively slack periods on another, so the whole labor profile is flattened.

The effect of "smoothing" labor peaks, in the context of this study, is to reduce the incidence and size of seasonal labor bottlenecks. The implication of using figures for a mean household, then, is to lower the opportunity cost of livestock in terms of foregone grain production. This is because this cost is incurred only as a result of the reallocation of labor during peak periods from crops to livestock. As peak labor requirements for crops are reduced, so is the opportunity cost of looking after cattle.

This study will use mean values derived from the sample of forty-one households to build a representative farm model, for two reasons. First,

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[1]The cotton grown in the research area is confined to only the most fertile patches.

the incorporation of assumptions tending to minimize the opportunity cost of on-farm livestock is consistent with the operational bias throughout the monograph -- if the results indicate that the opportunity cost of livestock activities is high, then these conclusions are only strengthened by underlying assumptions. Second, the circumstances do not indicate that the alternatives would be sufficiently more fruitful to justify the effort involved.[1] Thus the linear programming model used here is identical to the one obtained by constructing a separate tableau for each farm and then averaging each entry over the forty-one farms.

Structure of the Basic Agricultural Production Model.-- This subsection provides a brief overview of the structure of the basic linear programming model built from the data generated by the farm management survey. The objective of the exercise is to determine the pattern of land and labor allocation between crops and livestock which maximizes the (private) value of farm output. The maximand, or objective function, consists of a linear equation containing eleven crop and three livestock enterprises. Maximize:

$$R = \sum_{i=1}^{11} C_i X_i + \sum_{i=1}^{3} d_i Y_i$$

where:

C_i = the net cash revenue per hectare obtained from the i^{th} crop enterprise, expressed in CFA.

d_i = the net cash revenue obtained from the i^{th} livestock enterprise, expressed in CFA.

X_i = hectares of land allocated to the i^{th} crop enterprise.

Y_i = animals of the i^{th} variety: kept on the farm during year (the cattle enterprise represents two head.)

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[1] Collinson gives an alternative procedure for constructing a representative farm model, based on stratifying the sample according to, say, the timing of the peak period of labor use (1972, p. 136). Then, presumably, a composite peak profile would be built from the results for each strata. While there may be some value for data containing information from two separate seasons, this procedure does not appear to be worth the effort here. Furthermore, such an exercise performed on cross-sectional data may overstate the inflexibility of peak season labor requirements with respect to timing.

The objective function is maximized subject to a set of thirty-eight linear constraints. These consist of land constraints for each of four types of land, a labor constraint for each of twenty-six fortnights in the year, seven constraints on the maximum level of production permitted, and one minimum production level. The land constraints apply only to crop activities, since, by assumption, livestock is grazed on communal land; they are written:

$$\sum_{i=1}^{11} t_{ij} X_i \leq b_j \qquad j = 1, \ldots, 4,$$

where:

t_{ij} = 1 if the i^{th} crop can be planted on the j^{th} type of land.

= 0 otherwise (i.e. rice is only planted on lowland).

b_j = the area in hectares available of the j^{th} land type.

The labor constraints apply to both crops and livestock, and are represented by:

$$\sum_{i-1}^{11} v_{ij} X_i + \sum_{i=1}^{3} m_{ij} Y_i \leq f_j \qquad j = 1, \ldots, 26,$$

where:

v_{ij} = the number of hours required by the i^{th} crop enterprise in the j^{th} fortnight, in order to produce one hectare of each crop

m_{ij} = the number of hours required in the j^{th} fortnight by the i^{th} livestock activity in order to maintain one animal (or pair of animals in the case of steers)

f_j = the total number of hours of labor time available to the household in fortnight j.

The constraints on the maximum levels of output in fact reflect that some scarce factor of production other than labor and land is required by the enterprise concerned. These are written:

$$\sum_{i=1}^{11} r_{ij} X_i + \sum_{i=1}^{3} s_{ij} U_i \leq G_j \quad j = 1, \ldots, 7,$$

where:

r_{ij} = 1 if there is an area limit on the i^{th} crop
= 0, otherwise

s_{ij} = 1 if there is a limit on the number of animals of the i^{th} type that can be kept.
= 0, otherwise

G_j = the maximum levels of the j^{th} enterprise or combination of enterprises.

and:

$r_{ij} = 0$ if $s_{ij} = 1$

$s_{ij} = 0$ if $r_{ij} = 1$ for all i, j.

The one minimum constraint concerns the principal food grain, millet. It ensures that a minimum area of farm land (h) is put under millet cultivation:

$$\sum_{i=1}^{11} n_i X_i \leq h$$

where:

n_i = 1 if X_i is a crop combination including millet.
= 0, otherwise.

Finally, there is the usual set of nonnegativity conditions:

$X_i \leq 0$

$Y_i \leq$ for all i.

The basic model does not incorporate direct activity interactions where pursuing one activity increases the value of another. An example of this would be the boost in yields from the extra manure available from keeping cattle on the farm. For methodological simplicity, this element is incorporated directly into the objective function value of cattle as a cash return to that enterprise. Another pertinent example would be the effect on labor requirements and yields of crops from using animal traction, made possible by keeping cattle on the farm. This question will be dealt with in detail in chapter ten, which extends the methodology used here and in chapter nine.

Capital is not dealt with explicitly as a resource to be allocated among activities, for three reasons. First, as was seen in chapter six, sample members used virtually no purchased inputs in agricultural activities. Second, the maximum production constraints serve the same purpose as a capital constraint in cases relating to specific activities. The maximum area that can be put under dry season vegetables is an example: the constraint effectively limits production to the area that can be sustained by hand irrigation. If owning a pump ever becomes an option for the peasant--both in terms of physical availability and financial affordability--then this assumption may have to be revised. For the time being, the assumptions made are consistent with the objective of a generally applicable model. Third, a capital constraint would most likely operate on livestock activities. The objective of the exercise is to show that labor constraints alone preclude keeping cattle; to the extent that this is the case, a capital constraint on livestock would be redundant.

The tableau of the basic model (I) is displayed in Table 8.1. Activities (or enterprises) run across the top of the table. The objective function values (c_i, d_i) are found directly below the activity labels. The column furthest to the left gives the labels of each resource used or other constraint imposed on production. The figures immediately to the right of these labels are the levels of resource supplies (b_j, f_j) or production levels (g_j) which cannot be exceeded. The last element in the column is the minimum food grain constraint which states that at least 2.43 hectares of land must be planted with some combination involving millet. The figures in the body of the table are the input-output coefficients corresponding to t_{ij}, v_{ij}, m_{ij}, r_{ij}, s_{ij}, n_i, mentioned above. Table 8.2 gives the key to each of the labels in the model.

Activities and Objective Function Values

This section discusses the crop and livestock enterprises offered by the model as farm production alternatives. The nature, scale, and underlying assumptions of each activity are examined. The derived objective function values for one hectare of each crop enterprise are generally conservative. However, they are based on careful microeconomic research. The estimated coefficients for livestock activities tend to be on the high side. This is especially true for cattle, which has an intentionally over-optimistic estimate of net revenue for a two animal enterprise. The purpose is to give small-unit cattle fattening operations a fair chance of being chosen by optimal programs. The estimate for sheep and goats is intuitively plausible, but based on a relatively small amount of information. The coefficient for swine represents the author's best guess given a lack of suitable data. The considerations underlying the choice of labor requirements for each activity and discussions of the sensitivity of results to the chosen coefficients are reserved for later in the chapter.

Crop Activities and Objective Function Values.-- This subsection examines the possibilities permitted by the model for choices among crops and the derivation of the objective function coefficients for crop enterprises.

The choice of possible crop activities is determined by what mixtures are typically grown on the four varieties of land identified in chapter five. Sorghum requires land that is both well drained and relatively high in organic content. This essentially limits sorghum cultivation to house land during the rainy season. Sorghum is typically intercropped with millet and cowpeas. Vegetables, maize, and cotton and tobacco are also limited to house land during the wet season, since in-village land is not sufficiently rich in nutrients and lowland is flooded. Bush fields are usually less fertile than house land and too far from the compound for the adequate care and supervision of high labor input, high value crops. Thus, available supplies of house land can be allocated to some combination of millet, sorghum and cowpeas, wet season vegetables, maize, or cotton and tobacco.

TABLE 8.1

TENKODOGO FARM LINEAR PROGRAM MODEL I

			HOUSMS 37,700	WET VEG 145,000	MAIZE 20,800	CTNTBC 93,200	INVGNUT 19,500	INVGMCP 23,600	RICE 39,800	ROOTS 135,000	DRY VEG 145,000	BUSHMCP 23,000	BUSHNUT 37,700	SHPGOAT 1,100	PIG 1,750	2 STEERS 14,000
HOUSLD	0.75	≥	1	1	1	1	0	0	0	0	0	0	0	0	0	0
INVGLD	1.71	≥	0	0	0	0	1	1	0	0	0	0	0	0	0	0
LOWLD	0.29	≥	0	0	0	0	0	0	1	1	1	0	0	0	0	0
BUSHLD	1.10	≥	0	0	0	0	0	0	0	0	0	1	1	0	0	0
LABOR 1	556	≥	134	0	0	0	0	134	22	1	0	141	0	8	3	84
2	556	≥	170	0	280	0	115	170	204	26	0	179	121	8	2	84
3	556	≥	159	0	549	0	174	159	264	0	0	167	188	6	4	105
4	556	≥	172	0	119	0	109	172	327	10	0	181	114	6	9	105
5	556	≥	146	53	589	67	216	146	380	16	0	153	227	6	12	105
6	556	≥	157	6	392	6	293	157	355	91	0	165	308	6	6	105
7	556	≥	105	231	200	293	142	105	283	259	0	110	149	6	7	105
8	556	≥	86	875	38	1,100	102	86	171	256	0	90	107	6	6	105
9	556	≥	85	88	74	88	29	85	31	42	0	89	30	6	10	105
10	556	≥	27	277	0	10	17	27	40	66	0	28	18	6	8	105
11	556	≥	5	235	0	264	22	5	45	300	0	5	23	6	2	105
12	556	≥	28	201	0	88	106	28	127	313	0	29	111	6	11	105
13	556	≥	32	109	0	792	265	32	114	175	0	34	278	6	9	105
14	554	≥	176	0	0	378	329	176	194	101	78	185	345	6	13	105
15	556	≥	94	0	0	110	38	94	31	106	104	99	40	4	6	105
16	556	≥	8	0	0	1,144	3	8	4	98	174	8	3	4	8	105
17	556	≥	0	0	0	440	0	0	0	215	398	0	0	4	14	35
18	511	≥	0	0	0	220	0	0	0	118	454	0	0	4	9	35
19	505	≥	0	0	0	0	0	0	0	62	450	0	0	4	9	35
20	495	≥	0	0	0	0	0	0	0	30	335	0	0	4	7	35
21	450	≥	0	0	0	0	0	0	0	53	391	0	0	4	7	35
22	471	≥	0	0	0	0	0	0	0	20	416	0	0	5	9	35
23	425	≥	1	0	0	0	0	1	0	4	303	1	0	6	6	84
24	455	≥	3	0	0	0	0	3	0	0	386	3	0	7	2	84
25	424	≥	8	0	71	0	0	8	0	0	291	8	0	8	8	84
LABOR 26	368	≥	21	0	69	0	0	21	0	0	37	22	0	8	4	84
MAXMV	0.096	≥	0	1	1	0	0	0	0	0	0	0	0	0	0	0
MAXCT	0.244	≥	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MAXRT	0.19	≥	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MAXDV	0.06	≥	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MAXSG	20	≥	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MAXPG	10	≥	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MAXBO	1	≥	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MINFD	2.43	≤	1	0	0	0	0	1	0	0	0	1	0	0	0	0

TABLE 8.2

KEY TO LABELS IN THE BASIC TABLEAU

COMPONENT	LABEL	ITEM
Crop Enterprises	HOUSMS	Millet, Sorghum, and Cowpeas (Grown on HOUSLD)
	WET VEG	Wet Season Vegetables (Grown on HOUSLD)
	MAIZE	Maize (Grown on HOUSLD)
	CTNTBC	Cotton and Tobacco (Grown on HOUSLD)
	INVGNUT	In-Village Field Groundnuts (Grown on INVGLD)
	INVGMCP	In-Village Field Millet and Cowpeas (Grown on INVGLD)
	RICE	Rice (Grown on LOWLAND)
	ROOTS	Starchy Root Crops (Grown on LOW-LAND)
	DRY VEG	Dry Season Fruit and Vegetables (Grown on LOWLAND)
	BUSHMCP	Bush Field Millet and Cowpeas (Grown on BUSHLD)
	BUSHNUT	Bush Field Groundnuts (Grown on BUSHLD)
Livestock Enterprises	SHPGOAT	Sheep and Goats (1 Animal)
	PIG	Swine (1 Animal)
	2 STEERS	Adult Bullocks (2 Animals)
Land Resources	HOUSLD	House Field Land
	INVGLD	In-Village Field Land
	LOWLD	Lowland Fields
	BUSHLD	Bush Field Land
Labor Resources	LABOR 1 … LABOR 26	Labor each fortnight, beginning May 9, 1976 (for the conversion from fortnights to calendar dates, see Table 3.1 p. 74)

TABLE 8.2 (Cont.)

KEY TO LABELS IN THE BASIC TABLEAU

COMPONENT	LABEL	ITEM
Maximum Production Levels	MAXMV	Maximum house land area suitable for maize and wet season vegetables at the same time
	MAXCT	Maximum house land area suitable for cotton and tobacco
	MAXRT	Maximum lowland area suitable for starchy root crops during one season
	MAXDV	Maximum lowland area feasible for hand irrigation of dry season fruit and vegetables
	MAXSG	Maximum sheep and goats that can be kept using same labor coefficients and assumption of no land requirement
	MAXPG	Ibid. for swine
	MAXBO	Ibid. for cattle
Minimum Production Levels	MINFD	The minimum amount of farm land that households are willing to crop with millet

Following the actual practice of sample members, the use of in-village land in the model is restricted to either millet and cowpeas or groundnuts. Both of these crop mixtures grow well on the less fertile but well-drained upland soils. Crops which require a great deal of water, combined with soil which is high in organic content, are planted on lowland. These areas contain the only fields which permit the harvesting of crops well beyond the end of the rainy season since the water table is near the surface and hand irrigation is feasible. Therefore, lowland can be allocated in the model to rice, starchy root crops,[1] or dry season fruit and vegetables. Like in-village land, bush land is used only for millet and cowpeas and groundnuts.[2] Since the labor requirements for bush fields are slightly greater than for in-village fields because of travel time, they are considered as separate activities.

The net revenue from one hectare of each crop enterprise in the basic model is computed in Table 8.3 using price and yield data from the previous chapter. The prices refer to harvest time market prices in Tenkodogo, as reported in Table 7.12. The yields pertain to the average yields for individual crops within a given crop combination on a given type of land, as taken from Table 7.6. The results in Table 8.3 provide the coefficients for the crop enterprises in the linear program.

Livestock Activities.-- The basic model incorporates three livestock activities. These are raising sheep and goats, swine, and cattle. Poultry is not included because of the lack of suitable data on labor requirements. Furthermore, the principal constraint on increased poultry production in the tropics is most likely capital (Weitz, 1971, p. 63). In this context, poultry production is viewed as a residual activity dependent upon household wealth, and thus can properly be excluded from a model of smallholder land and labor allocation. A more complete model would also include donkeys and horses as an activity. This is not done here because of the lack of evidence as to the returns to this enterprise, as well as for

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[1] Cassava and sweet potatoes are typically planted in high ridges which keep the stalks and leaves above water level during the rainy season.

[2] Occasionally sorghum is grown on bush fields, but this is rare in Tenkodogo, and thus not considered in the model.

TABLE 8.3

COMPUTATION OF THE REVENUE FROM ONE HECTARE OF EACH CROP ENTERPRISE IN THE BASIC MODEL

(a) Crop Enterprise	(b) Individual Crop	(c) Land Type	(d) Average Yield (Kg./Ha.)	(e) Price (CFA/Kg.)	(f) Value of 1 Ha. Individual Crop (CFA/Ha.)	(g) Net Revenue from 1 Ha. of Crop Enterprise (CFA/Ha.)	(h) Enterprise Label
Red Sorghum,	Red Sorghum		584	19	11,096		
Millet and Cowpeas	Millet	House	343	34	11,662	37,700	HOUSMS
	Cowpeas	Land	713	21	14,973		
Wet Season	Tomatoes						
Vegetables	Pimento	"	4,000	40	160,000	145,000	WET VEG
	Okra						
Maize	Maize	"	650	32	20,800	20,800	MAIZE
Cotton and	Cotton	"	400	33	13,200		
Tobacco	Tobacco		400	200	80,000	93,200	CTNTBC
In-village	Peanuts	In-village	346	46	15,916	19,500	INVGNUT
Groundnuts	Voandzeia S.	Land	180	20	3,600		
In-village Millet	Millet	In-village	280	34	9,520	23,600	INVGMCP
and Cowpeas	Cowpeas	Land	672	21	14,112		
Rice	Rice	Lowland	561	71	39,831	39,800	RICE
Starchy Root	Cassava	"	3,000	45	135,000	135,000	ROOTS
Crops	Sweet Potatoes						
Dry Season Fruit	Mangoes	"	8,000	20	160,000	145,000	DRY VEG
and Vegetables	Oignons						
Bush Millet	Millet	Bush	273	34	9,282	23,000	BUSHMCP
and Cowpeas	Cowpeas	Land	652	21	13,692		
Bush Groundnuts	Peanuts	"	820	46	37,720	37,700	BUSHNUT

SOURCES:
(a) The basic unit for which labor, land and yield data are available.
(b) This covers virtually all crops grown by sample members.
(c) From the classification in chapter five.
(d) From chapter seven, Table 7.6, according to crop enterprise and land type.
(e) From chapter seven, Table 7.12.
(f) = (d) x (e)
(g) = sum of (f) within each crop enterprise
(h) at the head of Table 8.1
(i) Assumes that a maximum of 15,000 CFA per hectare is spent on seeds, insecticide, water buckets, hired help picking mangoes, etc. In fact, it is likely that much less than this is actually spent, since the use of purchased inputs is very low.

simplicity.

Sheep and goats are incorporated as a joint activity because of the relatively small size of the average household herd.[1] In more northerly areas of the Savannah and Sahel, these two activities should be separated. This is because household herds are likely to be larger, as are individual animals. The labor requirements for sheep and goats are slightly different, since the latter have a tendency to roam away from the village if not tethered. Swine are incorporated as a production alternative because of the attractiveness of keeping animals which survive well in the climate and which are such impressive converters of waste vegetable matter to saleable meat.[2]

The cattle activity included in the basic model is labeled as "2 STEERS." The labor requirements correspond to estimates for two head of cattle, male or female, excluding any milking labor. The objective function coefficient is set sufficiently high to cover either the case of two dairy cows or that of two bullocks kept for a combination of animal traction and growing out for sale at age six.[3] In the first interpretation, extra labor requirements for producing and marketing milk are ignored, which makes the activity seem more attractive than it really is. This is consistent with an operational bias in model construction which favors livestock over crop activities. In the second interpretation, the activity corresponds to that advocated by the proponents of mixed farming in the West African Savannah. This enterprise involves purchasing young male animals at approximately two years of age, training them for traction by age three or four, and selling them for meat soon after age six. This strategy is seen as both a means of increasing the profitability of growing-out young animals in more humid areas and as increasing the profitability of animal traction (Robinet, 1972; Tacher, Lachaux, and Nicolas, 1969). The basic model does not provide for modification of crop yields and labor requirements through animal traction, although the extended model in chapter ten does. Thus, the cattle enterprise in the

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[1]Shown in chapter 6 to be under eight animals.

[2]See footnote 1, page 90.

[3]As will be demonstrated shortly.

basic model corresponds to the situation where traction equipment is not available to the farmer, or else he cannot afford it, or he simply judges that animal traction is not worth the extra labor time, even if yields increase considerably and animals are available. The cattle option in Model I is akin to smallholder cattle feeding schemes and/or dairy activity.[1]

Derivation of the Objective Function Value for Cattle.-- The objective function coefficient for cattle is set at the highest value that the author could derive from either the existing data in the literature, or the calculations in chapter six, or any combination of the two. The chosen value of 14,000 CFA is the hypothesized maximum net annual returns to keeping two head of cattle on-farm (as opposed to entrusting them) for any purpose except traction during one year. This should not be confused with the net return to keeping cattle *per se*, which was investigated in chapter six. The latter concerns the rate of return to capital invested in cattle. The farmer receives some revenue from cattle whether he entrusts them or keeps them himself. On the other hand, the coefficient in the basic model represents the maximum *extra* amount of revenue a farmer might gain by looking after cattle himself, as opposed to entrusting them to the Fulani. The model assumes that the household already possesses two head.[2] Therefore, there is no capital constraint in choosing to undertake the cattle enterprise *on the farm* (within the model). It is only a question of supplying extra household labor in return for extra farm revenue.

The extra revenue accruing to farmers from looking after their own dairy cattle is assumed to consist of the usufruct of the milk and manure which would otherwise revert to the herdsman. The extra returns to keeping male cattle on the farm are usufruct of manure, the absence of small gifts which would otherwise be made to the Fulani, and better weight gains for animals destined to be sold for meat. In accordance

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[1] If a mixed dairy-and-meat interpretation is preferred, the coefficient of the next subsection remains valid, since the spectacular meat weight gains posited there would not be valid for lactating cows.

[2] Chapter six showed that the mean household holding is between one and two head.

with chapter six and the results in Delgado (1977), it is assumed that other returns to cattle such as calves revert to the owner, whether he keeps the cattle himself or entrusts them to a herder outside the village.

Table 6.5 in chapter six contains data on the stream of expected annual benefits from milk and manure for one cow. The mean expected annual benefit for two female cattle is 5,142 CFA (chapter 6, p. 171). Any subsidiary advantages, such as those stemming from the better care of calves by the active owners, are likely to be included in the 14,000 CFA coefficient of the basic model.

The value of the recoverable manure produced by an adult steer was estimated in chapter six at 1,300 CFA (p. 165). An annual gift per head of 500 CFA is often given to the Fulani herdsmen in the case of male cattle, since they produce no milk (Delgado, 1977). Thus, the maximum extra revenue from keeping two head of male cattle on-farm (without animal traction) rather than entrusting them is 3,600 CFA.[1]

In the absence of ox-plowing, the primary purpose for keeping male animals on-farm is to produce cattle with higher carcass weight and fat content. This study will use the most optimistic estimates available in the literature to derive the returns to on-farm fattening, as opposed to Fulani grazing, over a one year period. To further prejudice the analysis in favor of this activity, it is assumed that none of the value increases reported in the experiment station data are attributed to selling older, as opposed to fattened, animals.[2] Furthermore, figures for years prior to 1976 are inflated at a generous rate of 11.5% compounded annually.[3] The results are added to the estimated gains from manure and the savings

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[1]Not including extra weight gains attributable to a better diet on the farm. As will be seen, the coefficient chosen covers these as well.

[2]This is clearly an untenable assumption, made only in order to better refute the argument. The farmer reaps the benefits of weight gains attributable to increased age whether the animals are kept on-farm or by the Fulani.

[3]This is based upon the compounded average annual rate of increase in meat prices in Ouagadougou of 11.5% between 1969 and 1976. The analysis presupposes a price of 117 CFA per kilogram (with bone) in 1969 (RHV, MDR, B.A.I.S.E., 1975) and 280 kg. in 1976 (Herman, 1977).

from not making gifts to herders. The calculations are presented in Table 8.4. The highest estimate, based on experimental station conditions with ample feed stuffs and a ready market in Dakar, is a total of 14,000 CFA. This figure will be used as the coefficient of the " 2 STEERS" enterprise. It should be clear that this number greatly overstates the advantages of on-farm management of cattle in the research area, in the author's opinion. This is consistent with the pro-cattle methodology used throughout.

Derivation of the Objective Function Values for Sheep and Goats, and Swine.-- The objective function values of sheep and goats, and swine are hard to determine with accuracy because of a lack of data of any type. The annual benefits of keeping small stock, as opposed to cattle, are computed in terms of the extra value of animals grown out one year on the foodstuffs available in Tenkodogo. The estimated coefficient for sheep and goats is 1,100 CFA per animal. The comparable figure for swine is 1,750 CFA. The extra expected value of owning sheep, goats, or swine attributable to possible births of young stock are not taken into account.[1]

This figure for sheep and goats are derived for 1972 data from Senegal presented by M'Bodji (1973, p. 267). He cites experiments in feeding small stock peanut and cowpea stalks and stems which resulted in a mean net revenue for the year of 700 CFA per head. Using the 11.5% average annual inflation for (beef) meat prices, the figure obtained is 1,100 CFA in 1976. This number seems intuitively acceptable as an objective function coefficient representing annual gains, since a three year old sheep or goat sold for 3,000 to 4,000 CFA in Tenkodogo in 1976.

The coefficient for swine is based on inconclusive estimates of key production parameters for Upper Volta. The resulting figure of a net annual revenue of 1,750 CFA per head is tenuous at best, given the lack of any real data. The derivation of the coefficient, given in Table 8.5, serves only to clarify the underlying assumptions. The next chapter contains a detailed sensitivity analysis of all the coefficients.[2]

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[1]The justification for this is that giving birth most likely precludes the rapid weight gains which form a basis for arriving at the objective function coefficient. In any event, the figures here are intentionally low, relative to values for cattle, in order to favor the latter.

[2]The result in Table 8.5 should be interpreted as the author's best informed guess of the correct coefficient. The true returns to small-scale swine farming in the Savannah is a research issue which has yet to be resolved.

TABLE 8.4

COMPUTATION OF THE MAXIMUM RETURNS TO KEEPING TWO STEERS ON-FARM FOR ONE-YEAR FATTENING (1976 PRICES AND EXPERIMENT STATION CONDITIONS)

		I	II	III	IV
(a)	Source of Estimate:	Serres (1973)	Sarniguet (1973)	Lhoste (1973)	M'Bodji (1973)
(b)	Type of Data:	Average of Trials in 1970 and 1972 in Madagascar	Average of Trials in Sudan 1963 and 1966	Estimates for Cameroon Using 1973 Data (Best Estimate of Three)	Mean Reported from Data for Senegal ("2500-5000 CFA per Head") (1973)
(c)	Annual per Head Net Revenue from Fattening in CFA	-1,088	1,800	3,560	3,750
(d)	Same for Two Head	-2,176	3,600	7,120	7,500
(e)	Converted to 1976 CFA	-3,363	7,713[h]	9,870	10,396
(f)	Manure and Herding Gifts Saved, in 1976 CFA	3,600	3,600	3,600	3,600
(g)	Net Extra Revenue for Keeping Two Head on Farm in 1976 CFA (Set to Nearest 100 CFA)	200	11,300	13,500	14,000

[a]I.E.M.V.T. (1973). These are the proceedings of a "state-of-the-arts" colloquium on the subject.

[b]Actual results are based on active data; experiment station conditions.

[c]in CFA of the year of experiment.

[d]= (c) x 2

[e]Using an 11.5% annual rate of increase in the price of meat in Ouagadougou 1969-1976 (RHV, MDR, B.A.I.S.E., 1975; Herman, 1977)

[f]See text.

[g]=(e) + (b)

[h]Assuming that prices were stable through 1969, which approximately describes the situation.

TABLE 8.5

DERIVATION OF THE NET ANNUAL REVENUE PER HEAD
OF SWINE PRODUCTION

Item	(CFA)
Producer Sale Price[a], age 15 months (Carcass weight = 40 kg)[b]	6,000
Costs	
Purchase Price[a], age 3 months (Carcass weight = 16 kg.)[c]	-2,150
Tax[d]	- 100
Net before Feed Costs:	3,750
Cash Cost of Grasses and Bushes[e]	-0-
1/2 Kg/day Supplement of Dried Brewers Grains x 365 days x 11. CFA/kg.[f] =	2,000
	1,750 CFA

[a]The producer purchase price per kilogram of carcass weight in Tenkodogo in 1976 was approximately 150 CFA/kg.

[b]The 40 kg. carcass weight is from S.E.D.E.S., Recueil Statistique, 1975, p. 313.

[c]This assumes that the animal attains 2/5 of its carcass weight in the first three months. (See Williamson and Payne, 1959, pp. 321-22).

[d]Information from O.R.D. Field Office, Tekodogo.

[e]The "cost" of these is incurred through the labor time expended: The size of the ration is an average figure from Williamson and Payne, 1959, p. 329.

[f]The key assumption is that the farmer can obtain feed supplements commensurate with the assumed weight gains for 2,000 CFA per year per animal. In fact, there is no proof of this for the Tenkodogo area. The price of 1,100 CFA per 100 kg. sack is the cost of the dry residue at the brewery in Ouagadougou. Tenkodogo producers in the sample used the bran left from the confection of millet beer, which they obtained through family ties with the beer maker.

Resource Supplies and Requirements

This section discusses the availability of land and labor in the model for allocation to crops and livestock, and the resource requirements for producing one unit of each activity. The model includes 2.75 hectares of land distributed among three categories of soils. The fourth category of land, bush fields, is unrestricted. The labor supply consists of a peak availability of 556 hours per fortnight during the agricultural season.[1] The availability of labor for allocation to crops and livestock decreases after December. This is because the advent of the dry season requires greater attention to nonagricultural and domestic work. The fortnightly labor requirements for crops are drawn from chapter four (pp. 108-120). The lack of substitutability between labor in different fortnights--implicit in the linear programming methodology--is somewhat justified by the rigidity of the timing requirements for agricultural operations. The fortnightly labor requirements for livestock are also based upon the results in chapter four (pp. 120-130). There is an inherent difficulty in calculating per animal labor requirements because of economies of scale in herding. While the coefficients for cattle and swine refer largely to adult labor transferable to crop production sheep and goat labor is primarily that of children engaged in nonarduous tasks. The labor estimates for sheep and goats in chapter four are accordingly revised downwards, for use in a comparison with labor devoted to (arduous) crop activity.

Land Availability.-- The land supplies available for cultivation in the basic model are mean household values established from data for the combined M[illegible]i and Bisa sample in Table 5.7 of chapter five (p. 144). The total area of house fields permitted is .75 hectares; the total area of in-village fields is 1.71 hectares; the maximum allowable amount of lowland fields is .29 hectares. The bush field area available for cultivation was originally specified at 1.10 hectares. After the initial runs, however, bush field area was left unconstrained, in accordance with the theory that

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[1]For an average household with "5.22 workers," this corresponds to 53 1/4 hours a week per person available for crop and livestock tasks.

bush field land is still available for the asking.[1] Thus, the model posits that 2,75 hectares of restricted land of different varieties and an unlimited amount of "free" bush land is available.

Because animals are grazed on communal lands, livestock are assumed to require no farm land. Thus, the limits on land availability have no effect on livestock enterprises. This is yet another way of biasing the results in favor of livestock, because it ignores the external diseconomy implicit in grazing on communal pasture. Although one household in partial equilibrium may have unlimited grazing land close to the village, clearly this is not the case if all households decide to hold livestock. Thus, a model built with the objective of supporting a policy of livestock intensification would have to place a shadow cost on land use by animals. For the purposes here, it is sufficient to ignore this point and proceed as if grazing land is costless in itself, even though a substantial amount of labor time must be spent taking cattle to communal pastures which are increasingly further away from the village.

Labor Availability.-- The estimate of the number of hours of work available to the model farm each fortnight is derived from averages over the forty-one sample farms. The issue in labor availability in this context is to adequately reflect changes over fortnights in the amount of time available for crop and livestock work. Following the discussion in chapter four, total household labor availability, including cooperative and hired labor, is broken down into five sectors. These are crop, livestock, domestic, nonagricultural work, and social activity (pp. 103-107).

A comprehensive model of the farm would include a composite nonagricultural enterprise using capital and labor to produce revenue. Pottery, weaving, petty commerce, and beer brewing are prime examples of the sorts of nonagricultural activities carried out in the villages by sample members. This alternative for labor allocation is excluded as an enterprise in the model for two reasons. First, there is some doubt as to the

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[1] This is done by specifying the supply of bush land as a relatively large number, say five hectares. In practice, bush land was never fully used (beyond 1.10 hectares), thus the relaxation of the constraint had

appropriate returns to a given allocation of labor. Second, and most importantly, sample members typically spend very little time on these pursuits during the growing season (see Figure 4.2, p. 103). This is the period of peak labor use and thus most subject to labor bottlenecks.

Instead, the approach used in the basic model views nonagricultural and domestic work as enterprises requiring differing, but predictable, amounts of labor each fortnight over the year, with the heaviest requirements coming during the dry season. This assumes that a household of a given size needs a flow of domestic and nonagricultural "maintenance" work, but that tasks can either be put off until the dry season, or else fall heaviest at that time. Examples of the former are tool refurbishing and construction work. Examples of the latter are fetching water from a distance when wells run dry and stocking up on dry firewood before the next wet season. Many domestic and nonagricultural tasks can be hurried during the peak period of labor use in July, but only on the condition of taking things more slowly in March. Examples of this would be child education, meal preparation, and emergency repairs on leaky roofs.

Thus, the labor hours available per farm for crop and livestock work are at a maximum during the growing season, but decline thereafter. This is particularly noticeable as the hot season begins in earnest at the beginning of April. This procedure used to derive the exact number of hours of labor available for crop and livestock work over fortnight (f_j) is based upon the household averages depicted in Figure 4.2 (p. 103).

$$f_j = \underset{j}{\text{Min}} \left[\begin{array}{l} \underset{j}{\text{Max}} \ (C_j + L_j) \\ \\ T_j - (N_j + D_j) \end{array} \right.$$

where

$$T_j - (N_j + D_j) = C_j + L_j + S_j$$

and

C_j = total household hours (including hired and cooperative labor) devoted to crop activities;

L_j = total household hours devoted to livestock activities;

S_j = total household hours allocated to social activity.

N_j = total household hours allocated to nonagricultural work

D_j = total household hours allocated to domestic work

T_j = total household hours, all activities and pursuits

This says that the labor availability for crops and livestock in fortnight j is equal to either the maximum amount of hours devoted to crops and livestock during any fortnight of the year or the amount of total labor hours available in fortnight j after domestic and nonagricultural activity is provided for, whichever is smaller.

This implies that laborers on the model farm cannot work at crop and livestock enterprises for more hours per fortnight than the average farm did at its yearly peak. On the other hand, the model farm may be constrained to less than the peak number of hours. This would be the case for each fortnight j where the sum of crop, livestock, and social activities is less than the yearly peak on the average farm. This would be the case where nonagricultural and domestic enterprises are relatively high in a given fortnight.

A glance at the left hand column of Table 8.1 shows that the result of this procedure is to fix the model farm labor supply at 556 hours per fortnight, for periods 1 to 16.[1] This corresponds to the peak labor allocation to crops and livestock of period five (4-17 July) on the average farm. After the middle of December, the hours available for crops and livestock decline steadily as the dry season progresses.

This implication of this procedure is to provide a generous supply of labor to the model. Household members are permitted to work at the annual peak rate of the average farm during the entire crop season. This rate may in fact only be sustainable for a small number of fortnights. The model implicitly assumes that all the time devoted to social activity on the average farm is available for use on crops and livestock, provided that work hours do not exceed the annual maximum of the average farm. In

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[1]This corresponds to the crop season from May 9 until December 18, 1976. The one exception is fortnight 14, where there is a shortfall of two hours.

fact, social activity may not be as elastic as supposed, since some social practices (visiting in-laws) may be perceived by farmers as absolute necessities. The end result is, if anything, to reduce rather than aggravate annual labor bottlenecks in the model. This is consistent with the objective of demonstrating that even with assumptions favorable to livestock production, such bottlenecks preclude on-farm cattle enterprises.

Resource Requirements for Crops.-- The objective function coefficients for crops express the returns per hectare of land. Therefore, the land requirement for achieving a return equal to the maximand coefficient is one hectare. The interesting issue is then to derive the number of hours of labor required each fortnight to obtain the revenue from one hectare of each enterprise. The linear programming methodology assumes a fixed coefficient linear production function. Therefore, every resource specified in the column under each activity in Table 8.1 must be supplied in the exact amount required in order to produce one unit of the enterprise. The only justification for such assumptions, other than methodological convenience, is the rigidity of the timing of labor inputs discussed in chapter four (p. 104). Weeding labor must be supplied after the weeds have begun growing in July but before the big rains in August. Millet must be harvested after the ears have dried out, but before the grain is eaten by birds and uncorralled livestock. To the extent that peak requirements are inflexible, a fixed coefficient production function is indicated, using labor variables for different periods.

The labor requirements per fortnight for one hectare of each crop enterprise are taken from the average values in Table 4.13 (p. 114). It is somewhat difficult to separate the labor allocation between wet and dry season fruit and vegetables, given the method of data collection. A somewhat arbitrary division is achieved by splitting the last column in Table 4.13 into periods 1-13 (May 9 - November 6), which correspond to the wet season, and periods 14-26 (November 7 - May 7), the dry season. Fortnight 14 also represents a saddlepoint in the distribution of labor to fruit and vegetables. Wet season crops are harvested in late October and dry season crops are planted in late November.

Some crop enterprises require a specialized type of land or some other resource. These effectively limit the amount of units of this enterprise that can be undertaken, given the assumptions underlying the land and labor requirement given in Table 8.1 These special resource requirements are embodied as production constraints and will be discussed below.

Resource Requirements for Livestock.-- It is particularly difficult to specify the "correct" labor requirements per fortnight for livestock on a per animal basis. This is because of the existence of economies of scale in herding. The per animal requirements based on a herd of ten animals will be higher than those based on a herd of twenty animals. The figures in Table 8.1, given on a per animal basis, relate to an average household herd size of eight sheep and goats and six pigs. The cattle coefficients are for a two animal enterprise.

The labor requirements for cattle were derived in chapter four (pp. 125-130) from data pertaining to the Fulani, and displayed in Table 4.17 (p. 129). The coefficients for swine are taken from Table 4.15 (p. 122). The figures for sheep and goats are revised estimates which are considerably less than the figures reported in chapter four. This is because of the problem raised by the fact that most of the labor required to look after sheep and goats is that of children.[1] This is not the case for swine or cattle.[2]

The labor supplied to all enterprises each fortnight includes child and female adult labor on an hour for hour basis with adult male labor. The labor requirements for crop enterprises are specified in terms of total labor actually supplied to those activities each fortnight by the average sample farm. Treating livestock enterprises in the same way, however, favors the conclusion that such activities have a high opportunity cost in terms of crops, since the result is to attribute relatively high labor requirements to animal enterprises. This is particularly true

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[1]Bearing in mind that the labor of children under eight was not recorded by the survey, thus not included here.

[2]Data from the four households who kept swine indicate that most of the labor was supplied by adult males. The labor requirements for cattle were formulated in chapter four taking the type, as well as quantity, of labor input into consideration (pp. 123-130).

if a livestock activity uses only the labor of boys 8-15 years old, while crop cultivation requires the whole family. Often children spend hours playing together while ostensibly watching the flock. For these reasons, the per animal labor requirements for sheep and goats derived from the farm management survey overstate the labor savings implied by reducing bovine enterprises in favor of crops. It is unlikely that hours spent watching sheep could be fully transferred by children to weeding millet.

A new set of labor coefficients was derived for sheep and goats, as represented in Table 8.1. The highest labor input per animal occurs in the first month after the start of the rains. Small ruminants are tethered each day and supervised at the periphery of the in-village fields. Pasture other than the newly sprouting sorghum is scarce. Surveillance is maintained throughout the rainy season, but is less crucial than the first month, when sheep and goats can quickly destroy a large surface area. The labor requirements per fortnight are minimal after the harvest as animals graze the stubble and by-products. Labor input increases again as water and in-village pasture run low at the end of the dry season.

The basic model was run alternatively with both sets of figures. The effect of the change is to favor sheep and goats over swine production, leaving cattle and crops virtually unchanged. The subsequent runs were made with the new set of coefficients. Chapter nine includes a further sensitivity analysis of results with respect to sheep and goat labor requirements.

Production Level Constraints

In addition to the limits imposed on output by resource supplies, the model incorporates eight direct constraints on the levels of certain enterprises. Seven of these are maximum permitted activity values and one is a minimum production constraint. The maximum output levels serve to express a resource constraint other than those of the basic land categories and labor periods. The limits on maize, wet season vegetables, cotton and tobacco, and starchy root crops take into consideration special soil characteristics required by these plants. These are not general to the overall categories of "house fields" or "lowland" incorporated in the set of land supplies. The maximum production levels for dry season vegetables and livestock represent implicit capital constraints on smallholder production. They also reflect that the assumptions underlying the labor and land coefficients are no longer valid beyond certain levels. The minimum area planted in food grains is the one explicit behavioral constraint in the model. It embodies the hypothesis that farmers are unwilling to rely upon the market beyond a certain point for their supply of millet. A methodology is developed to select the smallest land area actually allocated to food grains by sample members and to derive an estimate in hectares commensurate with the size of the model farm. The result is that 2.43 hectares, or 63% of average holdings, must be put into one of the three enterprises involving millet. The sensitivity of optimal production strategies to this estimate, both in terms of the value and variety of output, forms an important part of the analysis presented by this study.

Maximum Output Levels.-- Certain maximum production constraints ensure that the optimal program only includes levels of activities that are plausible in the real world. The theoretical justification for their use is that the simple two factor production model excludes constraints on other scarce resources which are relevant to only one or two of the enterprises. In the basic model, the excluded resource is either soil characteristics or capital availability.

The first three production constraints are examples of the former problem. Maize and wet season vegetables are typically planted in very small patches immediately outside the compound wall. They share the same soil which, since the founding of the farm, has been the recipient of the sheep dung and the night soil of the household. This is the most fertile earth with the best water retention (without being flooded) on the farm. Without the extra production constraint, MAXMV, the program would be free to choose to allocate the entire supply of houseland, *ceteris paribus*, to vegetables and maize, even though the underlying assumption of soil quality is violated. Similarly, only a fraction of house land is suitable for cotton and tobacco, and not all holdings classified as "lowland" are suitable for cassava and sweet potatoes.

The principal problem with the use of direct output constraints is to know the correct level to specify as the maximum. The procedure used here to obtain the output ceiling for activity i (Q_{max_i}) follows the rule:

$$Q_{max_i} = \text{Min} \left[\begin{array}{l} 3.85 \, \underset{j}{\text{Max}} \, P_{ij} \\ \\ \underset{j}{\text{Max}} \, Q_{ij} \end{array} \right. \qquad j = 1, \ldots, 41$$

where:

P_{ij} is the percentage of the landholdings of household j under the i^{th} crop or combination of crops;

Q_{ij} is the amount of land of household j, expressed in hectares, under the i^{th} crop or combination of crops.

This says that the maximum output level is either the maximum percentage of household land holdings in the sample attributed to that enterprise times the average total landholding, or the maximum household area across the sample in enterprise i, whichever is smallest. This procedure ensures that the chosen output ceiling is both a maximum based on the sample data and that it reflects the scale of the average farm. Data on the maximum household values of Q_i and P_i are contained in Tables 5.11 and 5.12 respectively (pp. 150-151).[1] The results for MAXMV, MAXCT, and MAXRT are displayed in Table 8.1.

The remaining four output ceilings apply to activities which in the real world are limited by a capital constraint not included directly in the model. Thus, the Dry Season Fruit and Vegetable enterprise is limited to 600 square meters, which seems to be about the limit that can be irrigated by hand, given the assumed labor coefficients.[2] The other three

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[1]To get the maximum Q and P for a combination of vegetables and maize, the separate values for the two activities were added together within each household before obtaining the maximum values over households for the two enterprises considered together.

[2]In fact, this was the maximum area of fruit and vegetables cultivated by any sample member (see Table 5.11, p. 150).

production ceilings relate to the livestock activities. The maximum levels are, somewhat arbitrarily, set at twenty sheep and goats, ten pigs, and one pair of cattle kept on-farm. The justification for this is that more extensive holdings in any one of these categories implies a stock of wealth and herding knowledge beyond the capacities of sample members.[1] In fact, the maximum sample farm holdings of sheep and goats and swine were seventeen and five head, respectively (Table 6.7, chapter 6). The last production constraint is a minimum output floor.

The Minimum Food Grain Production Constraint.-- The main purpose of a linear programming model of farm behavior is to identify production strategies which maximize net household revenue. This is of interest primarily in comparison with the actual behavior of sample farms. Howeve the model also needs to provide a means for exploring why actual behavior departs from maximizing behavior (if it does). The minimum food grain constraint is different from the other components of the program in that it models farm preferences as opposed to resource supplies or requirements.

A central tenet of the principal hypothesis of this study, expressed in chapter one, is that sample farmers are typically unwilling to rely upon the market for their supply of the food staple, millet. This attitude is expressed, according to the hypothesis, in the large proportion of farm holdings planted with the staple food grain. More formally, farmers will not choose strategies which maximize farm revenue unless they also assure the on-farm supply of food. This theory about peasant behavior is incorporated into the program by specifying a minimum area that must be planted with millet. The issue is what minimum area farmers are comfortable with, as opposed to what quantity of land is necessary to feed the family in an average year. The problem is to specify this level correctly, in order that the model may be useful in explaining actual farm behavior.

The approach used here is to look at actual farm plantings of millet in 1976 in terms of both absolute acreage and proportion of household

[1]The cattle enterprise is limited to two animals principally because cattle activity of any size greater than one animal is sufficient to refute the hypothesis being investigated.

land holdings. Then, the minimum food grain area (MINFD) is derived as follows, using data from chapter five (pp. 150-151):

$$MINFD = Max \left[\begin{array}{l} 3.85 \min_j P_j \\ \\ \min_j Q_j \end{array} \right] \quad j = 1, \ldots, 41$$

where:

MINFD is the minimum area in hectares that the model farmer is willing to put under crop combinations involving millet;

P_j is the percentage of the land holdings of household j under millet;

Q_j is the area of holdings of household j under millet.

This says that MINFD is equal either to the smallest percentage of land under millet in the sample times the area of the model farm or to the smallest area in hectares, whichever is larger. This procedure, as in the case of the maximum constraints, ensures that the result if commensurate with the scale of the model farm.

The lowest proportion of household land devoted to millet by any sample member is thirty-eight percent. As explained in chapter five, however, this household is atypical in that it controls an exceptionally large area of lowland (p. 152). As such it is quite unrepresentative of farms in the area, as the histogram in Figure 5.1 suggests (p. 153). The tail of the distribution in Figure 5.1 is represented by the household with the next lowest proportion of land under millet, which is sixty-three percent. This number is used in conjunction with the size of the model farm of 3.85 hectares[1] to derive the minimum area that can be attributed to millet of 2.43 hectares. The sensitivity of results to changes in this estimate form an important part of the results of this study.

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[1]Including the average holding in bush fields of 1.10 hectares.

The basic model of the peasant farm in Tenkodogo is now complete. The next chapter gives the results of the optimization process where the only returns to on-farm cattle are milk, manure, and extra weight gains. A complete sensitivity analysis of parameters and assumptions in included. Chapter ten explores the case where on-farm cattle can also be used for animal traction purposes.

CHAPTER 9

RESULTS FROM THE BASIC MODEL AND THE OPPORTUNITY COST OF CATTLE IN TERMS OF FOOD GRAINS

The principal conclusion of this chapter is that cattle are not kept by the revenue maximizing model farmer. Forcing the farmer to keep two head of cattle on the farm lowers the value of overall output by eight percent. Sensitivity analysis shows that either a substantial increase in the net revenue from cattle (38%), or an equivalent decrease in resource requirements, are required before this enterprise even begins to enter the optimal solution set. Cattle are not kept even if the minimum requirements for food grain production are lowered. It is the case, however, that the cash opportunity cost of cattle decreases with decreased food grain output. With no minimum grain production level, approximately half of the millet output is replaced with small ruminant and swine production. On the other hand, considering food grains at their seasonal high value rather than at lowest prices is tantamount to imposing a minimum production level substantially higher than that in the basic model. This raises the opportunity cost of cattle. At the levels of production in the optimal solution of the basic model, the opportunity cost of the labor resources used to maintain two head of cattle on the farm is 1.21 hectares of millet and cowpeas. The cash opportunity cost of two animals is even higher than this figure if farmers are unwilling to reduce the allocation of land to food grains beyond the levels in the optimal solution to the basic model.

The Optimal Solution to the Basic Model and the Effect of Cattle Activities

The main result of the basic model is that on-farm cattle activities are not included in the optimal solution. Small ruminants are kept at the same level as that of the average farm in 1976. The optimal value of crop production is slightly above the value of crops produced by the average farm in 1976. The difference is attributable primarily to a lower proportion of model farm resources put into food grains than was the case for the average farm in 1976. This may be the result either of prices for food grains which were too low in the basic model, or the fact that farmers actually desire to produce a greater quantity of food grains than that indicated by the MINFD constraint. Land close to the village, including lowland, is fully used in the optimal solution. The binding constraints on further production in bush land are labor in the second half of August and in the middle of November. The former corresponds to the weeding of high value, high labor-input cash crops. The latter represents the harvest of millet. The next section will show that shifting labor from the cultivation of cotton and tobacco, rice, and cassava to millet reduces the labor bottlenecks in August and increases them in November. Beyond a certain point, labor in late July is also fully used up, reflecting the time spent weeding food grains.

The effect of forcing two head of cattle into the set of farm enterprises in the optimal solution is to lower the value of crop and livestock production by eight percent. This may seem a small amount given the magnitude of the assumptions made in the construction of the model. Nevertheless, it is highly significant that the introduction of cattle lowers the maximum attainable farm revenue, since the assumptions made in the construction of the model consistently favored the cattle enterprise relative to crops. Furthermore, it becomes clear that, so long as the option of entrusting cattle to the Fulani is available, keeping large stock on the farm does not offer such new and substantial profit opportunities that the farmer will jump at the chance of fundamentally changing his production habits in order to include looking after cattle.

Further effects of forcing the model farm to keep cattle, as opposed to entrusting them to the Fulani, are to force high value, high labor-input crops such as cotton and tobacco and rice out of the solution. The opportunity cost of harvesting labor in November increases considerably, reflecting a substantially greater labor bottleneck at that time. The opportunity cost of house land also increases. Results show that the value of overall production can be increased very substantially by either lowering the minimum food grain constraint or abandoning the forced cattle activity. This is interpreted as further evidence of the important labor conflict between the two enterprises.

The Optimal Solution to the Basic Model.-- The basic model of Table 8.1 above yielded the results displayed in Tables 9.1 and 9.2. The optimal production strategy involves a cash value of agricultural production of 134,835 CFA, including 128,784 CFA in crop production. It is significant that five to six sheep and goats are the only livestock kept. The optimal allocations are not unlike the actual allocations of the average farm in Table 5.11 (p. 150). The value of the optimal crop package exceeds that of the average actual package calculated in chapter seven (p. 218) by 14 percent. The difference between the two strategies is attributable primarily to a difference in the amount of millet cultivated. The average farm in 1976 had 3.24 hectares under food grain mixtures involving millet. The optimal bundle included only the minimum area specified in the MINFD constraint, 2.43 hectares. Results in the next section will show that raising MINFD makes "optimal" results approximate "actual average" results more closely. Lowering MINFD increases the value of production.

The optimal strategy with MINFD = 2.43 hectares (or 63% of holdings) involved substantially more attention to high value, high labor-input activities than did actual allocations. Starchy root crops, cotton and tobacco, and vegetables are the prime examples in this respect. The optimal package used substantially less land (23%) than the average farm did in 1976, most likely because, in the optimal program, resources were more concentrated in labor input crops than was the case in 1976. Significantly, groundnuts were ignored in the maximum bundle. Table 9.2 shows that the binding resource constraints in Run 1 are land close to the village (house, in-village, and lowland) and labor during two critical periods, fortnight 8 and 14. (Period 8 corresponds to the second half of August, when cassava, cotton, and vegetables are weeded. Fortnight 14 runs from November 7 to 20, the height of the millet harvest). The last column of Table 9.2 gives the list of dual activities. These are interpreted as the marginal change in the objective function value of adding one unit of a scarce resource.[1] Thus, the duals are taken as the "shadow

[1]Provided that the current optimal solution remains feasible (Wagner, 1969, pp. 140-141). The dual values represent a decrease in the maximand from moving away from the optimal solution level and thus have a negative sign.

TABLE 9.1

RESULTS FROM THE BASIC MODEL (RUN 1):
ENTERPRISES IN THE OPTIMAL SOLUTION

Activity	Enterprise Label	Optimal Level Chosen (in Hectares or Animals)	Upper Limits[a] Imposed by Constraints (in Hectares or Animals)	Changes in Maximand by Forcing the Choice of One Extra Unit of Enterprise[b] (in CFA)
Millet and Sorghum on House Fields	HOUSMS	.496	None	
Wet Season Vegetables	WETVEG	.096	"	
Maize	MAIZE	0	"	-115,386
Cotton and Tobacco	CTNTBC	.158	.244	
Groundnuts on In-Village Fields	INVGNUT	0	None	-40,624
Millet and Cowpeas on In-Village Fields	INVGMCP	1.710	"	
Rice	RICE	.040	"	
Starchy Root Crops	ROOTS	.190	.190	110,376
Dry Season Vegetables	DRYVEG	.060	.060	127,046
Millet and Cowpeas on Bush Fields	BUSHMCP	.224	None	
Groundnuts on Bush Fields	BUSHNUT	0	"	-23,043
Small Ruminants	SHPGOAT	5.501	20	
Swine	PIG	0	10	-560
Two Head of Cattle Kept On-Farm	2 STEERS	0	1	-5,250[b]

Maximized Objective Function Value = 134,835 CFA

[a]There were no lower limits. Maize and wet season vegetables were together constrained to .096.

[b]These figures, which are part of the standard linear programming output, are useful only for indicating relative tendencies. They are valid only for a small range around the current optimal solution. They also stem from the rigid assumption of the continuity of all enterprises which is an unfortunate aspect of the methodology. Thus, it is valid to say that a ".001 increase in the cattle enterprise would decrease the maximand by 5.25 CFA." However, it is likely that actually forcing the model farmer to keep two extra head of cattle, with the complete reallocation of resources that this would entail, would serve to decrease maximum obtainable farm revenue far beyond 5,250 CFA.

TABLE 9.2

RESULTS FROM THE BASIC MODEL (RUN 1): SLACKS AND DUALS IN THE OPTIMAL SOLUTION

ROW	AT	ACTIVITY	SLACK ACTIVITY	LOWER LIMIT	UPPER LIMIT	DUAL ACTIVITY
HOUSLD	UL	.75000	.	NONE	.75000	16297.35007-
INVGLD	UL	1.71000	.	NONE	1.71000	2197.35007-
LOWLD	UL	.29000	.	NONE	.29000	4475.52301-
BUSHLD	BS	.22385	.87615	NONE	1.10000	.
LABOR1	BS	372.26658	183.73342	NONE	556.00000	.
LABOR2	BS	472.22429	83.77571	NONE	556.00000	.
LABOR3	BS	431.72803	124.27197	NONE	556.00000	.
LABOR4	BS	467.96188	88.03812	NONE	556.00000	.
LABOR5	BS	423.25827	132.74173	NONE	556.00000	.
LABOR6	BS	449.32114	106.67896	NONE	556.00000	.
LABOR7	BS	418.23316	137.76684	NONE	556.00000	.
LABOR8	UL	556.00000	.	NONE	556.00000	10.52999-
LABOR9	BS	272.01161	283.98839	NONE	556.00000	.
LABOR10	BS	141.15159	414.84841	NONE	556.00000	.
LABOR11	BS	169.19018	387.90982	NONE	556.00000	.
LABOR12	BS	199.00806	356.99194	NONE	556.00000	.
LABOR13	BS	284.50783	271.49217	NONE	556.00000	.
LABOR14	UL	554.00000	.	NONE	554.00000	172.80335-
LABOR15	BS	296.52781	259.47219	NONE	556.00000	.
LABOR16	BS	251.24768	304.75232	NONE	556.00000	.
LABOR17	BS	156.18976	399.81024	NONE	556.00000	.
LABOR18	BS	106.39228	404.60772	NONE	511.00000	.
LABOR19	BS	60.78481	444.21519	NONE	505.00000	.
LABOR20	BS	47.80481	447.19519	NONE	495.00000	.
LABOR21	BS	55.53481	394.46519	NONE	450.00000	.
LABOR22	BS	56.26601	414.73399	NONE	471.00000	.
LABOR23	BS	54.37721	370.62279	NONE	425.00000	.
LABOR24	BS	68.95842	386.04158	NONE	455.00000	.
LABOR25	BS	80.90962	343.09038	NONE	424.00000	.
LABOR26	BS	97.48347	270.51653	NONE	368.00000	.
MAXMV	UL	.09600	.	NONE	.09600	119488.91213-
MINFD	LL	2.43000	.	2.43000	NONE	9916.31799

prices" or opportunity costs of fully used resources within a small range of the optimal solution. Alternatively, the dual may be considered the marginal value product of one unit of scarce resource when considering production as a whole. The opportunity cost of an extra hour's weeding of high value crops in late August is approximately 11 CFA per hour. The "shadow price" of an hour's labor during the food grain harvesting period in the middle of November is 173 CFA. This may be compared to a prevailing wage rate during the agricultural season of approximately 300 CFA per day. In practice, it is difficult to find workers for hire during the harvest period in November.

The last column of Table 9.1 records the marginal change in the maximand obtained by forcing the choice of one extra unit of each activity which is currently at its maximum or minimum (0) permitted level. The figures are significant primarily as indicators of the effect of such actions (see note b of Table 9.1). The numbers given are valid only for small ranges around the current optimal solution. The actual decrease in the objective function value of forcing the program to choose two steers may be much greater than indicated in Table 9.1, since a large change occurs and resources are significantly reallocated among different enterprises. Run 2 of the basic model bears this statement out. It is exactly similar to Run 1, except that the maximum permitted level of cattle in Table 8.1, MAXBO is changed to an equality. This forces the model farmer to keep exactly two head of cattle on the farm as part of the optimal strategy.

The Effect of Forcing One Unit of the Cattle Enterprise into the Optimal Solution of the Basic Model.-- The results of forcing the farmer to keep two head of cattle are shown in Tables 9.3 and 9.4. Comparison of these figures with the preceding results for Run 1 shows the net effect on resource allocation and optimal production strategies when two head of cattle are kept. The new objective function value has decreased by 10,238 CFA, or 8 percent of the previous level. The high value, high labor input activities of cotton, tobacco and rice have ceased entirely. Starchy root crop production declines by .031 hectares, or 10% of the previous level. Food grain levels remain at the lowest permissible level of 2.43 hectares, but production is shifted from the bush fields to the

TABLE 9.3

RESULTS FROM THE BASIC MODEL WITH FORCED CATTLE (RUN 2): ENTERPRISES IN THE OPTIMAL SOLUTION

Enterprise	Optimal Level Chosen (in hectares or animals)	Upper Limits[a] Imposed by Constraints (in hectares or animals)	Change in Maximand by Forcing the Choice of an Extra Unit of Enterprise (in CFA)
HOUSMS	.654	None	
WETVEG	.096	None	
MAIZE		None	-124,200
CTNTBC		.244	-438,777
INVGNUT		None	-432,882
INVGMCP	1.710	None	
RICE		None	-219,507
ROOTS	.159	.190	
DRYVEG	.060	.060	40,743
BUSHMCP	.066	None	
BUSHNUT		None	-423,438
SHPGOAT		20	-6,920
PIG		10	-15,626
2STEERS	1.000	-	-128,247

Maximum Value of the Objective Function = 124,597 CFA

[a]2STEERS = 1 was the only lower limit. Maize and wet season vegetables were jointly constrained to a maximum of .096 hectares.

TABLE 9.4

RESULTS FROM THE BASIC MODEL WITH FORCED CATTLE (RUN 2)
SLACKS AND DUALS IN THE OPTIMAL SOLUTION

ROW	AT	ACTIVITY	SLACK ACTIVITY	LOWER LIMIT	UPPER LIMIT	DUAL ACTIVITY
HOUSLD	UL	.75000	.	NONE	.75000	26729.70297-
INVGLD	UL	1.71000	.	NONE	1.71000	12629.70297-
LCHLD	BS	.21887	.07113	NONE	.29000	.
BUSHLD	BS	.06600	1.03400	NONE	1.10000	.
LABOR1	BS	410.24087	145.75913	NONE	556.00000	.
LABOR2	BS	501.82465	54.17535	NONE	556.00000	.
LABOR3	BS	491.89800	64.10200	NONE	556.00000	.
LABOR4	BS	525.14271	30.85729	NONE	556.00000	.
LABOR5	BS	467.87194	88.12806	NONE	556.00000	.
LABOR6	BS	502.07129	53.92871	NONE	556.00000	.
LABOR7	BS	423.80366	132.19634	NONE	556.00000	.
LABOR8	BS	438.91505	117.08495	NONE	556.00000	.
LABOR9	BS	326.93459	229.06541	NONE	556.00000	.
LABOR10	BS	207.75350	348.24650	NONE	556.00000	.
LABOR11	BS	187.37139	368.62861	NONE	556.00000	.
LABOR12	BS	242.12871	313.87129	NONE	556.00000	.
LABOR13	BS	221.15848	334.84152	NONE	556.00000	.
LABOR14	UL	554.00000	.	NONE	554.00000	1336.63366-
LABOR15	BS	356.83036	199.16964	NONE	556.00000	.
LABOR16	BS	150.44939	405.55061	NONE	556.00000	.
LABOR17	BS	93.03733	462.96267	NONE	556.00000	.
LABOR18	BS	80.98681	430.01319	NONE	511.00000	.
LABOR19	BS	71.85002	433.14998	NONE	505.00000	.
LABOR20	BS	59.86614	435.13386	NONE	495.00000	.
LABOR21	BS	66.88018	383.11982	NONE	450.00000	.
LABOR22	BS	63.13743	407.86257	NONE	471.00000	.
LABOR23	BS	105.24549	319.75451	NONE	425.00000	.
LABOR24	BS	114.45000	340.55000	NONE	455.00000	.
LABOR25	BS	120.90000	303.10000	NONE	424.00000	.
LABOR26	BS	137.31600	230.68400	NONE	368.00000	.
MAXMV	UL	.09600	.	NONE	.09600	118270.29703-
MINFD	LL	2.43000	.	2.43000	NONE	224277.22772

more productive house land. At face value, this has the interesting side effect of freeing more land just outside the village for grazing purposes. The net effect of the on-farm cattle enterprise on optimal production strategies, however, is to decrease the overall value of output and to take the place of cash crops (cotton, tcbacco, rice, cassava) activities.

Table 9.4 shows the net effect on resource use and opportunity costs of forcing in the cattle enterprise. The opportunity cost of one hour's harvesting labor in period 14 becomes 1,337 CFA. On the other hand, the "shadow price" of late August labor falls to zero as the cash crops are decreased. Labor in periods 4 (late June) and 6 (late July) are nearly used up. The absolute value of the dual variables corresponding to house and in-village land also increases substantially, while that of lowland vanishes. The implication is that keeping cattle while also attempting to grow food grains places a relatively high premium on new land close to the compound and decreases the value of extra lowland for crop purposes, although the actual pressure on this resource may increase if it is used as a source of forage.

The conflict between food grains and cattle is perhaps most evident in the changes occuring in the dual variable associated with the MINFD constraint when the latter is set at 2.43 hectares. In the optimal solution without forced cattle (Table 9.2), the marginal decrease in the overall value of production associated with a small increase in the MINFD constraint is 99 CFA per .01 hectares increase. In the run with forced cattle (Table 9.4), the comparable figure is 2,243 CFA. Similarly, Table 9.1 showed that the marginal decrease in the optimal value of production associated with an increase in cattle herding occurs at the rate of 2,625 CFA per head of cattle, within a small range around the optimal solution. The corresponding number in Table 9.3 is 64,124 CFA per head. The conclusion is that forcing farmers to keep cattle when they also feel that they must produce a minimum level of food grains (63% of holdings in this case) leads to a clearly sub-optimal solution. The overall value of production can be substantially increased in the model by either sacrificing food grains or on-farm cattle production. To the extent that farmers desire on-farm millet production, it is not surprising that they resist keeping cattle on the farm; in fact, all evidence indicates that

MINFD was set too low in the basic model.

The next section illustrates the sensitivity of these results to the specification of the model parameters which affect the optimal solution. Certain key assumptions concerning food grain prices and the minimum food grain constraint are also examined. In this context, only the objective function coefficients, resource supplies, and production limits are considered parameters. They are the key values which can be changed without altering the basic structure of the model itself. The consideration of the impact of changes in the basic structure of the model are reserved for the next chapter. An example would be animal traction which affects the input-output coefficients of the tableau. Changing the latter alters the model in such a way that a whole new program is created, necessitating a separate model and analysis.

Sensitivity of the Results from the Basic Model to Parameter Values and Basic Assumptions About Cattle and Food Grains

The major conclusion here is that, on the whole, the optimal solution to the basic model is not particularly sensitive to the choice of parameter values, as defined in the previous paragraph. This is especially true with respect to cattle production. The evidence indicates that the overall optimal solution is sensitive to labor supplies in period 14 (7-20 November) The dual variable for this resource changes following a four percent decrease or a seven percent increase in its availability. Cattle can enter the optimal solution only if this resource is increased (it may have to increase substantially). Since the estimate of labor availability errs only in being too generous (as explained earlier in the chapter), the supply of harvest labor is not judged to be an issue in this context. Sensitivity analysis of the objective function coefficient of cattle indicates that a 38 percent increase in net revenue from this enterprise is required to permit it to enter the optimal solution. This is tantamount to the result that a 28 percent decrease in resource requirements is required to achieve the same objective.[1] Given the very generous objective functions coefficient for cattle and the fact that such a reduction only permits ".31 of a 2 head enterprise" to be kept, it is fair to say that cattle will not be kept by a revenue maximizing farmer in the basic model. This is the case even if the parameters are substantially modified in favor of cattle.

The net effect of removing the minimum food grain production constraint is to replace half of the millet output with that of small ruminants and swine. Cattle are not kept at any level of MINFD. However, the higher MINFD, the higher is the income penalty from keeping cattle. Interestingly enough, evaluating millet at peak August prices is equivalent to imposing a MINFD constraint of 2.93 hectares, substantially above the lower limit in the basic model. This is the case even after allowing for 20 percent storage losses. The results suggest that either MINFD or the value of a hectare of food grains should be raised if the optimal solution of the basic model is to approach the actual behavior of sample farmers in 1976. Either of these assumptions greatly decreases the chances that farmers would wish to keep cattle.

Sensitivity of the Optimal Solution to Changes in the Objective Functions Coefficients.-- The main finding here is that most coefficients of the objective function would have to change substantially in order to affect the optimality of the solution in Table 9.1 Thus, the analysis in the preceding subsections remains valid even if there is a slight overestimation of the value of crops and an underestimation of the value of livestock. More specifically, a 38 percent increase in the net revenue from keeping two cattle on-farm would be necessary before this enterprise enters the optimal solution. It may be that a much larger increase is necessary, given the indivisibility of livestock.

Data on the sensitivity of the optimal solution to the net revenue attributable to each enterprise are given in Table 9.5. For activities

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[1]The production functions in the program are, by definition, linear and continuous. Thus, if other elements of the program are unchanged, a 38% increase in the objective function coefficient with resource requirements unchanged is the same as a 28% decrease in resource requirements with the net revenue unchanged. The decrease is due to an index number effect.

TABLE 9.5

SENSITIVITY ANALYSIS OF THE OBJECTIVE FUNCTION COEFFICIENTS IN THE BASIC MODEL (RUN 1)

Enterprise	Current Optimal Solution		Coefficient Range for Which Activity Enters or Leaves the Solution			
			Enters		Leaves	
Label	Level[a]	OFC[b]	OFC[c]	New Level[d]	OFC[e]	New Level[f]
HOUSMS[g]	.496	37,700			21,516	0
WETVEG	.096	145,000			29,614	.023
MAIZE	0	20,800	136,186	.073		
CTNTBC	.158	93,200			85,650	0
INVGNUT	0	19,500	60,123	.071		
INVGMCP	1.710	23,600			21,403	.840
RICE	.040	39,800			35,325	0
ROOTS	.190	135,000			24,624	0
DRYVEG	.060	145,000			17,954	0
BUSHMCP	.224	23,000			15,450	.066
BUSHNUT	0	37,700	60,743	.071		
SHPGOAT	5.501	1,100			900	0
PIG	0	1,750	2,310	1.97		
2STEERS	0	14,000	19,250	.31		

[a]From Table 9.1 in hectares or animal units.

[b]Objective Function Coefficients from Table 8.1, in CFA.

[c]Amount to which the O.F.C. must be raised in order for the enterprise to enter the solution.

[d]Level at which the enterprise currently not in the solution will enter if the O.F.C. is raised to the level specified in (c), in hectares or animal units.

[e]Amount to which the O.F.C. must fall in order for the optimal allocation in (a) to decrease.

[f]New level of enterprise when O.F.C. falls to the amount specified in (e).

[g]Labels as in Tabel 9.1. The full key to labels is given in Table 8.2.

that are chosen in the optimal solution, the relevant information is the objective function coefficient value at which the optimal activity level decreases. For example, the level of millet and sorghum on house fields (HOUSMS) remains optimal until the value of one hectare falls to 21,516 CFA. At and beyond that point, the new optimal level of production is zero. For enterprises not chosen in the optimal solution, the pertinent data is the objective function coefficient level at which the activity enters a solution in a positive manner. For example, a new optimal solution involving .071 hectares of groundnuts on in-village fields (INVGNUT) is indicated when the coefficient of the latter attains 60,123 CFA.

The results in Table 9.5 indicate that it is unlikely that maize or groundnuts will become part of the optimal strategy in the absence of truly substantial price and/or yield increases. The value of one hectare of in-village groundnuts would have to triple before the activity would enter the basis. On the other hand, a 32 percent increase in pork liveweight prices would be necessary to encourage swine production. More importantly from the point of view of this study, a 38 percent increase in the net revenue from two head of cattle is necessary for the latter to be included in the optimal solution. Since labor is the only factor of production for cattle in the model, this is tantamount to the result that a 38 percent uniform reduction in the labor requirements for cattle is required before they would be kept by a revenue maximizing farmer. Furthermore, even this substantive change is associated with only an optimal level of .31 of two steers. Given the indivisibility of the latter, it is quite possible that a much larger increase in the objective function coefficient would be required to make keeping cattle an "economic" (optimal) solution.[1]

Of the non-millet crop mixtures, rice and cotton-plus-tobacco are the activities that seem most sensitive to price. A decline of

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[1]The labor requirements in the model are for a two head enterprise. They cannot be halved for a one animal activity because of economies of scale in herding. As the previous section demonstrated, forcing the program to choose the entire two animal unit incurs more than a 10,000 CFA opportunity cost, or 70% of the value of the cattle objective function coefficient.

approximately one tenth of their value is enough to make them leave the optimal solution. The apparent sensitivity of in-village millet and cowpeas is misleading. The results indicate that at a level of returns per hectare for INVGMCP, it becomes preferable for the program to abandon food grain production on in-village land. However, this is only done in favor of switching production of millet to bush fields. This illustrates the well-established point that as the fertility of in-village land declines, there is likely to be increased pressure on bush land.

Sensitivity of the Estimated Opportunity Costs to Changes in Resource Supplies and Production Constraints.-- This section gives estimates of the range around the value of each nonzero dual variable for which the "shadow price" remains unchanged.[1] The given value of the dual in question then represents the opportunity cost of scarce factors of production while resource supplies remain within those limits.[2] The information presented is useful in determining the sensitivity of the estimated "shadow prices," or estimated marginal changes in the overall value of production, to changes in resource supplies. When the supply of a resource is lowered beyond the range given, presumably its opportunity cost per unit exceeds the value indicated by the current dual variable. Furthermore, the range of resource availability applicable to a given dual variable value indicates the extent to which a resource (or production limit such as MINFD) can be raised or lowered at the same net opportunity cost (the dual) per unit of production.

The results for the basic model (Run 1) are given in Table 9.6. They indicate that the marginal value products of most of the fully used resources do not change over a relatively large range of resource supply levels. The exception is millet harvest labor (LABOR 14). In this case, a 4 percent decrease of a 7 percent increase in the number of hours supplied will change the dual value. Table 9.6 also shows that the change

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[1]Each resource supply is varied in isolation, assuming that the other retain the values used in the original problem.

[2]Provided the current optimal solution remains feasible. (Wagner, 1969, pp. 140-141).

TABLE 9.6

SENSITIVITY ANALYSIS OF THE RESOURCE SUPPLIES AND PRODUCTION LIMITS IN THE BASIC MODEL (RUN 1)

Resource or Product[a]	Amount Available[b]		Marginal Product of One Unit[c]	Range to Which the Marginal Product Applies[d]	
Label	(Quantity)	(Unit)	(CFA)	Lower Level (Unit given in (b))	Upper Level
HOUSLD[e]	.750	Hectares	16,297	.257	.972
INVGLD[f]	1.710	"	2,197	.840	1.932
LOWLD[g]	.290	"	4,476	.250	.450
LABOR8[h]	556	Hours	11	443	617
LABOR14[i]	554	"	173	533	595
MAXMV[j]	.096	Hectares	119,488	.025	.226
MINFD[k]	2.43	"	9,916	2.23	2.57

[a]Only binding constraints are considered.

[b]From Table 8.1

[c]The dual activity; this assumes that the current optimal basis remains feasible within the range specified in (d).

[d]Range for which the marginal product in (c) applies.

[e]House land

[f]In-village Land

[g]Lowland

[h]Labor from 15 to 28 August

[i]Labor from 7 to 20 November

[j]Maximum maize and wet season vegetable field area

[k]Minimum food grain field area

in the overall value of production associated with a one hectare change in the MINFD constraint is constant only over a small range, from 2.23 to 2.57 hectares. Thus, the net cost of increasing the minimum level of food grain production grows larger after the 2.57 hectare level is surpassed. It will presumably decrease when the constraint is lowered beyond the 2.23 hectare level. Since the minimum food grain constraint is a behavioral relationship which embodies a hypothesis concerning peasant behavior, the sensitivity of results to different specified levels is of particular interest. The next subsection examines the impact on the results of the basic model of widely different assumptions concerning prices, yields, and minimum desired production levels of food grains.

Sensitivity of the Results of the Basic Model to Widely Different Assumptions Concerning Food Grain Production.-- The sensitivity analysis in the previous subsections served to indicate the effects of minor changes in coefficient values and production limits. This subsection examines the effects of major seasonal price increases and the relaxation of the food grain constraint. The results indicate that a doubling of the revenue from each hectare put under millet barely affects the optimal allocation of resources. Without the minimum food grain production constraint, however, the basic model with the old prices has a very different optimal solution. Millet production is halved, while sheep, goats and pigs enter the optimal production strategy up to their permissible levels. Cattle are still not kept. The change in net revenue from cattle required for large stock to become profitable is much smaller, however, at twelve percent.

The model handles the seasonal variation in millet prices described in chapter seven by assuming that the farmer can store surplus grain until prices are highest during the next rainy season. He than sells the grain minus the storage losses (and/or the discount for late payment). The revenue (objective function coefficient) for all millet activities is doubled, and the model rerun to observe the effects of this marketing strategy.[1] The results are given in Table 9.7 under the label of Run 3, along with comparative data. In addition to the substantial increase in the total returns to the farm, the principal result of this procedure is to shift house land under cotton and tobacco (CTNTBC) to millet-sorghums on house land (HOUSMS). The labor thus liberated from a high to a low labor input crop is added to that from small ruminants in order to increase the area of bush millet fields in the new optimal solution. Run 4 in Table 9.7 increases the millet objective function coefficients of the basic model by a factor of three, with no effect on the optimal solution in Run 3. It is interesting to note that the MINFD constraint in Runs 3 and 4 is not binding. This implies that using the seasonal maximum millet price by itself ensures the production in the optimal strategy of a supply of food grains adequate to meet the MINFD requirements. The actual practice of Tenkodogo's farmers of putting a large proportion of their resources into food grain production (see the last column of Table 9.7) thus might be explained either by a desire for on-farm self-sufficiency (MINFD constraint approach), or by reference to peak season food grain prices (Run 3 approach) while retaining the assumption that they seek to maximize their revenue. In practice, both the desires for self-sufficiency and to take advantage of seasonal high prices are likely to affect farmer psychology.

Returning to the basic model of Table 8.1, the question of interest then concerns the optimal solution if food grain prices remain at their original level and there is no food grain constraint. The results of the basic model with MINFD suppressed are given in column five of

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[1]This takes the 250% increase in millet prices observed between January and August 1976 as the point of departure. Then assuming a 20% rate of storage losses, the net effect on the objective function coefficient (= Price x Yield) is 250% x 80% = 200%. This assumes that the same price increases and storage losses also pertain to sorghum and cowpeas, which is permissable for the purposes here. This operation also illustrates the case of neutral technological change on a small number of farms in isolation. This would be the case where an infusion of capital increased yields relative to the fixed inputs of labor and land. Prices in the latter case remain constant because only a small number of farms are concerned, thus the overall supply of millet in the economy is barely affected.

TABLE 9.7

SUMMARY OF THE OPTIMAL SOLUTIONS TO THE BASIC MODEL UNDER DIFFERENT ASSUMPTIONS

Units	Description of Model:	As in Table 8.1	Run 1 with Forced 2 STEERS	Run 1 with OFC[a] of all Millet Activities Doubled	Ditto, But OFC Tripled	Run 1 with No MINFD	Run 1 with MINFD=2.93	Actual Average Farm in 1976[b]
	Run No.: / Enterprise[c]	1	2	3	4	5	6	
Hectares	HOUSMS	.496	.654	.654	.654	.541	.650	.723
	WETVEG	.096	.096	.096	.096	.096	.096	.005
	MAIZE	0	0	0	0	0	0	.020
	CTNTBC	.158	0	0	0	.113	.004	.002
	INVGNUT	0	0	0	0	0	0	0
	INVGMCP	1.710	1.710	1.710	1.710	.764	1.710	1.540
	RICE	.040	0	0	0	.040	.040	.190
	ROOTS	.190	.159	.190	.190	.190	.190	.060
	DRYVEG	.060	.060	.060	.060	.060	.060	.005
	BUSHMCP	.224	.066	.617	.617	0	.570	1.007
	BUSHNUT	0	0	0	0	0	0	0
Head	SHPGOAT	5.501	0	0	0	20	0	5.8
	PIG	0	0	0	0	10	0	.3
2 Head	2STEERS	0	1	0	0	0	0	0
	Objective Function Value:	134,834	124,597	206,656	285,849	138,317	128,216	111,382

NOTES: [a]OFC = Objective Function Coefficient = Net Revenue from One Unit of Enterprise

[b]Values for the actual average farm in 1976 come from Table 5.11 and tables 6.9 and 6.10. The production of millet in housefields is calculated by taking the average area of houseland available and subtracting the allocations to the other housecrops. Millet on in-village fields = INVGLD - INVGNUT, since groundnuts were rarely grown in bush fields. Bush millet is what is left from the average area planted of 3.27 hectares.

The value of the produce of the average farm in 1976 is calculated using the linear programming coefficients, which gives a slightly lower value than the more precise estimation based on individual crops in chapter seven.

[c]Enterprise labels from Tables 8.2 or 9.1 (MS = millet and sorghum; MCP = millet and cowpeas; CTNTBC = cotton and tobacco)

Table 9.7. The main finding is that cattle are still not part of the optimal solution. The absence of the food grain constraint, however, does reduce the penalty associated with keeping cattle to 1,747 CFA above the amount of net revenue that the enterprise would bring in. The implication is that a twelve percent decrease in labor requirements or an equal increase in the revenue from two head of on-farm cattle (objective function coefficient) would bring this activity into the optimal solution, in the absence of a required minimum millet production level.

In the new program (Run 5), the overall value of production is only three percent higher than in Run 1. However, there has been a massive reallocation of labor away from food grains and into small stock. Millet production falls by 46 percent, principally on bush and in-village fields. Small ruminants and swine, on the other hand, are kept up to their maximum permissible levels. The latter, it will be recalled, are limited by an implicit capital constraint on further out-put. The conclusion is that to the extent that farmers are profit maximizers, a new absence of concern about on-farm self-sufficiency of food grains may well be translated into increased holdings of small stock, as opposed to on-farm cattle. The relaxation of the need to devote so many resources to millet, however, does make it less costly to hold cattle.

An increased concern about farm production of millet, on the other hand, is represented in the model by an increased MINFD constraint. The latter was raised in Run 6 to 2.93 hectares, or one-half hectare above the MINFD limit of the basic model.[1] The results in column six of Table 9.7 show that most cotton and tobacco and all small ruminant activities are reduced in favor of the expanded food grain production. The predicted income penalty for keeping two head of cattle in this situation rises to over 200,000 CFA. Resource allocations to wet and dry season vegetables, starchy root crops, and rice remain unchanged from the solution to the basic model. Again, the principal trade-off between farm enterprises is that between millet and small ruminants. A required increase in the former leads to a optimal solution with reduced amounts of the latter and other activities relatively unchanged.

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[1]The problem becomes infeasible at MINFD = 3.12 Ha.

Finally, the model can be used to explore the new optimal solutions suggested by wide-scale adoption of new food grain technologies.[1] The exercise requires assumptions about the food grain market and how increased supplies will affect prices. Further assumptions are also necessary concerning farmer access to credit for the implementation of the innovations. All this surpasses the scope of this study, but should be borne in mind for further investigation. Once the objective function coefficients for millet activities are adjusted to show new price and yield relationships, the MINFD constraint needs to be revised downwards. This will, per force, be at a lesser rate than the rate of yield increase if the marginal on-farm propensity to consume food grains is greater than zero.[2]

The Opportunity Cost of On-Farm Cattle and the Minimum Food Grain Constraint

The first section of this chapter showed that the net effect of forcing a cattle enterprise into the optimal solution of the basic model was to lower the overall value of output by approximately 10,200 CFA. Since the net addition to revenue from the large stock activity alone is 14,000 CFA, it follows that the opportunity cost of two head of cattle is 24,200 CFA.[3] The second section of this chapter implied that this opportunity cost increases with higher levels of food grain production. The basic model assumes that 63 percent of farm land is put into crop combinations involving millet. Since this is a minimum with respect to actual farm data in 1976, it seems likely that in most cases the cash opportunity cost of resources necessary for keeping cattle on

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[1]For the time being, these are not available for dry land millet cultivation in Upper Volta.

[2]Since some of the new production increases are consumed by the farmer.

[3]The resources used to maintain two head of cattle bring in 14,000 CFA in the livestock activity, but are capable of earning this sum plus 10,200 CFA if optimally reallocated among other activities.

the farm is even greater. Furthermore, we saw that evaluating food grain output at seasonally high prices rather than yearly lows raises the level of grain output in the optimal solution just as substantially as raising the minimum permitted level of food grain production in the basic model.

In response to these problems, this section derives an estimate of the opportunity cost of two head of cattle directly in terms of foregone millet output. The result has the advantage of being independent of prices, since the trade-off between the two enterprises is established solely on the basis of requirements for scarce resources. The disadvantage of the procedure is that a small amount of inefficiency is introduced into the program by assuming that only food grains are sacrificed in order to produce livestock.[1]

The point of departure as before is the optimal solution to the basic model, found in Run 1 (see Table 9.1). Land and labor allocations to all activities except those involving millet are fixed in a new program, Run 7. Then, two head of cattle are forced into the solution set and the MINFD constraint removed. The new optimal solution in Run 7 thus includes two head of cattle and the non-millet activities previously chosen as optimal. Food grain enterprises are diminished by just enough to free the minimum of labor required for maintaining the two head of cattle. The results are given in Table 9.8 which show that bush millet has disappeared entirely and in-village millet area is reduced. The net effect of the two cattle enterprises is to use the labor devoted previously to 1.21 hectares of millet and cowpeas.[2]

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[1]The procedure in the first section allowed the output of other crops and livestock to be reduced as well in order to produce the highest value package involving two head of cattle. Since food grains form a large proportion of output, the degree of inefficiency is fairly small as will soon be apparent. Using the objective function coefficient for bush millet, 24,200 CFA is equivalent to 1.05 hectares of millet and cowpeas.

[2]Chapter seven showed very little difference in the yields of millet and cowpeas on bush as opposed to in-village fields. The two cases are lumped together here.

TABLE 9.8

CALCULATION OF THE OPPORTUNITY COST OF TWO HEAD OF ON-FARM CATTLE IN TERMS OF MILLET AND COWPEAS

Enterprise	Optimal Solution to the Basic Model (in hectare or animal units)	Same, With All Activities Except Food Grains Fixed, and Cattle Forced In	Net Change
HOUSMS	.496	.496	0
WETVEG	.096	.096	
MAIZE	0		
CTNTBC	.158	.158	
INVGNUT	0	0	
INVGMCP	1.710	.723	-.987 Ha
RICE	.040	.040	
ROOTS	.190	.190	
DRYVEG	.060	.060	
BUSHMCP	.224	0	-.224 Ha
BUSHNUT	0	0	
SHPGOAT	5.501	5.501	
PIG	0	0	
2STEERS	0	1.0	+1.0 x animals
Optimal Objective Function Value (FCFA)	134,834	120,401	Δ=-1.21 Ha of MCP + 2 Head of Cattle

SOURCES: See text

This also serves to diminish the net overall value of farm output by 14,400 CFA, or eleven percent of the previous optimal solution. The 50 percent reduction in millet area would correspond in 1976 to a decrease in farm production of 340 kg. of millet and 800 kg. of cowpeas.

Since the point of departure, as before, is the basic model, the scarce resources which require a decrease in millet production in order to produce cattle are labor in late August and labor in mid November.[1] Stated in the terms of chapter one, peak season labor requirements operate to place a prohibitive opportunity cost on cattle kept on the farm. This result holds where the farmer starts with a relatively low proportion (63%) of household land under food grains and is willing to reduce this allocation further. The results in the previous section indicate that if a higher proportion of land is under food grains at the beginning, or farmers are unwilling to reduce allocations to millet below 63 percent, then the actual oash opportunities cost of cattle is even greater than that implied by 1.21 hectares of food grains. This is the case because higher value cash crops must then be sacrificed. Since actual behavior in 1976 indicates that self-sufficiency in food grains is a major farmer objective, the results here should be interpreted as saying that, even under the most favorable assumptions, farmers have a very distinct interest in not keeping cattle on the farm.

The results in this chapter depend upon the assumption that on-farm cattle are not used for animal traction in any way that affects the yields or labor requirements of crops. The next chapter extends the analysis to cover this case.

[1]These are the binding constraints in the optimal solution to the basic model. It is assumed that cattle do not require land.

CHAPTER 10

INTRODUCING ANIMAL TRACTION INTO THE MODEL

This chapter introduces bovine animal traction into the basic model in an attempt to derive a profitable livestock enterprise involving a combination of growing animals out for meat, ox power, and a source of manure. In the absence of the possibility of direct observation of traction results in the research area, the effect of ox plowing on the yields and labor requirements of different crops is derived from the most enthusiastic accounts available in the literature. The resulting model shows that animal traction adds very little to the maximum revenue attainable by a model farmer. When the cost of traction equipment and the optimistic nature of the underlying assumptions are taken into account, it is clear that ox plowing is a losing venture in the Tenkodogo area. This finding is considerably strengthened when farmers are required to cultivate a substantial area of food grains in the model, as is the case with a behavioral minimum food grain constraint equal to the smallest amount of millet cultivated by sample members in 1976. Under these circumstances, using animal traction on millet is clearly suboptimal. Using ox plowing on cash crops alone does not improve the maximum obtainable farm income over what it would be if the animals were simply left idle. The problem is the high opportunity cost of labor in November; this is aggravated by concentrating in millet, a crop that is harvested during that month. The use of labor to maintain cattle during November results in forfeited grain production. The value of that forfeited production surpasses the benefits obtainable from the combined beef cattle-cum-traction enterprise. Even with the possibility of animal traction, the optimal strategy for the farmer is still to entrust his cattle to Fulani herdsmen. The greater his desire to be self-sufficient in food grains, the greater is his loss in keeping his own cattle on the farm.

Overview of the Model with Animal Traction

This section places the basic model of chapter eight into the context of the Francophone West African debate on the advantages of animal traction. A number of authors have proposed a joint cattle enterprise, combining the growing out of purchased young males with animal traction, in order to successfully integrate livestock with crop raising. The objective of this section is to derive a new model which incorporates the effects of animal traction on agriculture, thereby adding to the benefits projected for on-farm cattle in previous chapters. The optimal solution to the new linear model will indicate whether it is at least possible to have a net revenue from using traction that is superior to the maximum attainable farm revenue in the old basic model. Care is exercised to avoid the underestimation of benefits from traction in order to give the case in favor of this activity a fair chance. In the absence of the possibility of direct observation of bovine animal traction in the research area, the effects of ox plowing on the yields and labor requirements of crops are gauged from an authoritative French study done on this subject in Upper Volta. Since this work is the center piece of the pro-traction literature produced by the expatriate community of agricultural technicians in Upper Volta, its use ensures that as favorable a case as possible is made for the enterprise.

The Issue and the Approach.--The issue to be resolved here is whether the combination of bovine animal traction with the manure production and beef growing-out enterprise is likely to provide profitable new opportunities for Tenkodogo farmers. Chapter nine showed that, in the absence of animal traction, farmers maximize their revenue by concentrating in crops and small stock, to the exclusion of on-farm cattle. Field studies by French experts on African livestock questions raise some concern about the profitability of animal traciton in a traditional smallholder setting (Tacher, Lachaux, and Nicolas, 1969; Mesnil, 1970). In response to these concerns, some experts have suggested that the combination of bovine animal traction with the type of growing-out cattle enterprise typified by "2 STEERS" in the basic model may make the joint activity profitable, even if the individual components are not (Boudet, 1969; Tacher, Lachaux, and Nicolas, 1969; Robinet, 1972). Presumably this would be the case by providing an extra return to the (supposedly) constant cash or labor cost of maintaining the animals. The proposed strategy involves the purchase of two young males which are trained for traction by age four. They are sold between ages six and eight for meat (Ibid.).

Since no one in the sample--and very few individuals in the region--used bovine animal traction, this hypothesis cannot be tested here using direct observation.[1] The approach used, therefore, relies upon showing that the yield and labor requirement changes predicted by the expatriate proponents of bovine animal traction operate to decrease farm revenue in the basic model. The source of these predictions is a joint paper by staff members of the two principal agricultural research stations in Upper Volta, entitled: "State of the Arts in the Association of Crop and Stock Raising in Upper Volta."[2] This appears to be the most authoritative statement to date of the conventional expatriate wisdom on the subject. For brevity, the figures cited will be referred to as the "I.R.A.T. predictions."[3]

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[1]Figures from the Center-East O.R.D., which includes Tenkodogo, show that there were 52 teams of plow oxen in 1975, for a region with 365,000 inhabitants in 1976.

[2]Dupont de Dinechin et al., 1969. This is my translation of: "Données Actuelles Sur l'Association de l'Agriculture et de l'Elevage en Haute-Volta."

[3]IRAT-Institut de Recherches Agronomiques Tropicales, the institute employing experts cited in the previous footnote.

The I.R.A.T. Predictions in the Context of the Basic Model.--The I.R.A.T. study claims that bovine animal traction raises yields of sorghum, peanuts, and cotton by a factor of two to three. The procedure also changes labor requirements, according to this account. The time required for seed bed preparation decreases in all three cases due to the use of the plow. The I.R.A.T. article is not clear as to whether animal traction affects other tasks directly or only by changing the pattern and density of plants in the field. In any event, the predictions state that weeding labor requirements increase slightly for sorghum and peanuts, but not for cotton. Harvesting labor requirements increase greatly, however, primarily because of the yield increases. The latter require extra labor for harvesting and transporting the extra produce. Given the labor-intensive methods used, there is little in the way of economies of scale.

It should be clear that the author in no way endorses these estimates, which were made by a research group with a vested interest in animal traction programs. The point here is to follow the implications of the I.R.A.T. statements through the production process, to gauge the overall effect of this activity on farm output if the predictions are true. This is done via the labor allocation scheme of the basic model, which takes into account the opportunity cost of labor. The new model assumes that the farmer uses animal traction on a wide variety of crops, including food grains. The choice within the model relates to which crops to produce, but not to the technique employed. The last section deals with the case where the farmer is permitted to choose whether to use traction on food grains or not. The result of not using traction on any crops is equivalent to the results of the previous chapter where traction is not considered.

The I.R.A.T. predictions for yield increases stemming from the use of animal traction are given in Table 10.1. The table converts the French estimates into a form usable in the basic model. Following the policy of making animal traction as attractive as possible, millet

TABLE 10.1

THE I.R.A.T. ANIMAL TRACTION YIELD MULTIPLIERS IN THE CONTEXT OF THE BASIC MODEL

I.R.A.T. Activity	Basic Model Activity	Yield Multipliers[a]	Added Cash Cost of Intermediate Inputs[b] (CFA-Ha.)	New Net Revenue per Ha. for Enterprises in Basic Model with Animal Traction[c]
	HOUSMS			82,940
Sorghum	INVGMCP	2.2	875[e]	51,045
	BUSHMCP			49,725
Peanuts	INVGNUT	2.9	875[e]	55,675
	BUSHNUT			108,455
Cotton	CTNTBC	3.3	12,500[f]	295,060
	Rice[d]	2	0	76,100

SOURCES: [a]Derived from figures in Dupont de Dinechin et al., 1969, p. 282. The increase in yields predicted for each enterprise using animal traction is obtained by multiplying the pre-traction yields by these numbers.

[b]The minimum extra input in subsidized fertilizer and insecticide in order to achieve the pre-icted yields.

[c]= Objective function coefficients in the basic model multiplied by (a), minus (b)

[d]In order to make the most favorable case for animal traction, it is assumed, rather arbitrarily, that plowing increases rice yields by a factor of two. The I.R.A.T. study makes no mention of this crop.

[e]= 25 kg. of fertilizer x 35 CFA = 875 CFA/Ha.

[f]= 100 kg. of fertilizer + 16 liters insecticide + rental on sprayers = 12,500 CFA/Ha.

yields are assumed to increase as much as those of sorghum, even though there is some evidence that this is not the case (De Wilde, 1967, II, p. 389). In the same vein, the yield of rice crops is increased by a factor of two, even though the I.R.A.T. study does not mention this crop. The justification for this is that plowing may be especially useful in the aeration of the relatively dense lowland soils.

Small cash costs of the minimum purchased inputs (other than traction equipment) necessary for achieving the predicted yields are netted out from the objective function coefficients. The subsidized price of inputs serves to insure that the estimated cash costs understate the true expense involved, particularly since these items are typically not available in Tenkodogo. Finally, the traction option is assumed to be available to a sufficiently limited number of farmers that any ensuing yield benefits will not depress the market price of outputs. Besides being realistic, this also serves to ensure that the objective function coefficients in the animal traction program are as high as possible.

The I.R.A.T. predictions for the effect of animal traction on labor requirements are contained in Table 10.2. Seed bed preparation labor requirements for sorghum, peanuts and cotton decline, while weeding time increases. Harvest labor inputs for all three crops are up sharply because of greatly increased yields. The added rice enterprise has also modified labor requirements in the animal traction model although the I.R.A.T. article does not mention this crop. The somewhat arbitrary hypothesis here is that plowing reduces seed bed preparation by 60 percent. As in the case of the I.R.A.T. estimate for cotton and tobacco, it is assumed that the presence of the animal traction option does not affect labor requirements for weeding rice.[1] Only one negative effect

[1]Much of the rice weeding actually involves transplanting shoots by hand.

TABLE 10.2

THE I.R.A.T. ANIMAL TRACTION LABOR MULTIPLIERS[a] IN THE CONTEXT OF THE BASIC MODEL

I.R.A.T. Task		Seed Bed Preparation	Weeding and Maintenance	Harvesting and Processing
Basic Model Labor Period		Fortnights 1, 2, 17-26	Fortnight 6	Fortnight 14
I.R.A.T. Activity	Basic Model Activity			
Sorghum	All Food Grains	0.83	1.25	2.5
Peanuts	All Ground-nuts	0.5	1.5	2.84
Cotton	Cotton and Tobacco	0.58	1	5.8
	Rice[c]	0.4	1	2

SOURCES: [a]The numbers in the body of the table are derived from figures in Dupont de Dinechin et al., 1969, p. 281. The change in labor requirements predicted for each enterprise using animal traction is obtained by multiplying the pre-traction requirements by these numbers.

[b]The correspondence between task and time period is derived using Table 4.12 (Chapter 4, page 111). Also see the text.

[c]In order to make the most favorable case for animal traction, it is assumed, somewhat arbitrarily, that plowing reduces seed bed preparation by 60%, does not affect weeding (which is largely transplanting in the case of rice), and increases harvest labor in direct proportion to the predicted increase in yields.

of animal traction on this crop is assumed in the model: the projected twofold increase in yields doubles the amount of labor time required per hectare to harvest and transport output.

The correspondence between cropping tasks and the fortnights when labor requirements must be supplied is derived from the data in chapter four (page 111). In a final effort to present the case as favorably to the traction proponents as possible, the labor requirements for crop enterprises are reduced according to the proportions stated in Table 10.2 for <u>every</u> fortnight which might involve seed bed preparation work. However, increases in requirements due to weeding are only registered during fortnight 6 (late July), even though by the same logic every coefficient in fortnights 3 to 8 should be multiplied by the figures in Table 10.2. Furthermore, the extra labor requirements for harvesting are only taken into consideration for fortnight 14 (mid November). Again, a consistent logic would involve increasing all the coefficients from periods 9 through 16.

A few final adjustments remain in order to introduce animal traction into the basic model. These also operate in favor of the pro-livestock case. First, the supply of bush land is explicitly increased to five hectares in response to the argument that traction permits the farmer to cultivate a greater area. Second, the original minimum food grain constraint of 2.43 hectares is decreased by the same factor that yields are assumed to increase in Table 10.1. This gives a new MINFD level of 1.10 hectares. Finally, a forcing unit ensures that two head of cattle are kept in the optimal solution, in order to provide the required animal power. The new Model II, taking account of the predicted effects of animal traction, is displayed in Table 10.3. The next section discusses the results of various runs with this model and performs a sensitivity analysis of parameters.

TABLE 10.3

TENKODOGO FARM LINEAR PROGRAM MODEL II
(Assuming Traction Boosts Labor Requirements and Yields)

			HOUSMS 82,940	WET VEG 145,000	MAIZE 20,800	CTNTBC 295,060	INVGNUT 55,675	INVGMCP 51,045	RICE 76,100	ROOTS 135,000	DRY VEG 145,000	BUSHMCP 49,725	BUSHNUT 108,455	SHPGOAT 1,100	PIG 1,750	2 STEERS 14,000
HOUSLD	.75	≥	1	1	1	1	0	0	0	0	0	0	0	0	0	0
INVCLD	1.71	≥	0	0	0	0	1	1	0	0	0	0	0	0	0	0
LOWLD	[illegible].29	≥	0	0	0	0	0	0	1	1	1	0	0	0	0	0
BUSHLD	[illegible]	≥	0	0	0	0	0	0	0	0	0	1	1	0	0	0
LABOR 1	556	≥	111	0	0	0	0	111	9	1	0	117	0	8	3	84
2	556	≥	141	0	280	0	58	141	82	26	0	149	61	8	2	84
3	556	≥	159	0	549	0	174	159	264	0	0	167	188	6	4	105
4	556	≥	172	0	119	0	109	172	327	10	0	181	114	6	9	105
5	556	≥	146	53	589	67	216	146	380	16	0	153	227	6	12	105
6	556	≥	196	6	392	6	440	196	355	91	0	206	462	6	6	105
7	556	≥	105	231	200	293	142	105	283	259	0	110	149	6	7	105
8	556	≥	86	875	38	1,100	102	86	171	256	0	90	107	6	6	105
9	556	≥	85	88	74	88	29	85	31	42	0	89	30	6	10	105
10	556	≥	27	277	0	10	17	27	40	66	0	28	18	6	8	105
11	556	≥	5	235	0	264	22	5	45	300	0	5	23	6	2	105
12	556	≥	28	201	0	88	106	28	127	313	0	29	111	6	11	105
13	556	≥	32	109	0	792	265	32	114	175	0	34	278	6	9	105
14	554	≥	440	0	0	2,192	931	440	388	101	78	463	976	6	13	105
15	556	≥	94	0	0	110	38	94	31	106	104	99	40	4	6	105
16	556	≥	8	0	0	1,144	3	8	4	98	174	8	3	4	8	105
17	556	≥	0	0	0	440	0	0	0	215	398	0	0	4	14	35
18	511	≥	0	0	0	220	0	0	0	118	454	0	0	4	9	35
19	505	≥	0	0	0	0	0	0	0	62	450	0	0	4	9	35
20	495	≥	0	0	0	0	0	0	0	30	335	0	0	4	7	35
21	450	≥	0	0	0	0	0	0	0	53	391	0	0	4	7	35
22	471	≥	0	0	0	0	0	0	0	20	416	0	0	5	9	35
23	425	≥	1	0	0	0	0	1	0	4	303	1	0	6	6	84
24	455	≥	2	0	0	0	0	2	0	0	386	3	0	7	2	84
25	424	≥	7	0	71	0	0	7	0	0	291	8	0	8	8	84
LABOR 26	368	≥	17	0	69	0	0	17	0	0	37	22	0	8	4	84
MAXMV	.096	≥	0	1	1	0	0	0	0	0	0	0	0	0	0	0
MAXCT	.244	≥	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MAXRT	.19	≥	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAXDV	.06	≥	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MAXSG	20	≥	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MAXPG	10	≥	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MAXBO	1	=	0	0	0	0	0	0	0	0	0	0	0	0	0	1

The Optimal Production Strategy Using Animal Traction on Food Grains and Cash Crops

The principal result in this section is that, even under the most favorable assumptions, animal traction is a very marginal enterprise in the model farm when it is used on all major crops. The value of the optimal production package in Model II, with no restriction on the amount of food grain to be produced, is only 3,485 CFA or 3% higher than the equivalent value in the optimal solution to the basic model without ox power, where cattle are consigned to the Fulani. However, this figure ignores the cost of traction equipment and any risks involved in working with unfamiliar equipment. It is also based on the doubtful premise that the plow oxen also return 14,000 CFA per year in manure and increased liveweight (for eventual meat sales) benefits. Even if traction equipment were costless, did not depreciate, and the draft team gained weight at the best rate observed for steers in feed lots, the net gain from a combined on-farm cattle and traction enterprise is very small. It also depends upon the farmer changing his production strategy to precise new optimal levels of each activity. Most significantly, the new optimal output bundle with traction produces only a small amount of food grains. When the minimum food grain production level is raised above a level equivalent to 1.5 hectares in the old basic model, the new optimal output package under traction is actually worth less than that in the basic model where on-farm self-sufficiency in food grains is met (MINFD = 2.43 ha.).

The Optimal Solution to the Model with Animal Traction and No MINFD Constraint.--This subsection contains the results from the maximization of the objective function of Model II (Table 8.3), without any minimum food grain production level. The lack of the latter ensures that the solution obtained is optimal with respect to the purely technical conditions imposed by land and labor requirements. Including the behavioral condition embodied in MINFD only adds an extra restriction on the optimal solution. Thus, any other solution to Model II cannot involve a higher value of production than the optimal solution of Model II with no minimum food constraint.

The results are given in Table 10.4, and show that the highest value of production that can be obtained in the model with traction used on food grains, peanuts, rice, cotton and tobacco is 141,806 CFA. This is three percent above the comparable value for the basic model without animal traction which corresponds roughly to the actual situation in Tenkodogo (see Table 9.7). Thus, the net return for undertaking the bovine animal traction enterprise on all crops except vegetables, maize, and cassava, is only 3,489 CFA. This figure depends upon the extremely favorable yield assumptions made in the previous section while assessing the impact of animal traction. Furthermore, <u>no account has been made of the cost of traction equipment</u>. The latter sold in Tenkodogo for 43,000 CFA in 1976.[1] Thus, <u>the maximum</u> return on funds invested in traction equipment in this context, with no allowance for depreciation or the risks involved in using unfamiliar material, is eight percent. This is less than half the expected return to cattle entrusted to the Fulani, as calculated in chapter six. Of course, the actual returns to animal traction are likely to be less than the maximum possible returns, as in all areas of economic decision making. This only strengthens the argument against investment in ox plows destined to be used on the majority of farm holdings.

The slack and dual variable values corresponding to the optimal solution in Run 9 are given in Table 10.5. They show that neither in-village nor bush land is used at all, however house fields and lowland are cultivated up to their respective limits. Thus, the most noticeable effect on resource use of introducing this form of animal traction is to lower the value of in-village land, while placing a high premium on lowland.

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[1] Figure from ORD field office Tenkodogo. In part because no one bought equipment in 1976, the ORD offered the same rig in 1977 at the subsidized price of 25,000 CFA.

TABLE 10.4

RESULTS FROM THE MODEL WITH ANIMAL TRACTION AND NO MINFD CONSTRAINT (RUN 9): ENTERPRISES IN THE OPTIMAL SOLUTION

Enterprise Label	Optimal Level Chosen (in hectares or animals)	Upper Limits[a] Imposed By Constraints (in hectares or animals)	Change in Maximand by Forcing the Choice of an Extra Unit of Enterprise[b] (in CFA)
HOUSMS	.654		
WETVEG	.096		
MAIZE			-124,200
CTNTBC		.244	-23,726
INVGNUT			-69,652
INVGMCP			8,816
RICE	.040		
ROOTS	.190	.190	+97,535
DRYVEG	.060	.060	110,631
BUCHMCP			-12,601
BUSHNUT			-22,930
SHPGOAT	20.00	20.00	+292
PIG	.14	10.00	
2STEERS[c]	1.00	1.00	-135

[a]There were no lower limits. Maize and wet season vegetables were jointly constrained to a maximum of .096 hectares.

[b]Valid for only small regions around the optimal solution.

[c]Forced into the solution.

[d]One unit = 2 animals.

TABLE 10.5

SLACKS AND DUALS IN THE OPTIMAL SOLUTION TO THE MODEL
WITH ANIMAL TRACTION AND NO MINFD CONSTRAINT (RUN 9)

ROW	AT	ACTIVITY	SLACK ACTIVITY	LOWER LIMIT	UPPER LIMIT	DUAL ACTIVITY
HOUSLD	UL	.75000	.	NONE	.75000	23709.23077-
INVGLD	BS	.	1.71000	NONE	1.71000	.
LOWLD	UL	.29000	.	NONE	.29000	23869.23077-
BUSHLD	BS	.	5.00000	NONE	5.00000	.
LABOR1	BS	317.57092	238.42908	NONE	556.00000	.
LABOR2	BS	344.71862	211.28138	NONE	556.00000	.
LABOR3	BS	340.11523	215.88477	NONE	556.00000	.
LABOR4	BS	353.74877	202.25123	NONE	556.00000	.
LABOR5	BS	345.51969	210.48031	NONE	556.00000	.
LABOR6	BS	386.10385	169.89615	NONE	556.00000	.
LABOR7	BS	377.37215	178.62785	NONE	556.00000	.
LABOR8	BS	421.57785	134.42215	NONE	556.00000	.
LABOR9	BS	299.68108	256.31892	NONE	556.00000	.
LABOR10	BS	284.52846	271.47154	NONE	556.00000	.
LABOR11	BS	309.91462	246.08538	NONE	556.00000	.
LABOR12	BS	328.72338	227.27662	NONE	556.00000	.
LABOR13	BS	295.48277	260.51723	NONE	556.00000	.
LABOR14	UL	554.00000	.	NONE	554.00000	134.61538-
LABOR15	BS	274.94985	281.05015	NONE	556.00000	.
LABOR16	BS	220.59046	335.40954	NONE	556.00000	.
LABOR17	BS	181.72231	374.27769	NONE	556.00000	.
LABOR18	BS	165.94077	345.05923	NONE	511.00000	.
LABOR19	BS	155.06077	349.93923	NONE	505.00000	.
LABOR20	BS	141.79615	353.20385	NONE	495.00000	.
LABOR21	BS	149.52615	300.47385	NONE	450.00000	.
LABOR22	BS	165.04077	305.95923	NONE	471.00000	.
LABOR23	BS	224.44785	200.55215	NONE	425.00000	.
LABOR24	BS	248.75262	206.24738	NONE	455.00000	.
LABOR25	BS	267.17646	156.82354	NONE	424.00000	.
LABOR26	BS	257.90723	110.09277	NONE	368.00000	.
MAXMV	UL	.09600	.	NONE	.09600	121290.76923-
MINFD	BS	.65400	.65400-		NONE	.

The value of the dual variable associated with the latter indicates that the opportunity cost of lowland within a small range of the optimal solution is calculated at the rate of 23,869 CFA per hectare.[1] The sole binding labor constraint pertains to fortnight 14 (7-20 November) and is attributable to a harvest labor bottleneck. The estimated labor opportunity cost of 135 CFA per hour is comparable to the equivalent value of 118 CFA calculated in the basic model without either animal traction or a minimum food grain production level. The significance of these findings will be explored further at the end of this chapter.

The Optimal Solution to the Model with Animal Traction and a Minimum Level of On-Farm Food Grain Production.--In contrast to the previous subsection, the results given here pertain to the case where farmers are subject to a behavioral constraint to produce food grains. There are two major findings. First, the farm in Model II cannot produce as much food grain using traction as the farm in the basic model could without traction. Second, the maximum income that can be earned by the farmer in this model quickly falls below that available without cattle and traction when food grains are cultivated beyond a certain point. This occurs when the total land area under some combination involving millet is large enough to produce grain equivalent to that yielded by approximately 40 percent of land holdings in the old model.

The minimum food grain production level in Model II (Table 10.3) was set at 1.10 hectares in order to produce the same amount of grain, after the projected yield increases due to animal traction, as the 2.43 hectares in the basic model of Table 8.1. However, Model II is

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[1]Compared with 11.421 CFA per hectare in the optimal solution to the basic model without animal traction or a minimum food grain constraint.

infeasible with MINFD set at this level. In other words, the land and labor constraints incorporated in the model with animal traction are such as to prevent the farmer from producing 1.10 hectares of millet-sorghums with the resources at hand. The program becomes feasible only when MINFD is lowered to 1.10 hectares. Given the postulated yield increases due to traction, this amount of land produces the same amount of grain as 2.24 hectares in the old basic model.

The optimal solution to Model II is given in Table 10.6, with MINFD relaxed just to the point where a solution is feasible. Only crop combinations involving millet and sorghum are grown and livestock is limited to the two steers required for animal traction. The maximum value of the overall production is 100,868 CFA. This is a 25 percent decrease from the 134,834 CFA obtained in the basic model where cattle are entrusted to the Fulani and MINFD is set at 2.43 hectares (Run 1). Thus, the farmer in the model requiring bovine animal traction ends up with a less valuable production bundle <u>and</u> less farm-produced food grain.

Table 10.7 portrays the values of the slack and dual variables corresponding to the optimal solution in Table 10.6. The most noticeable change in resource use as a result of including the minimum food grain production constraint is that lowland ceases to be cultivated. The opportunity cost of house land, as measured by the dual variable[1] has risen to the rate of 31,895 CFA per hectare for small changes in the vicinity of the optimal solution. Harvest labor in fortnight 14 now has a greatly increased opportunity cost, as measured by the corresponding dual variable. The implications are that forcing farmers to use animal traction to cultivate food grains increases the value of fertile house land and seriously aggravates a harvest labor bottleneck.

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[1]Under the usual qualifying conditions.

TABLE 10.6

RESULTS FROM THE MODEL WITH ANIMAL TRACTION AND ALL RESOURCES DEVOTED TO FOOD GRAINS (RUN 10): ENTERPRISES IN THE OPTIMAL SOLUTION

Enterprise Label	Optimal Level Chosen (in hectares or animals)	Upper Limits[a] Imposed By Constraints (in hectares or animals)	Change in Maximand by Forcing the Choice of an Extra Unit of Enterprise (in CFA)[b]
HOUSMS	.654		
WETVEG	.096		
MAIZE			-124,200
CTNTBC		.244	-3,811,706
INVGNUT			-1,675,030
INVGMCP	.366		
RICE			-645,182
ROOTS		.190	-52,756
DRYVEG		.060	
BUSHMCP			-44,076
BUSHNUT			-1,705,904
SHPGOAT		20.00	-10,053
PIG		10.00	-22,417
2STEERS[c]	1.00[d]	1.00	-181,192

[a]There were no lower limits. Maize and wet season vegetables were jointly constrained to a maximum of .096 hectares.

[b]Valid for only small regions around the optimal solution.

[c]Forced into the solution.

[d]One unit = 2 animals.

TABLE 10.7

SLACKS AND DUALS IN THE OPTIMAL SOLUTION TO THE MODEL
WITH ANIMAL TRACTION AND ALL RESOURCES DEVOTED TO FOOD GRAINS

ROW	AT	ACTIVITY	SLACK ACTIVITY	LOWER LIMIT	UPPER LIMIT	DUAL ACTIVITY
HOUSLD	UL	.75000	.	NONE	.75000	31895.00000-
INVGLD	BS	.36645	1.34355	NONE	1.71000	.
LOWLD	BS	.	.29000	NONE	.29000	.
BUSHLD	BS	.	5.00000	NONE	5.00000	.
LABOR1	BS	197.27045	358.72955	NONE	556.00000	.
LABOR2	BS	227.88409	328.11591	NONE	556.00000	.
LABOR3	BS	267.25227	288.74773	NONE	556.00000	.
LABOR4	BS	280.51818	275.48182	NONE	556.00000	.
LABOR5	BS	259.07436	296.92564	NONE	556.00000	.
LABOR6	BS	305.58509	250.41491	NONE	556.00000	.
LABOR7	BS	234.32373	321.67627	NONE	556.00000	.
LABOR8	BS	276.75909	279.24091	NONE	556.00000	.
LABOR9	BS	200.18664	355.81336	NONE	556.00000	.
LABOR10	BS	159.14427	396.85573	NONE	556.00000	.
LABOR11	BS	132.66227	423.33773	NONE	556.00000	.
LABOR12	BS	152.86873	403.13127	NONE	556.00000	.
LABOR13	BS	148.11855	407.88145	NONE	556.00000	.
LABOR14	UL	554.00000	.	NONE	554.00000	1858.97436-
LABOR15	BS	200.92273	355.07727	NONE	556.00000	.
LABOR16	BS	113.16364	442.83636	NONE	556.00000	.
LABOR17	BS	35.00000	521.00000	NONE	556.00000	.
LABOR18	BS	35.00000	476.00000	NONE	511.00000	.
LABOR19	BS	35.00000	470.00000	NONE	505.00000	.
LABOR20	BS	35.00000	460.00000	NONE	495.00000	.
LABOR21	BS	35.00000	415.00000	NONE	450.00000	.
LABOR22	BS	35.00000	436.00000	NONE	471.00000	.
LABOR23	BS	85.02045	339.97955	NONE	425.00000	.
LABOR24	BS	86.04091	368.95909	NONE	455.00000	.
LABOR25	BS	91.14318	332.85682	NONE	424.00000	.
LABOR26	BS	101.34773	266.65227	NONE	368.00000	.
MAXMV	UL	.09600	.	NONE	.09600	113105.00000-
MINFD	LL	1.02045	.	1.02045	NONE	766903.71795

The Effect of the Introduction of Animal Traction upon the Choice of Enterprises

This section shows that a farmer concerned solely with maximizing his revenue will significantly alter the composition of his output bundle when forced to use animal traction on all major crops relative to the package he would produce without ox power. The introduction of bovine traction favors rice and sorghum production relative to cotton and tobacco. Swine output falls to near-zero levels, reflecting a reallocation of labor from pig production to maintaining the draft team. Finally, a profit maximizing farmer forced to use traction on food grains would cultivate only a small area of millet.

A comparison of the output bundles in Models I and II requires some preliminary manipulations of the kind used in the previous section with respect to specifying the level of the basic MINFD constraint in the traction model. This is because animal traction is assumed to increase output per unit of land. Thus, the millet harvested from one hectare of land with hand cultivation could allegedly be produced on .45 hectares of land using ox plowing, assuming that there is sufficient extra labor for the latter task. Therefore, a comparison of the optimal solutions to the basic and traction models requires that the optimal land allocation of the former be converted into units of land of output value equivalent to those used in the traction model. Thus, an allocation of 2.2 hectares to food grains in the basic model produces the same amount of grain as one hectare of the same enterprise in Model II, assuming a 2.2-fold yield increase due to bovine traction.

The optimal solutions to the basic model with and without a MINFD constraint are thus converted from the values given in Table 9.7, using the conversion coefficients for different crops suggested by Table 10.1. The latter correspond to the yield multipliers attributable to animal traction. The results are displayed in the first two columns of Table 10.8. The other columns of this table give the optimal solutions

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TABLE 10.8

The Optimal Solutions to the Basic Model Compared with Those of the Model with Traction

(Areas in the optimal solutions to the basic model are divided by the yield increases ascribed to traction to make them comparable to areas farmed in Model II)[a]

Units	Description of Model:	Basic Model with MINFD = 1.10[b]	Basic Model with No MINFD[c]	Traction Model with No MINFD[d]	Traction Model with MINFD = 1.10[e]	Traction Model with MINFD = 1.02[f]	Basic Model (No traction) with MINFD = 1.10 and 2 steers forced in[g]
	Run No.: Enterprise	1	5	9	11	10	2
	HOUSMS	.225	.246	.654		.654	.297
	WETVEG	.096	.096	.096		.096	.096
	MAIZE	0	0	0		0	0
	CTNTBC	.048	.034	0	I	0	0
	INVGNUT	0	0	0	N	0	0
Hectares	INVGMCP	.777	.339	0	F	.366	.777
	RICE	.020	.020	.040	E	0	0
	ROOTS	.190	.190	.190	A	0	.159
	DRYVEG	.060	.060	.060	S	0	.060
	BUSIMCP	.102	0	0	I	0	.030
	BUSHNUT	0	0	0	B	0	0
Head	SHPGOAT	5.501	20.0	20.0	L	0	0
	PIG	0	10.0	.14	E	0	0
2 Head	2STEERS	0	0	1.02		1.0[h]	1.0[h]
CFA	Objective Function Value	134,834	138,317	141,806	-	100,868	124,597

SOURCES:

[a]See text for explanations, conversion coefficients are from Table 10.1

[b]From Table 9.7, 1.10 hectares in Model II is equivalent to 2.43 hectares in Model I

[c]From Table 9.7

[d]From Table 10.4

[e]See text

[f]From Table 10.6

[g]From Table 9.7

[h]Forced into the solution

to the traction model with and without a MINFD constraint.

The first comparison concerns the solutions of Runs 5 and 9 in Table 10.8. The former corresponds to the basic model without MINFD, while the latter represents the case of animal traction without a MINFD limit. There are four points to note. First, the farmer in Run 9 is obliged to keep two steers to provide animal power, while the optimal strategy in Run 5 does not involve cattle. Second, the cultivation of sorghum and rice increases with the introduction of ox plowing. Third, swine and, somewhat surprisingly, cotton and tobacco production are virtually nil in the optimal strategy for the traction case. This is probably due to the high seasonal labor requirements for those enterprises. The choice of House Field Millet-Sorghums over Cotton and Tobacco in the optimal solution most likely also reflects the artificially high yield increases posited for sorghum in the traction model. One would expect the introduction of animal traction, a priori, to favor cotton cultivation over sorghum in the real world, since traction is often associated with high yield increases in cotton (see Table 10.1). Third, the total area involving some combination of millet in the optimal solutions of the two models is virtually unchanged, as is small ruminant production. Thus, the overall impact of the introduction of animal traction in the model, in the absence of a MINFD constraint, is to increase rice and sorghum production at the expense of swine and cotton and tobacco, leaving millet virtually unchanged.

The picture changes in comparing the optimal solutions to the basic and traction models when a minimum food grain production level is specified. This occurs in Table 10.8 in Runs 1, 10, and 11. The MINFD level of 1.10 hectares in Run 1 as given in Table 10.8 corresponds to 2.43 hectares of land under millet-sorghums where there are no yield increases due to animal traction. Chapter eight showed that this is the minimum amount of food grain that a household the size of the model farm actually cultivated in 1976. The model with forced animal traction on all major crops, however, is unable to grow even this amount of millet. This is because of the November labor conflict between millet cultivation and the maintenance of cattle on the farm. The relatively low overall value and size of production in the traction model with a minimum food grain production level indicates that a farmer would be unlikely to grow more than .654 hectares of millet and sorghum using ox plowing if profit were his only motivation. The next section argues, conversely, that farmers are unlikely to adopt animal traction practices if their major motivation is on-farm self-sufficiency in food grains.

Labor Bottlenecks and the Effect of a Desire for On-Farm Self-Sufficiency in Food Grains upon the Adoption of Animal Traction and On-Farm Cattle Production

The previous section showed that it was not in the interest of the model farmer to put a large portion of his holdings under food grains if he uses animal traction on all his major crops. This section shows that it is not in his interest to use animal traction on any of his crops if he also wishes to grow the amount of millet consistent with the minimum food grain requirement of sixty-three percent of land holdings in the basic model. This is because of the labor requirements for looking after two head of cattle during the crop growing season. The farmer under these conditions is better off not keeping cattle on the farm at all, as long as he can entrust them to the Fulani.

Table 9.3 in the previous chapter contains the optimal production strategy where the farmer maintains two steers on the farm, but does not use them for traction cultivation. This corresponds to the case of the basic model with two forced cattle and a MINFD constraint. As before, the desire for self-sufficiency in food grains is assumed to be satisfied if farm millet output is equal to that quantity that can be harvested off 2.43 hectares in the absence of animal traction. The question now arises as to the optimal production strategy, at this level of MINFD where the farmer is free to limit the use of traction techniques to any group of crops that he chooses.

A new "mixed" model is constructed to investigate the potential of this option. The activities using animal traction in Model II (p. 284) are added to the basic model (p. 230), thus creating a composite model with twenty-one enterprises to choose from. This enables the maximization procedure to select only those traction activities which maximize farm income. The results, which are displayed in Table 10.9, show that the maximum attainable farm revenue in this instance is the same as the income from leaving the two steers idle and cultivating by hand. Chapter nine showed that the maximum attainable farm income can be increased further by simply entrusting the animals to the Fulani and concentrating in crops.

This paradoxical result concerning the economics of animal traction of the variety described in the I.R.A.T. article is attributable to the high opportunity cost of labor during peak periods. The simultaneous requirements of maintaining two head of cattle on the farm during the cropping season and achieving self-sufficiency in food grains operate to create a very tight labor bottleneck in November. Even high extra returns to cash crops with little extra labor requirement are insufficient to boost farm income. There is simply not enough manpower to take advantage of the opportunities.

In sum, there are four main conclusions from the work in this chapter. First, even under the most favorable circumstances (most notably, MINFD=0), the animal traction activity adds very little to the farmer's potential for increasing his income. When the cost of traction equipment, its depreciation, and the risks inherent in using unfamiliar equipment are considered, it seems likely that ox plowing is a losing proposition. Thus animal traction of the type portrayed in the 1969 I.R.A.T. paper (Dupont de Dinechin <u>et. al.</u>) does not provide a <u>panacea</u> for the problems of unprofitable small-scale growing-out operations. Second, this conclusion is significantly reinforced if farmers also wish to put a large portion of their resources into millet production. The results here show that cultivating both food grains and cash crops with traction under these circumstances significantly lowers the maximum income potential of the farm. Furthermore, even if the farmer already has a plow team and equipment, the last section showed that he gains no extra potential revenue

TABLE 10.9

COMPARATIVE OPTIMAL STRATEGIES USING ANIMAL TRACTION WHERE SELF-SUFFICIENCY IN FOOD GRAINS IS REQUIRED

Enterprises (Solution in hectares unless specified otherwise)	Steers kept but no Traction Allowed	Traction Required on Cash Crop and Food Grains[a]	Traction Optional on all Crops
House Millet (hand cultivation)	.654	n.a.	.654
House Millet (traction)	n.a.	.654	0
Wet Season Veg. (hand cultivation)	.096	.096	.096
Maize (hand cultivation)	0	0	0
Cotton and Tab. (hand cultivation)	0	n.a.	0
Cotton and Tab. (traction)	n.a.	0	0
Village Nuts (hand cultivation)	0	n.a.	0
Village Nuts (traction)	n.a.	0	0
Village Millet (hand cultivation)	1.710	n.a.	1.710
Village Millet (traction)	n.a.	.366	0
Rice (hand cultivation)	0	n.a.	0
Rice (traction)	n.a.	0	0
Starchy Roots (hand cultivation)	.159	0	.159
Dry Season Veg. (hand cultivation)	.060	0	.060
Bush Millet (hand cultivation)	.066	n.a.	.066
Bush Millet (traction)	n.a.	0	0
Bush Nut (hand cultivation)	0	n.a.	0
Bush Nut (traction)	n.a.	0	0
Sheep and Goats (head)	0	0	0
Swine (head)	0	0	0
Two Steers (2 head)	1.00[b]	1.00[b]	1.00[b]
Maximum Value of Protection	124,597	100,868	124,597

NOTES: (a) MINFD relaxed to where solution is feasible

(b) forced in

from using them. Third, the solution which maximizes potential farm income, whether there is a MINFD constraint or not, is simply to entrust cattle to the Fulani rather than keeping them near the compound. The problem with animal traction in this context is the same as that of the cattle growing-out enterprise. This is that the labor required to maintain cattle on the farm has a very significant opportunity cost at some point during the growing season (during November in Model II). This opportunity cost is accentuated when relatively large quantities of food grains are grown. In this context, it is the opportunity cost of labor during peak periods which serves to render animal traction uneconomic, even if the yield increases and seed bed preparation labor savings from this technique are substantial.

CHAPTER 11

CONCLUSIONS AND POLICY RECOMMENDATIONS

This chapter begins by reviewing the major results of this inquiry which show that, while on the whole cattle are a profitable enterprise in Tenkodogo, farmers do better to entrust their animals to specialized Fulani herdsmen. This is principally the result of a labor conflict between crops and livestock during November which is aggravated by a widespread desire on the part of farmers to be self-sufficient in food grain production. The use of steers for animal traction in addition to growing-out for beef on the farm does not change these conclusions. The same results are likely to apply to other regions in the West African Savannah which fulfill the six basic conditions that represent the underlying assumptions of the Tenkodogo farming system model. These are: the availability of a cattle entrusting option, relatively high population density, the absence of a suitable forage crop, the lack of agro-industrial by-products for feedstuffs, the effective absence of means to relieve seasonal labor bottlenecks, and the presence of unfavorable soil and land tenure conditions for animal traction.

The principal policy recommendation for Tenkodogo is to use the scarce development funds destined for the direct support of cattle production intensification to support the cattle entrusting system, rather than to encourage stockraising by sedentary peasants. The traditional peasant-herder relationship allows the farmer to invest in cattle at little opportunity cost of resources other than that of the capital involved. It also offers employment in their chosen occupation to the Fulani, a factor which should not be neglected.

In areas similar to Tenkodogo, but without a cattle entrusting option, the desirability of keeping more cattle depends upon the opportunity cost of labor as well as that of capital. In the current state of the arts in crop raising, increased livestock production appears to offer new opportunities for expanding rural incomes and export earnings. Policies designed to favor the cattle enterprise in this context should focus upon five critical issues: the reduction of the peak season labor requirements for animals, raising the returns to a given labor commitment, the easing of labor bottlenecks in food grain production, the abandonment of bush field cultivation in favor of more intensively cultivated in-village plots, and a decline in the opportunity cost of peak season labor from an increased confidence in the market to supply food staples. The curious result emerges that the structural changes in the farming system required to allow sedentary cattle production primarily necessitate improvements in the production methods for food grains.

A Brief Review of Results

The most important implication of the results contained in chapter nine is that keeping cattle on the farm for extra liveweight gains and the usufruct of milk and manure--as opposed to entrusting them to specialized herdsmen--is an enterprise of very dubious profitability in Tenkodogo. This conclusion stems from the high opportunity cost of labor during the harvest season in November. While this result holds even assuming that farmers have no special preference for food grain production, it is reinforced if peasants are in fact unwilling to plant less than sixty-three percent of their land holdings with crop combinations involving millet, the food staple.

This last figure corresponds to the actual minimum proportion of holdings thus cultivated by sample members in 1976. A model starting from the same level of food grain production, with resources otherwise optimally distributed, showed that the net effect of diverting labor resources for the maintenance of two head of cattle on the farm was to lower the production of millet-plus-cowpeas by 1.2 hectares. This foregone crop production, which measures the opportunity cost of livestock in terms of food grains, can be conservatively evaluated at approximately 28,500 CFA.[1] This is the extra amount that farmers would have to make from keeping cattle on the farm, represented by the revenue from milk, extra crop yields due to manure, and any other benefits from controlling their own cattle themselves.

Otherwise, they could do better by entrusting any cattle they owned to Fulani herdsmen, while devoting their energies exclusively to crops and small stock.

Chapter ten shows that specifically including access to animal traction techniques as an added bonus for keeping cattle on the farm (as opposed to entrusting them) does not serve to make the on-farm cattle enterprise a more attractive package from the farmer's standpoint. Under the most favorable assumptions, the maximum attainable increase in farm revenue from using animal traction was only of the order of three percent of the total annual revenue without keeping cattle. At the same time, the cost of traction equipment was thirty-three percent of the same farm income. Considering that the projected revenue increase is a miximum limit, while farm equipment in Upper Volta is likely to be ready for scrapping or serious repair after a few seasons use, it is a safe conclusion that few farmers will rush to keep cattle on the farm for traction purposes.

This conclusion is strengthened if farmers also desire to produce food grains. When peasants feel obliged to produce at least that amount of millet yielded on average by forty percent of their pre-traction field area, the use of animal traction actually decreases the maximum attainable farm income relative to what they could make by concentrating exclusively in crops and small stock without ox-plowing. Furthermore, using traction on the food grains (millet and sorghum) as well as on peanuts, rice, cotton and tobacco results in a twenty percent decrease in the maximum attainable farm income relative to just leaving the ani-

[1]Using the net revenue per hectare for millet and cowpeas grown on in-village land, based on the seasonally low harvest prices.

mals idle. This is the case when the mimimum acceptable food grain production level is that amount of millet produced by sixty-three percent of pre-traction land holdings (the minimum amount of grain produced by a sample household in 1976). At this level of food grain production the situation improves somewhat if the use of traction is confined to the primarily-for-cash crops, such as peanuts. However, the resulting maximum attainable farm income still remains eight percent below what it would be if the farmer simply entrusted his cattle to the Fulani and cultivated by hand.

The poor showing of on-farm cattle in the model can be attributed to the fact that labor in the middle of November is a binding constraint in the optimal solutions to all the models. In other words, the labor requirements of different activities come into conflict during this period. The more November labor an enterprise uses, the more it must be profitable in order for it to be considered for inclusion in the optimal solution. This is because the higher the labor requirement at this time, the more other activities must be reduced in order to make room for it. In sum, labor in November has a positive opportunity cost and enterprises requiring a large amount of labor at this time incur a high opportunity cost in terms of other outputs. Two factors contribute significantly to this finding.

First, cattle kept on the farm engender a relatively high use of labor for feeding and supervising the animals throughout the cropping season, including November. The underlying assumptions here, as made explicit in the discussion of the Fulani experience in chapter four (pp. 125-130), are that the lack of a viable forage crop and industrial by-products for feed, combined with a relatively high rural population density, forces the farmer to either gather feed outside the village or to supervise grazing in bush areas in order to prevent crop damage. Because of the physical strength and sense of responsibility required to prevent crop damage at this time of year, these tasks typically must be performed with the high opportunity cost labor of young adult males.

Second, the millet enterprise also has a high and rigid requirement for labor in November, for use in harvesting. The grain is usually too wet for cutting prior to this time and is severely damaged by birds and rampaging livestock if left on the stalk much after this month. Concentrating a large portion of resources in millet production creates a labor bottleneck during the harvest period. The higher food grain output is, the higher the opportunity cost of mid-November labor will be. This is because increasing millet output further restricts the amount of labor available at this time to other (increasingly) higher value, uses.

These two factors act together to support the principal hypothesis stated in chapter one. To wit, the high opportunity cost of November labor, which is made even higher by a desire for on-farm self-sufficiency in food grains, coupled with a high labor requirement for feeding and supervising animals at this time, offer an economic explanation of why peasants do not look after their own cattle, but instead prefer to entrust them to the Fulani.

It is noteworthy that this overall result is not particularly sensitive to the labor requirements for cattle. In the presence of a minimum food grain production level in the basic model consistent with the smallest proportion of farmland actually cultivated with millet by sample members, a thirty-eight percent decrease in labor requirements for cattle is required before this activity becomes profitable enough for an income-maximizing farmer to adopt it in the model. Of course such a reduction is easily conceivable, especially for a short period of time. However, it should be borne in mind that the assumptions in the model concerning the returns to crops and cattle are very much slanted in favor of the latter. Despite these favorable assumptions, cattle still come off poorly in a comparison. Even if the labor requirements for cattle are set too high in the model (and there is no evidence that they are), it is clear that this activity will not provide the very high extra returns sometimes projected for it. In the absence of this essential "selling point," it seems unlikely that subsistence farmers who have no tradition of looking after cattle will suddenly be willing to radically change their lifestyles in order to keep large stock on the farm, rather than entrust them to nearby Fulani.

The point is reinforced by the observation that the financial incentive for keeping cattle on the farm decreases as the minimum food grain production requirement increases. Chapter five showed that the mean proportion of sample farm holdings put under millet-sorghum (83 percent) in 1976 was substantially above the minimum of 63 percent specified in the model. Furthermore, chapter nine showed that evaluating millet at its seasonally high price minus storage costs, as opposed to its much lower harvest price, is tantamount to specifying a minimum food grain field area of 77 percent of holdings. Thus, either a strong desire for on-farm self-sufficiency in food grains, or the possibility that farmers evaluate food grain production at high August prices, is likely to insure that millet will account for a proportion of farm land allocations in excess of the minimum of 63 percent used in the basic model. The consequence of this is that cattle labor requirements must be decreased by significantly more than 38 percent for this activity to be part of the production strategy which maximizes farm income. In the case of Run 3 (Table 9.7), where millet output is evaluated at the high August prices and 77 percent of farm land is cultivated with millet in the optimal solution, sensitivity analysis indicates that the labor requirements for cattle would have to decrease by 86 percent before the enterprise could enter the optimal solution. This is equivalent to saying that if cattle require attention more than one hour per day in November, the opportunity cost in terms of foregone grain is too high. Thus, the labor requirements for cattle (given the situation in Tenkodogo) and the minimum level of food grain production specified in the basic model are not controversial aspects of the model as far as the results are concerned. However, there are a number of other key assumptions which do affect the overall conclusions with respect to the desirability of on-farm cattle production and animal traction. These assumptions are valid for Tenkodogo, but they may well be invalid for other specific areas in southeastern Upper Volta. The next section examines those requirements and how they affect the results.

Critical Assumptions and How They Affect the Conclusions

There are six major characteristics of the physical and economic environment of Tenkodogo which are crucial to the final determination of the profitability of keeping cattle on the peasant smallholder farm. These are embodied in the models of chapters nine and ten as implicit or explicit structural assumptions. To the extent that any one of them is not correct, as may well be the case in areas other than the sample region, the models in this study require revision. It is quite possible that on-farm cattle enterprises would significantly increase the potential farm income in models which incorporate these changes, leading to different conclusions about the merit of peasant livestock schemes. The crucial assumptions in question are the existence of the Fulani entrusting option, a relatively high rate of population density ($40/km^2$), the absence of a viable forage crop, the lack of an abundant supply of agro-industrial by-products for feedstuffs, the effective absence of a seasonal manpower supply or labor augmenting technology to relieve November labor bottlenecks, and the presence of soils and land tenure arrangements unfavorable to the use of animal traction.

The conclusions of this study are roughly correct for areas of West Africa where these six conditions are met. Policy makers concerned with identifying sites for small-scale peasant livestock intensification schemes should search for zones where at least one of these assumptions does not hold. Because of their importance, each one of the conditions will be examined in turn.

The Existence of the Fulani Cattle Entrusting Option.--The models used in the previous three chapters all assumed that the model farmer already possesses two head of cattle and that he has the choice of keeping them himself or entrusting them to Fulani herdsmen. The objective function coefficient for cattle in the basic model represents the net extra revenue gained from having physical possession of the animals, as opposed to the legal ownership of them. This corresponds to the value of cattle manure used as a soil amendment, milk, and any benefits attibutable to the better care of particular animals by the actual owners. The other returns to cattle presumably accrue to the legal owner of the animals whether he keeps them himself or entrusts them to a herdsman. These would be the ownership of newborn calves and the net profit from the sale of the animals.

In the absence of the option to entrust cattle to a specialized herding ethnic group like the Fulani, the net return to cattle would have to include the ownership benefits as well as the physical possession benefits, since the only way the farmer could make profits from cattle would be to look after them himself. The decision problem now becomes whether to own livestock or not, as opposed to the former problem of where to keep them. The new conceptual framework becomes much more complicated than the simple exercise in chapter nine.

The first change required in a new model is a substantially increased net return to cattle, to reflect the ownership benefits as well as the possession benefits of cattle. It would also no longer be valid to assume away a capital constraint. The returns to ownership of cattle, as opposed to the benefits from having them on the farm, are returns to scarce capital as well as returns to labor. In this instance, the desirability of on-farm cattle enterprises would be determined by the opportunity cost of capital as well as that of labor. In any event, a much more complicated model embodying capital as a constraint would be required to investigate the results of on-farm stockraising. In view of the expected rates of return to cattle ownership of the order of twenty percent calculated in chapter six, it seems quite possible that keeping cattle on the farm, as opposed to not owning cattle at all, would be a desirable activity.

A Relatively High Rate of Population Density.--The immediate research area has an estimated population density of 41 inhabitants per square kilometer. The northern part of the zone has an average density of 95 inhabitants per square kilometer, while the comparable figure for all Upper Volta is $20/km^2$. Upper Volta ranks only behind Togo and Benin as the most densely populated country in Francophone West Africa.

Thus, the research zone has an above average rate of population density relative to the rest of the Savannah zone. This is significant because the pressure of population on arable land is a key factor in the incidence of damage to crops from livestock. Where there is plenty of land, the herdsman can establish a permanent homesite on arable land which is far from the crop growing sites of grain farmers. Thus, the herdsman can grow a small amount of his own produce--which appears to be an important consideration for the Fulani--while keeping the animals away from peasant bush fields of millet. When the perimeter of bush fields begins to encroach upon traditional grazing areas, the instances of crop damage are likely to increase, as has been the case in the research area in recent years.

Since the herdsmen are liable for crop damages caused by their animals, a rise in the population density increases, ceteris paribus, the risk of serious financial liabilities. Thus, greater care and responsibility must be exercised in supervising the herd. Furthermore, the greater the pressure on land, the farther villagers must go into the bush in order to find abundant sources of forage grasses. Therefore, the greater the population density, the higher the labor requirement for looking after cattle. The relatively high density in the research area is associated with a relatively high daily labor requirement for maintaining cattle in the village.

Other areas in the Savannah zone, however, including other areas in southeastern Upper Volta, have a significantly lower number of inhabitants per square kilometer. It presumably requires less labor time to fetch forage for corralled cattle, or to take animals to safe pastures in these areas. The decreased risk of crop damage also implies that the responsibility for supervising animals can be entrusted to children rather than to the more careful and stronger young adults.

Therefore, the labor coefficients for the cattle enterprise used in the models of chapters nine and ten may significantly overstate the quantity and quality of labor input required to look after cattle in areas with a much lower population density. Although the previous section showed that labor requirements would have to be lowered by at least two-fifths in order for it to make a difference in the model results, it should be borne in mind that a lower population density tends to favor the success of on-farm cattle projects.

The Absence of a Viable Forage Crop.--One of the major problems facing the would-be peasant producer of finished cattle in Tenkodogo is the absence of a viable forage crop in an environment subject to a seven month dry season. Under these conditions, grasses such as *stylosanthes* lose their perrenial characteristics. This prevents the farmer from being able to rely upon a fenced-in pasture for grazing his animals year round. Results from the more humid Bouaké region of the Ivory Coast, with less than a five month dry season, indicate that it is potentially feasible to pasture two head of cattle year-round on one hectare of *stylosanthes* (S.E.D.E.S., 1972; Ruthenberg, 1974; Serres, Hübl, and Roider, 1975). Thus, the labor coefficients in the models of chapters nine and ten do not apply to areas which have a five month dry season or less, or else have a total rainfall superior to 1,100 mm per year. These areas are generally to the south of the Voltaic Savannah, but do include a small portion of the southwest of the country. A model different from the one used here would have to be applied in this instance.

The Lack of a Supply of Agro-industrial By-products for Feedstuffs.--In order to make the most favorable case for livestock enterprises, it was assumed in chapter eight that a limited amount of agro-industrial by-products, such as brewers' grains, were available for adding to the feed ration of on-farm cattle. This is somewhat unrealistic for Tenkodogo, and indeed for large areas of the Voltaic Savannah, however the favorable assumption only strengthens a research conclusion that goes against fattening large stock. On the other hand, the conclusions of chapters eight and nine clearly do not apply to areas benefiting from special circumstances in this regard. A farmer with the good fortune to have access to an unlimited supply of by-products from a sugar mill or a beer factory should consider taking advantage of this externality for stall-fattening cattle. Clearly, the labor coefficients and calculated net returns to cattle in the basic model do not apply to these special conditions.

<u>The Effective Absence of Measures to Relieve a November Labor Constraint</u>.--The models in chapters nine and ten implicitly assume that no special measures can be brought to bear in order to relieve a seasonal labor bottleneck. The methodology set forth in chapter eight fixed total labor availability during the cropping season at the level of the actual 1976 maximum input of labor to crops and livestock during any fortnight of the year.[1] This takes care of the objection that household members and their friends (cooperative labor) can substantially expand their labor output during short periods, since the labor availability in the program is already set at the peak level encountered during the year.

The results in chapters nine and ten would be modified, however, if supplementary harvest labor could be hired during November, or if a technological innovation introduced labor savings in the harvesting of the millet crop. In practice, there does not appear to be a pool of agricultural manpower for hire in the Tenkodogo region at this time of year. Young men with a desire for a cash income typically go south to the coastal countries to help with the cultivation of high value tropical export crops. Pineapples are an example of the latter, since they engender a demand for labor at this time. Older men who wish to remain near their families can almost always receive land of their own for cultivation, if they so desire. Similarly, what technology is available for easing the labor burden of harvesting is typically not within the reach of the Tenkodogo peasant. Even donkey carts used in the transport of grain cost more than most of them can afford.[2] Other mechanical

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[1]The actual methodology was a little more complicated than this, as reference to chapter eight will show. The effect was to fix the labor availability in period 14 (the middle of November) at 554 hours per fortnight or 0.4 percent below the maximum annual allocation of 556 hours in fortnight 5. This is an insignificant difference.

[2]A donkey cart, to which no organized credit scheme applies, cost approximately 44,000 CFA in Tenkodogo in 1976, not including the animal. Chapter seven estimated an average annual farm cash income from all sources in the vicinity of 30,000 CFA. Excluding the canton chiefs, no one in the sample owned a donkey cart.

devices to aid in the harvesting are out of the question in the current context.

It is conceivable, but unlikely, that farmers in other areas of the West African Savannah would have more discretion in relieving harvest labor bottlenecks in millet production. In any event, this is a key area of policy interest. The section below on "policy recommendations" will explore this issue further in the context of regions similar to the research area. The crucial point here is that any action which smoothes out or reduces the labor requirements for millet in Novmeber works to favor the adoption of on-farm cattle enterprises by reducing the opportunity cost of labor at this time.

The Presence of Conditions Unfavorable to Animal Traction.--The case against bovine animal traction in chapter ten was not based upon the actual observation of the effects of this practice, since very few farmers in southeastern Upper Volta use these methods. The proper interpretation of the results in chapter ten is that if traction has the implications for both yields and labor requirements that its principal proponents claim, then it is not a good practice for the Tenkodogo area. A fully adequate case against animal traction in Tenkodogo, of course, would require actual observations of the consequences of this method on yields and labor input.

There are at least two important aspects of the research area, however, which support the conclusion in chapter ten. These are the absence of soils that would support the type of crop most likely to benefit from animal traction and the spatial characteristics of the fields themselves. The latter pertain to the typical shape, size, and location of plots.

The well-aerated tropical ferruginous topsoils that cover four-fifths of the average Tenkodogo smallholding typically will not support sorghum. They are sandy and contain a relatively small amount of organic material. It is also possible that they lack one of the trace minerals essential to sorghum. This crop is usually grown only on the house fields immediately surrounding the compound. Similarly, only a small portion of house fields contain the nutrients necessary for growing cotton. Thus, the vast majority of lands on which traction would be used are suited primarily to growing millet, cowpeas, and peanuts. The results of an extensive French extension experiment in the sixties on similar soils show poor yield benefits and labor savings from using donkey traction on these crops (Mesnil, 1970). On the other hand, cases where animal traction has had some success at raising net farm income have usually involved richer soils and crops such as cotton and sorghum.[1]

The spatial characteristics of the fields of a typical farm also hinder the use of animal traction in this region. Chapter five showed that the typical sample farm had seventeen different fields, distributed over a wide area. Some of them are in relatively swampy lowland, some are on the high ground (but not all together), some are near the house, and at least one is several kilometers away in bush. Furthermore, the mean field size is less than one quarter of a hectare. Finally, the plots usually have an irregular shape resembling the mythical gerrymander. The arable surface of the village would look like a jig-saw puzzle from the air if the boundaries of fields belonging to each household were well defined. A substantial labor input is required to use bovine animal traction under these conditions. This is because of the time spent travelling between fields while taking care to avoid crop damage to neighbors and the time spent turning around within a given field.

Thus, it is clear that the research area is not endowed with the ideal conditions for the introduction of animal traction, yet there is an avowed government interest in this policy for the Tenkodogo region. The lesson from chapter ten should be that it is not enough to focus upon the projected yield benefits versus the cost of equipment. The labor time involved in ox cultivation and maintaining the draft team is also a significant cost factor. Programs which seek to promote a farm livestock package involving animal traction will have a better

[1]As for example in the Mandoul Valley of Southern Chad or, reportedly, in the Dédougou region of western Upper Volta.

chance of success, other things being equal, in regions where conditions exist such that this procedure does not make significant new demands upon labor time in peak periods.

Merits and Methods of Livestock Intensification in Tenkodogo

The policy concern with increasing cattle exports from southern areas set forth in chapter one, and the high rates of return to cattle ownership in the Savannah calculated in chapter six, serve to encourage some form of increased livestock production in southeastern Upper Volta in the foreseeable future. The policy questions concern who should receive the benefit of livestock production interventions and what system of production is best suited to the area. The results of this study show that in the Tenkodogo region cattle management should be left to specialized herdsmen, rather than to the sedentary farmers. Peasant smallholders can benefit by increasing their output of small ruminants and swine while investing some of their savings in cattle entrusted to the Fulani. Government and donor agency interventions designed to increase the output of beef cattle for export should support the existing entrusting system, which entails the grazing on range land of herds belonging to several owners. These conclusions are most likely valid for any area in West African Savannah north of the tenth parallel for which the six assumptions discussed in the previous section remain valid. If any one of the assumptions does not hold for a given region, then farmers may find it profitable to take advantage of special opportunities for fattening steers and/or to use animal traction. In particular, if the cattle entrusting system does not exist in a given area, or if trust has irrevocably broken down between herdsmen and peasants, farmers may be forced to look after their own stock if they wish to obtain the resale and breeding profits from animals.

Reasons for Directing Livestock Interventions to the Fulani in Tenkodogo.--The tradition practiced by Mossi and Bisa peasants in the research area of entrusting cattle to Fulani herdsmen is advantageous to both parties.[1] It allows the peasants to discretely invest their savings in cattle at little opportunity cost other than that of the capital involved. In the context of the technologically stagnant agriculture of Tenkodogo, the latter is likely to be lower than the returns from cattle, which are on the order of twenty percent per annum. At the same time, herdsmen gain employment in their preferred occupation through the use of the peasant herds. The data in chapter six showed that sixty percent of the animals in the sample Fulani corrals belonged to neighboring farmers or urban proprietors.

Society as a whole gains from the mutual specialization of the farmers and herdsmen in the research area. The Fulani are able to make a living from herding because of the economics of scale in this occupation. The latter are particularly evident in the seasonal transhumance which takes herders away from their home base for three months of the year. The farmers, on the other hand, can better concentrate their labor resources on crop growing. It is also convenient for all concerned to have a local supply of dairy products, milk, and manure.[2]

Finally, the entrusting system serves to keep the peace between herdsmen and farmers. The competition for land resources between their respective occupations and the increasing risk of crop damage are always potential sources of conflict. Presumably mutual economic interest has a mollifying effect. This last point is important because the mixed farming models examined in this study implicitly ignore the needs of the herdsmen. At the limit, the success of these strategies would either force the Tenkodogo Fulani out of business through the loss of

[1]The strengths and weaknesses of this relationship are discussed in greater detail in Delgado (1977) pp. 74-82.

[2]The farmers in the research area could usually obtain small quantities of manure from neighboring Fulani for use as an ingredient in the indigenous cement used for construction purposes. It was more difficult to get larger quantities for use as fertilizer, since the herdsmen desired to use the product of their corrals themselves.

clients, or oblige them to adopt crop farming as their primary occupation. The effect of the latter alternative would be to lose any applicable social benefits of specialization and the division of labor.

Thus, if it is desirable to intensify cattle output in areas similar to Tenkodogo, there are also a number of good reasons to direct the policy interventions to the Fulani system of production. This should have priority over small-scale mixed farming projects in the distribution of scarce resources. The next subsection deals with specific policy recommendations for supporting the cattle entrusting system in Tenkodogo.

Policy Recommendations for Supporting the Peasant-Herder System in Tenkodogo.--There are a number of policy actions urgently required to support the traditional cattle entrusting system beyond the usual livestock improvement interventions which are beneficial regardless of the production system involved. The usual projects, which are also desirable in this context, concern dry season waterpoints, dips and other preventive medicine projects, and improved marketing facilities.[1] The need for the first is somewhat location-specific, since some areas have adequate surface water throughout the year and others do not. The last two items are generally lacking throughout southeastern Upper Volta. The policy actions specifically required in support of the peasant-herder system are less well known and therefore require elaboration here. They concern lowering the special risks of keeping cattle in a crop growing area and promoting the socially optimal division of labor between herdsmen and farmers.[2] The primary risk in managing cattle in Tenkodogo is that of expensive lawsuits from animal-induced crop damage. Herders are held responsible for these incidents regardless of the ownership of the livestock involved. This means that they

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[1]The Fulani sample cited a dam to provide dry season surface water as their first wish. They also desired better access to innoculations, and were prepared to pay for them.

[2]Also see Delgado (1977) pp. 84-90.

must spend a great deal of time during the cropping season keeping the animals away from bush fields. The Fulani are even reluctant to take the herds into the village in the dry season because of the vegetable and cassava plots which are still being cultivated at that time. This discourages the herder from the socially beneficial practice of grazing the crop stubble and thereby fertilizing the fields with the animal droppings.[1] The risk of crop damage grows each year as peasant bush fields expand into zones that were previously used by the Fulani as grazing areas. There are three policy actions that would help to reduce this risk and thus would lower the costs of livestock production.

First, policy makers should be encouraged to confer with canton chiefs--the traditional arbiters of land use--and delineate those areas which are not yet exploited agriculturally. In Tenkodogo, these lands can be found on the periphery of the wet season river valleys. While it is hard for canton chiefs to resist pressures on them to allocate more arable land, this form of range management appears to be the only solution for the immediate future.

Second, policy emphasis should be put on the official recognition of cattle tracks through village cropping areas. Several customary routes exist in Oueguedo, although no agreement exists as to where the trail side ends and house fields begin. Several cattle paths have been delineated by the government and used with considerable success along the major north-south national cattle routes. The trails consist of single cement posts spaced approximately 100 meters apart in a line. Herders are not liable for any damage sustained by crops within fifty meters on either side of the posts. Presumably the village tracks would have smaller widths.

Third, the continued viability of the peasant-herder system also depends upon <u>sharing</u> the risk of retribution for crop damage between the cattle managers and proprietors. Voltaic policy makers should be

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[1]The absence of tractors makes the plowing-under of millet stalks infeasible at the time of writing.

urged to evolve a judicial code specifically delineating some of the financial responsibility to the owners of the animals. This action may also serve to encourage the acceptance of a land use policy among the peasant constituency.

With respect to the social optimality of the cattle entrusting system, the implication of the results of this study is that it is better for everyone concerned to have the Fulani look after cattle, while the farmers raise small stock and grow crops. However, the extent of the specialization in herding that is socially optimal remains an open question. Accordingly, one of the policy recommendations for supporting the herder-peasant cattle entrusting system is further research into optimal production strategies for herdsmen, both from the point of view of the individual and that of society. The next subsection attempts to define the principal research issues involved.

Further Research Issues in the Social Optimality of the Cattle Entrusting System.--The major issue here is whether or not the Fulani should grow crops. It may well be in the interest of the herdsmen to do so while it is not to the benefit of society as a whole because of three important externalities. These concern the value of manure as fertilizer, the ownership of Fulani herds, and the risk involved in not having a subsistence supply of millet.

First, the concentration of the village cattle around Fulani compounds makes this land very productive for crop growing. However, the herdsmen have only a limited amount of time available for this enterprise. They plant late because of the seasonal transhumance and skimp on the weeding. The crops grown are primarily millet and sorghum. The combination of high fertility with low labor input leads to average or mediocre yields relative to peasant cultivation with high labor inputs on infertile soil. It is highly likely that the transfer of manure from Fulani millet fields to Mossi and Bisa vegetable gardens would substantially increase the overall social product.

Second, if herders act to maximize their own profits, they will return early from the seasonal transhumance and skimp on animal care to grow crops if the net revenue from the latter exceeds that from the former. In this calculation, the individual herdsman balances the ownership benefits of livestock for only the forty percent of the herd that he owns versus the entire benefit of his crop production.[1] Therefore, the extra benefits accruing to the cattle owners as a group from complete herder specialization in livestock (lower animal mortality, greater weight gains) would have to be at least two and a half times as great as the extra benefits from crop cultivation, before the former would compare favorably to the latter. Thus, there is a built-in bias towards herder diversification, even if the strategy that maximizes the social product is to have complete specialization.

Third, specializing entirely in animal production always raises the risk of losing everything to drought or disease. The animals are the herdsmen's capital. Selling beyond the normal off-take because of misfortunes would be akin to a farmer selling his land. Thus a propensity for risk aversion dictates some millet production even if this is a sub-optimal strategy.

Formulating policy recommendations for achieving the socially optimal division of labor between peasants and herders requires the identification of both the individual herdsman's interest and the most socially productive strategy. An inquiry of this nature requires information concerning the herder farming system that goes beyond the scope of this study. Nevertheless, any subsequent investigation should elaborate recommendations which take the three aforementioned externalities into account.

The final section of this study concerns the case where the assumptions underlying the basic model are valid, except that farmers do not have the option to entrust cattle to a separate herding group such as the Fulani. This would be the case for Savannah areas resembling

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[1]Since the benefits to herding remain fairly constant, even if the benefits to ownership increase.

Tenkodogo, apart from the fact that there has never been a resident herding group. This case would also apply to regions where the relations between herdsmen and farmers are so poor that entrustment of cattle is not practical as a general policy. Although the entrusting assumption is valid for most of the Voltaic Savannah, there are areas of policy interest with respect to cattle which contain little in the way of a permanent herding population.[1] Parts of the eastern ORD (Fada N'Gourma) are cases in point.

Policy Recommendations for Increasing Sedentary Livestock Production in Savannah Areas in the Absence of a Cattle Entrusting System

The previous section indicated that the absence of the cattle entrusting option increased the net revenue to the farmer from keeping cattle on the farm. Looking after cattle yourself now becomes the only way to get any revenue from this enterprise, whereas previously it was possible to make profits with virtually no commitment of labor or land. This will have the effect of increasing the net revenue attributable to the on-farm cattle enterprise up to the level previously represented by the combination of the income from entrusted cattle and the extra revenue from keeping the animals on the farm. Ultimately, the number of cattle kept by the revenue-maximizing farmer will depend upon the alternate uses of capital and labor. If capital has an opportunity cost of less than twenty percent and the rise in net revenue to on-farm cattle is greater than thirty-eight percent, a revised model of resource allocation will most likely include farm cattle in the optimal solution.[2] What is certain is that the labor conflicts

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[1]See Quéant and Rouville, 1969, for an example from western Upper Volta with an entrusting system similar to that of Tenkodogo. Permanent herding populations are distinguished from transient groups which have only temporarily come south to escape unusually dry weather.

[2]Based on the expected returns to livestock calculated in chapter six and the sensitivity of the objective function coefficient of cattle in the basic model of chapter nine.

between crops and livestock combine to lower the overall desirability of the livestock enterprises. In turn, this lowers the probability that farmers will respond to government programs designed to intensify this activity. Given the strong policy interest in increasing cattle production in Savannah areas stated in chapter one, this section will focus upon interventions that will facilitate an increased livestock output by sedentary farmers.

There are five issues involved in obtaining this objective. First, labor conflicts between crops and livestock can be reduced by interventions that lower the requirements for livestock during the crop season. Second, the other side of the coin is to increase the returns to owning cattle. Third, the opportunity cost of labor in peak periods can be reduced by decreasing the size and rigidity of seasonal bottlenecks in the labor requirements for food grains. Fourth, the land use conflict between bush fields and grazing areas accessible to villagers could be solved by increasing the productivity of in-village land. Fifth, policy actions which help to diminish the risk margins represented by the planting of millet in excess of subsistence needs will make more resources available for livestock production.

Each of the above issues will be considered in turn. The principal conclusion of this final section is somewhat counterintuitive. This is that the labor, land, and minimum food grain production constraints operate in such a way as to make the production and storage of millet and sorghum the desired forum for policy interventions designed to increase cattle output. This is because the farming system itself, which is heavily oriented to food grain production, will have to undergo fundamental changes in order to permit the simultaneous cultivation of food and output of cattle.

Reduction of the Labor Requirements for In-Village Cattle.-- Reducing the labor requirements for on-farm cattle during peak periods reduces labor conflicts between livestock and crops. It also raises the opportunity cost of labor in terms of cattle, thus favoring, *ceteris paribus*, the diversion of scarce resources to this enterprise. The specific actions advocated are the construction of communal fences, the consolidation of land holdings, and extension programs dealing with the care of animals and the processing of feedstuffs.

The construction of communal fences around large areas of house and in-village fields serves to lower the danger of crop damage from livestock. In turn this reduces the amount and quality of labor required to supervise the animals as they graze on every bit of grass available within the village. Children who might not otherwise be entrusted with this responsibility during the crop season could then share the burden of herding. The Fulani and Fufuldē-speaking Rimaibē reportedly build communal fences in the Djibo area of Upper Volta, where they are the predominant ethnic group in the region (Riesman, 1974, p. 26). The Mossi and Bisa farmers in the research area also use enclosures, but only around individual garden plots after the millet harvest. The Fulani in the North use thorn bushes (as do their Tenkodogo cousins for fencing corrals), while the southern farmers use woven millet stalks with an outer layer of thorn branches.

There are several problems with indigenous fences which necessitate some form of outside policy intervention to overcome. First, they are very time-consuming to make, particularly if millet stalks must be woven together. Second, they last only one season. Third, they are not much use against a determined assault by cattle, although they do provide some protection against small stock. More efficient and durable fencing materials, such as barbed wire, are generally not available on the Tenkodogo market. Such items are available commercially in the capital, but are subject to high import duties and commercial mark-ups.[1] A successful enclosure policy in the central village would require at a minimum some positive policy action to make these materials available to inhabitants at a price level commensurate with cost.

Even under those conditions, it would still not be profitable for a single farmer in isolation to fence his fields with durable materials. The expense would be enormous relative to the benefits that he would get in isolation. Nonetheless, policy makers should consider the cost-

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[1]Using crop land temporarily as pasture to restore its fertility.

benefit analysis of commercial fences with the materials provided by the O.R.D. The social advantages of this strategy would be quite large, since everyone's cost of maintaining livestock would be greatly reduced through decreased risk of crop damage if all the in-village millet fields were protected. The cost-benefit analysis of this strategy, like that of improving a market road that is poorly travelled in the wet season, should take into consideration that the existence of the improved facility creates a demand for itself. In this case permanent enclosures would be a step towards a mixed farming system with ley fallowing.[1]

Perhaps the greatest difficulty to be encountered in this form of project is eliciting the cooperation of the villagers. This should be feasible, however, once the cooperation of the traditional authorities is obtained. Communal fences present several positive aspects in this respect. First, everyone is concerned about crop damages. Second, almost every household owns some form of livestock, be it only a goat. Third, in-village fields are permanently cultivated. Fourth, commercial fences do not need to follow the irregular lines of individual fields but need only enclose large blocks. Clearly, further study should be devoted to this issue by policy makers concerned with village livestock development.

The second policy intervention required to reduce the labor requirements for cattle is the consolidation of fields belonging to one household. Villagers in the research area are typically so hostile to this policy that it may not be feasible in the Tenkodogo area itself. However, this should be a consideration in settlement programs designed to use land newly made available by onchocerciasis eradication in the river valleys. Land consolidation would considerably reduce the travel time between fields and make animal traction programs more attractive.

The third class of policy actions required to reduce the labor

[1]Using crop land temporarily as pasture to restore its fertility.

requirements for cattle are extension programs in the care and feeding of large stock and the production of silage from stalks, stems, and harvested grasses. These programs should incorporate as much as possible the practices of Fulani herdsmen who have evolved an impressive pharmacology based on local plants and diseases. Any program aimed at introducing cattle raising by peasant-farmers will have to deal with a generally total lack of experience with these animals within the village. Silage production may offer a partial answer to the lack of fodder during the dry season. It is this shortage that requires forays deep into bush for grazing at this time. Presumably, the major input to fodder processing would come after the labor bottlenecks associated with the harvest. It should be borne in mind, however, that most of the cowpea and peanut stalks produced by sample members are currently used to feed small ruminants.

Increasing the Returns to In-Village Cattle.--In addition to decreasing the labor requirements for cattle, policies designed to favor sedentary livestock production need to increase the return to this activity. More specifically, attention should be devoted to defraying the cost of maintaining an ox plow and team. One possibility would be the encouragement of equipment rental by owners. After finishing their own plots, they could conceivably lease the team to neighbors. It is not clear, however, that the communal character of Mossi and Bisa society will permit this form of transaction within the village, particularly if both parties belong to the same lineage.

It is worth noting, nonetheless, that the results from the traction model indicate that this strategy is not likely to radically alter the economics of ox traction. The model assumes that equipment is free, therefore an extra return to plow and team is attributable in the model to the latter. Even if the owner could rent his equipment to five farmers for 1,000 CFA each, the extra revenue would still not be enough to raise the net returns to on-farm cattle to the point where they become a profitable enterprise.[1] Since traction is primarily useful in seedbed preparation and labor is not in short supply at this time, it is also not likely that farmers will be willing to pay large amounts for this service.[2] The topic is nevertheless of sufficient interest to warrant further investigation.

Reduction of Labor Bottlenecks in Food Grain Cultivation.--The reduction of peak labor requirements for food grains permits the farmer to continue cultivating a fixed area of millet consistent with his desires to be self-sufficient in food staples, while transferring labor to the livestock enterprise. This can be achieved either through the reduction of overall labor requirements for a given amount of output, or through the shifting of input to periods where people are free to work longer hours. The paradoxical result of this is that it is the introduction of food grain technology which permits the expansion of cattle output.

It should be noted, however, that the net result of this technology on resource use is to raise, *ceteris paribus*, the opportunity cost of livestock in terms of food grains. In other words, while innovation of this sort makes it feasible to produce both more cattle and millet, it may become even more profitable for the farmer to divert all his capital and labor to the latter.[3] Technological progress which increases yields relative to labor requirements is most likely to favor livestock when the main assumption of the basic model in chapters eight and nine

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[1]The model results showed that the increase needed to achieve this was at least 38% of 14,000 CFA or 5,320 CFA. In any event, it is unlikely that leasing will be extremely profitable.

[2]Given the level of cash income in the research area.

[3]Depending upon what happens to the price of food grains.

holds: that farmers produce more food grain than is optimal in terms of revenue maximization, because of concern over subsistence production of food. In this context, increasing the output to labor input ratio of millet makes the chosen production strategy less sub-optimal, by transferring the labor freed by the new technology to livestock, while maintaining the same area of land under millet as before (at the floor level).

There are four recommended policy actions with the objective of relieving labor bottlenecks in food grain production. These concern both the spreading and overall reduction of the labor required to harvest a given amount of grain off a given field. First, efforts need to be made to facilitate the acquisition by small holders of existing labor-saving implements that have an impact on harvesting. Second, it should be a priority to develop yield-increasing technology which does not place an added burden on labor resources at peak periods. Third, the eradication of pests that eat millet on the stalk reduces the urgency in harvesting the mature grain. Fourth, the reinforcement with statutes of a village-level consensus concerning the dates when small stock are permitted to roam freely in the village would also decrease the penalty for late harvest. Each one of these recommendations will be examined in turn.

The donkey cart is a prime example of the potential offered by existing, but relatively inaccessible, technology.[1] Combined with improved tracks (cattle trails?), these implements offer the possibility of substantial labor savings in the collection and spreading of manure, the transport of the grain harvest, and in the gathering and carrying of forage materials to the compound. They also facilitate the marketing and purchase of millet in bulk quantities. Not surprisingly, every sample member interviewed expressed a desire to own this equipment. Only the village chiefs, however, actually possessed carts. There were

[1]The donkey cart used throughout Upper Volta consists of a steel body mounted on automobile tires. One animal is often used to haul from 300 to 400 kg. of bulk produce, firewood, or water over distances up to sixty kilometers. The original design was made by a missionary living forty kilometers to the north of Tenkodogo.

only eighteen such vehicles in the entire 450 square kilometer research area, according to the O.R.D. field office. The problem is the high purchase price (in excess of 50,000 CFA in 1977, not counting the animal) and an absence of credit facilities.

Policy makers should re-examine the financing requirements for equipment sold through the O.R.D. As it stands now, credit exists for animal traction implements which few people want. Would-be purchasers of donkey carts, however, must pay cash at commercial levels. The current philosophy behind this appears to be that animal traction benefits the household by (perhaps) increasing production, while donkey carts are so economic that they clearly serve to make money. Of course this is precisely the reason why credit policy should aim to facilitate the acquisition of this implement by lower income peasants, who would not otherwise be able to afford the purchase price.

In addition to facilitating the use of existing labor-saving equipment, it is necessary to undertake research on harvesting practices and to develop yield-increasing technologies which do not require more labor at seasonal peak periods. The objective for new harvesting practices would be to smooth out the labor input that is currently concentrated in the middle of November. Farmers typically wait two months after the millet has finished growing before harvesting, in order for the crop to dry on the stalk. There is then a rush to get the crop in before birds, locusts, and small stock destroy it. Research is recommended on the feasibility of drying a portion of the crop after early harvesting in late September and early October. This is a period of relatively slack labor use.

Perhaps the single best use of foreign assistance for Savannah agriculture is investment in agronomic research into dry land millet farming. This is a long term and costly commitment, the impact of which goes far beyond Tenkodogo.[1] The purpose of these comments is to relate

[1]The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) of Hyderabad, India, which is charged by the Consultative Group on International Agriculture Research with looking into these questions, has a research interest at the Saria and Kamboincé research stations in the Voltaic Savannah.

these concerns to the Tenkodogo farming system. Unlike the situation in many heavily populated Asian countries, unused land is available to most Tenkodogo farmers in the form of bush fields. Although the richest land close to the compound is in short supply, the resource which limits the overall level of production is seasonal labor. In the actual sample labor allocations for 1976 reported in chapter four, the binding constraints were July (weeding) and November (harvesting) labor. The optimal production strategy of the basic model, which put a smaller percentage of land under food grains than the average farmer did in 1976, was constrained by November labor. In this context, the objective of research should not be just to increase yields, but also to shunt any extra labor requirements away from the middle of July or November. Failure to do this could result in introducing a technology which involves a bumper crop that the farmer either cannot adequately weed, or that he cannot harvest.

Research on the breeding of new millet varieties should be concerned with developing a plant which matures earlier than the present strains (110 days), and thus is harvested earlier. If increased labor input during July and November is essential to new varieties, extension packages involving the new technology should also include some of the labor-saving programs commented upon in this section (e.g. donkey carts).

The net effect on livestock output of yield-increasing food grains technology which does not increase labor requirements in July and November also depends upon the resulting changes in the use of land, capital accumulation, and price changes. The question of land use will be deferred to a separate sub-section below. A technology which increases the profitability of the food grain enterprise but also relies upon heavy capital input will raise the opportunity cost of capital in terms of food grains. Other things being equal, this tends to shift new investment from livestock to millet production. On the other hand, higher farm profits make more capital available for diversification in livestock. Increased food grain output due to new technologies, associated with price-inelastic demand for millet, will tend to depress both the price of the food staple and farm cash incomes. But, the key point is that farmers can reduce the scarce July and November labor allocation to millet while continuing to produce the same amount of grain as previously, thanks to the new technology. The newly liberated resources can be channeled to extra livestock production. The reduction in the area of millet planted will tend to maintain food grain prices at their previous level.

A third form of policy intervention for the reduction of labor bottlenecks in food grain cultivation concerns the eradication of pests which feed upon the millet crop while it is on the stalk. The most vivid example of these are dense clouds of locusts which are seen in the Sahel and Savannah every few years after the rainy season. The insects can wipe out a field in a matter of minutes. Birds eat a substantial proportion of the crop each year, particularly in unguarded bush fields. These pests put a very tangible penalty on late harvesting since the longer a crop is left standing, the longer it is subject to damage. Furthermore, as neighboring fields are harvested, the remaining fields receive the brunt of the damage. Policy actions which lessen these dangers also remove the penalty from late harvesting and thus permit the spreading into December of the peak November labor requirements. This frees scarce labor at this time to be allocated to other tasks.

The fourth type of intervention recommended to help spread out harvest labor requirements involves supporting the authority of the village chief to fix the date when small ruminants can be released in the village. Sheep and goats are typically thethered or guarded by children during most of the cropping season. Pigs are shut up in mud-walled corrals. The animals grow restless by the end of the rainy season, as do their keepers. When only a small number of unharvested fields are left in the village, there is a great temptation to release the animals. Occasionally, this results in crop damage to the remaining crop stands, putting pressure on farmers to avoid being tardy in clearing all their in-village plots.[1] The system of fencing elaborated above also requires an early harvest to obtain the millet stalks to protect vegetable and cotton patches from small ruminants. In 1976, a consensus appeared to exist that it is "unneighborly" to release one's animals before everyone is finished harvesting. As the harvest season drags on, however, it becomes difficult to enforce compliance with this social code, since it can be argued that late harvesters are as much to blame as the livestock owners. A policy which aims to prolong the harvest period further should be backed up by action to protect participants in the same way they are protected by the crop damage statutes during the height of the rainy season.

Reduction of the Land-Use Conflicts Between Bush Fields and Pastures.--Increased livestock production by sedentary farmers will also involve increased competition for land resources. The principal points of contact between cattle and food grains are the peasant bush fields, as shown at the end of chapter five. This farmland is newly cultivated, for the most part. Chapter five shows that the presence of bush fields on a cross-section of farms increases with farm size and decreases with the area of in-village land available per worker on the farm (p. 148). The implication of this hypothesis is that population growth and declining yields on in-village land will force the expansion of bush field cultivation. This is because declining yields and population growth presumably force the cultivation of a larger area by any given farm. Furthermore, increased population growth increases pressure on in-village crop areas and creates new farms.

This hypothesis is consistent with the evidence of recent years showing that the perimeter of bush field cultivation is constantly intruding into traditional Fulani grazing areas. Not surprisingly, the reported instances of crop damage in bush fields are increasing steadily. The prognosis for cattle-raising by sedentary farmers

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[1]Which are typically harvested before the bush fields, even though the latter suffer greater damage from birds.

based on range grazing is not good under these circumstances. As crop fields expand further into bush areas, farmers must walk their cattle further away from the village each season for the daily grazing. This boosts the labor requirements for cattle, thereby raising the opportunity cost of cattle in terms of food grains. It also aggravates the bottlenecks in millet production, since farmers must spend increasingly more time travelling between fields.

Thus, one of the first actions required in order to promote the intensification of cattle output in Savannah areas, whether by the Fulani or peasant farmers, is control over the expansion of bush fields. An administrative decree is not sufficient to accomplish this, since farmers under present conditions require the extra land in order to make a subsistence living. Rather, the appropriate long term policy is to improve the productivity of the peasant farming system in order to allow existing farms to operate more intensively on in-village land. Such research could well take a fresh look at the yield, cost, and labor requirement consequences of using fertilizer on food grains.[1] Presumably peak labor-augmenting technology would limit the need for bush land to new households which want to establish a farm of their own and who are not in line to inherit family holdings in the village. Thus, as in the case of the labor bottlenecks discussed in the previous section, the appropriate land policy emphasis for increasing livestock production involves research into expanding the productivity of food grain cultivation.

Reduction of the Desired Minimum Subsistence Food Grain Production Level.--Chapters nine and ten show that the desire of farmers to plant a large proportion of their land holdings with millet lowers the maximum attainable farm income. Furthermore, it entails an opportunity cost of cattle in terms of food grains that is prohibitive at current price ratios. Finally, this cost increases along with the proportion

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[1]The conventional wisdom, which is based on data from the early sixties, is that mineral fertilizers do not pay on millet (De Wilde, 1967, II, pp. 384-88).

of farmland under millet. Therefore, a decrease in the minimum amount of land that farmers are willing to plant with food grains will tend to favor the optimality of production strategies in general and that of keeping cattle on the farm in particular.

Given the high variability in millet yields between different years, there is pressure on the farmer who wishes to be self-sufficient in food grain to plant a larger area than would be required in a year of average rainfall. This would ensure self-sufficiency even in years with poor yields. In years of average and good growing conditions, in this view, the farmer ends up cultivating more millet than he requires for subsistence. He may consume part of the supplement and sell part. Policy actions designed to lower the minimum food grain constraint may be most effective in lowering this "risk margin," represented by over-planting millet to provide for the case of poor yields. It is unlikely in the immediate future that farmers will abandon their desire to grow their own food. In the context of poor communications in rural West Africa, it is not clear that they should do so. The point is to reduce the risk of hunger for individual farmers in a given year in order to encourage the shift of resources into products (including livestock) which maximize overall income.

Further research should be directed to the question of improved on-farm and village level grain storage facilities. The purpose of these institutions would be to reduce storage losses through better techniques rather than to handle grain marketing. The owner of the millet would presumably be able to withdraw it as he sees fit. The existence of buffer stocks in the village may help to reduce the danger of running short of grain in any particular season or year. In the long run, improved feeder roads, transportation equipment, and regional storage facilities should make reliance upon the market to supply food grains less risky. It would then be more feasible to trade livestock for food grains at the harvest.

The overall conclusion of this work supports the view that traditional smallholders usually have solid economic reasons for their behavior. Accordingly, development policy needs to look carefully at what is in the interest of the individual farmer. The costs and benefits of sedentary livestock production include the incidence of this activity upon other farm enterprises. The successful introduction of village cattle-raising into a farming system that has hitherto not engaged in this activity requires an integrated approach to the farming system itself. In the absence of attention to critical points of resource allocation and the availability of food grains, it seems unlikely that sedentary farmer cattle production schemes will have much chance of success in areas similar to Tenkodogo.

APPENDIX A

TABLES OF SECONDARY DATA

This appendix contains tables of data compiled from published sources or primary data other than that collected by the author and his enumerators. The information concerns the distribution of the Voltaic cattle herds, population density and size, and rainfall in the research area.

TABLE A.1

ESTIMATES OF CATTLE HERD SIZE AND GEOGRAPHICAL DISTRIBUTION BY MAJOR AREA 1969 - 1976

Region	1969 (a)				1974 (b)				1976 (c)			
	Sahelian North	Central Savannah	Southern Savannah	Total	Sahelian North	Central Savannah	Southern Savannah	Total	Sahelian North	Central Savannah	Southern Savannah	Total
Area in Thousands KM^2	40.8	117.2	116.2	274.2	40.8	117.2	116.2	274.2	40.8	117.2	116.2	274.2
Cattle Herd Size (in Thousands of Head)	600	1,270	630	2,500	408	1,402	730	2,540	425	1,459	760	2,602
% of Total Herd	25%	51%	24%	100%	16%	55%	29%	100%	16%	55%	29%	100%
Average Cattle Density/KM^2	$15/KM^2$	$10.8/KM^2$	$5.4/KM^2$	$9.1/KM^2$	$10/KM^2$	$12/KM^2$	$6.3/KM^2$	$9.3/KM^2$	$10.4_{KM}{}^2$	$12.5_{KM}{}^2$	$6.5_{KM}{}^2$	$9.5_{KM}{}^2$
Net Change in % of Total Herd in a Given Area					-9%	+4%	+5%	-	0%	0%	0%	-
Net Increase in Herd Numbers form 1969					-32%	+10.4%	+15.9%		+1.6%	-29%	+14.9%	+4.1%
Net Change in Herd Density in Head/KM^2 from 1969					$-5/KM^2$	$+1.2/KM^2$	$+0.9/KM^2$	$+0.2/KM^2$	$-4.6/KM^2$	$+1.7/KM^2$	$+1.1/KM^2$	$0.4/KM^2$

Sources: (a) + (b) Herd sizes and densities from Tyc (1975).

(c) Using a 2% net annual rate of growth of herd size, Tyc's figures for 1974 were compounded annually, assuming no further change in distribution of herds between geographic areas. Net growth rate of herd size is taken from Fredet, (1972) p. 12.

TABLE A.2

PERCENTAGE DISTRIBUTION OF POPULATION IN UPPER VOLTA BY ETHNIC GROUP 1960-61

	Sahelian North	Mossi Plateau (Central part of Savannah Area)	Total
Mossi	8.2	82.5	48.0
Bisa	0.5	8.5	4.7
Fulani	81.2	7.0	10.4
Other	10.1	2.0	36.9*
Total	100.0	100.0	100.0

*Lobi 7.0%, Mandingo 6.9%, Bobo 6.7%, Senufo 5.5%, Gourounsi 5.3%, Gourmantche 4.5%, Miscellaneous 1.1%).

SOURCE: RHV, Service de Statistique et de la Mécanographie, Enquête Demographique Par Sondage en Republique de Haute-Volta 1900-61, Volume I, p. 44.

TABLE A.3

PERMANENT POPULATION OF RESEARCH AREA BY ETHNIC GROUP 1976

Area	Mossi	Bisa	Fulani	Other	Total	Persons Per KM^2
Oueguedo Canton (Excluding Pouswaka)	5,518	-	167	-	5,685	$^{95}/KM^2$ (Approx.)
Loanga Canton	-	9,970	305	-	10,275	$^{36}/KM^2$ (Approx.)
Research Area (Estimated)	7,000		692		18,700	$^{41}/KM^2$
Tenkodogo Sub-Prefecture (Excluding Ouargaye)	44,044	34,646	3,638	814	83,142	N.A.
Tenkodogo Prefecture (or District) Koupela ORD	138,053	169,460	12,642	44,403	364,558	$^{40}/KM^2$
% of Population in Oueguedo Canton	97%	-	3%	-	100%	
% of Population in Loanga	-	97%	3%	-	100%	
% of Population in Research Area	37%	59%	4%	-	100%	

SOURCE: 1976 Census Figures, (Unpublished). Consulted in Tenkodogo district administrative offices. These figures are for permanent residents inscribed on tax rolls and almost surely under represent the true number of Fulani herdsmen in the area.

Figures for peasant population of Pouswàka-Gando included in greater research area were not available. These have been estimated as 1,000 Bisa and 1,300 Mossi.

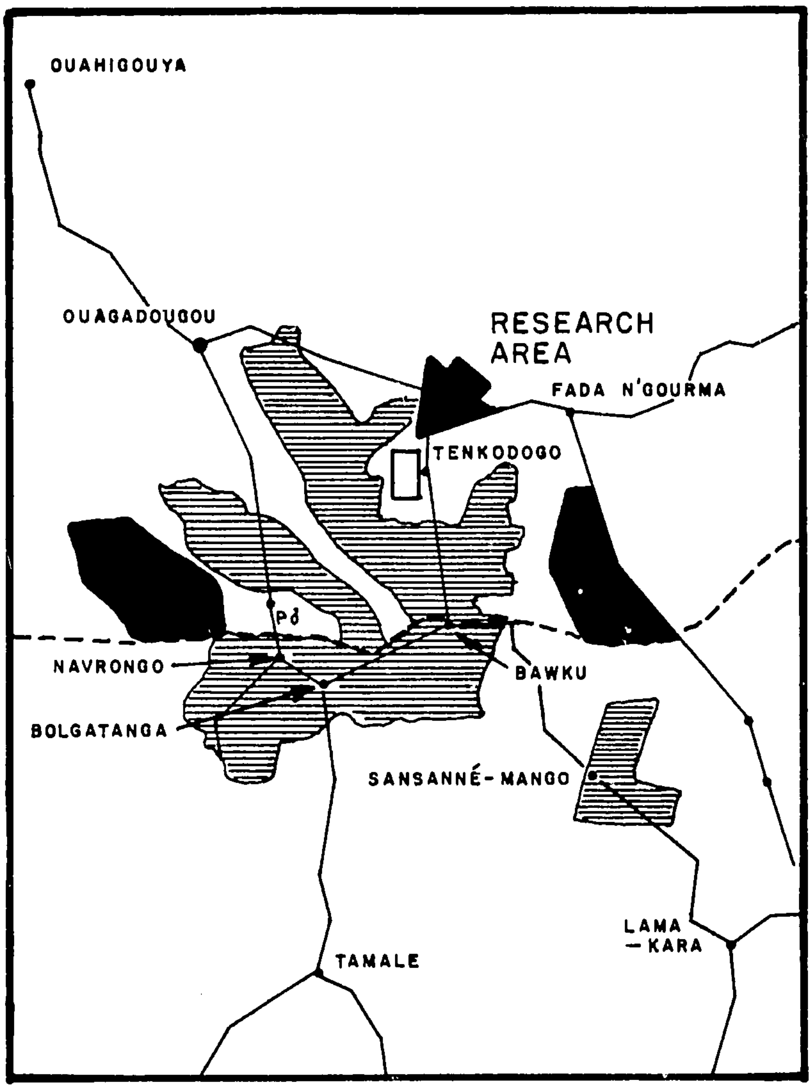
TABLE A.4

RAINFALL IN 1976 AT TENKODOGO O.R.D. FIELD OFFICE

Month	Monthly Rainfall in Area	No. of Days of Rain
January	0	0
February	0	0
March	Trace	N.A.
April	12	3
May	137.8	6
June	80.9	8
July	112.9	11
August	93.3	12
September	211.9	10
October	149.3	N.A.
November	Trace	N.A.
December	0	0
TOTAL	798.1 mm	Approximately 59

SOURCE: O.R.D. field office in Tenkodogo, March 1977. The average was approximately 950 mm per annum. (See Jeune Afrique, Atlas de la Haute Volta (1975) p. 14.

FIGURE A.I : Relation of the Research Area to the Onchocerciasis Control Program



Source : World Health Organization (1973) fig. 64, updated by the author.

Planned Project Zones

Suggested Project Zones

Road

Ghana - Upper Volta Frontier

APPENDIX B

TABLES OF PRIMARY DATA

This appendix contains tables of data collected by the author during the field interviews. The first thirty tables contain information on the number of hours worked by members of each age and sex category each fortnight, averaged over households. The last five columns give comparable information for cooperative labor by sex group, hours by hired workers, and totals for family and aggregate labor. Each entry is the mean of similar entries for each household. The fortnight codes in column one are the same as those on page 74 of the main text. Fortnight one begins on May 9, 1978. The last three tables in the appendix contain the list of estimated conversion units for measuring harvests (Table B.31), the mean number of agricultural implements found in each household (Table B.32), and the mean number of crop storage facilities per household (Table B.33).

TABLE B.1

MEAN HOUSEHOLD LABOR ALLOCATED TO FIELD PREPARATION EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	4.3659	25.276	.97561 -1	.80488	18.081	1.1626	0.	0.	0.	49.789	49.789
2	7.8780	40.431	2.6829	2.3989	34.211	2.7886	0.	0.	0.	90.390	90.390
3	7.2683	26.634	.56098	3.3496	47.285	2.9268	1.4390	0.	0.	88.024	89.463
4	5.7561	22.992	.51219	2.8293	39.089	2.3415	.68293	.29268	0.	73.520	74.496
5	2.2683	9.2358	.29268	1.6179	18.219	2.5610	1.7073	0.	0.	34.195	35.902
6	.29268	2.7967	.60976	.14634	4.5528	.97561	.97561	0.	0.	9.3740	10.350
7	0.	.70732	0.	0.	.57724	0.	0.	0.	0.	1.2846	1.2846
8	.48780 -1	.54471	0.	0.	.49593	0.	0.	0.	0.	1.0894	1.0894
9	.97560 -1	5.8293	.48780 -1	1.9106	5.2032	.53659	0.	0.	0.	13.626	13.626
10	.36585	3.8455	0.	.55284	2.1138	0.	0.	0.	0.	6.8780	6.8780
11	.36585	4.7317	0.	0.	.14634	0.	0.	0.	0.	5.2439	5.2439
12	.36585	2.0976	.29268	0.	0.	0.	0.	0.	0.	2.7561	2.7561
13	0.	1.6341	2.2683	0.	.39024	0.	0.	.97561 -1	0.	4.2927	4.3902
14	0.	.47154	0.	0.	.53659	0.	0.	0.	0.	1.0081	1.0081
15	0.	0.	0.	0.	0.	0.	0.	.12195	0.	0.	.12195
16	0.	0.	0.	0.	.17073	0.	0.	0.	0.	.17073	.17073
18	0.	0.	0.	0.	.14634	0.	0.	0.	0.	.14634	.14634
20	0.	.24390 -1	0.	0.	0.	0.	0.	0.	0.	.24390 -1	.24390 -1
24	0.	.48780 -1	0.	0.	0.	0.	0.	0.	0.	.48780 -1	.48760 -1
25	0.	2.3659	.19512	.19512	1.0244	0.	0.	0.	0.	3.7805	3.7805
26	2.9268	10.537	.65041	.80488	3.0000	0.	0.	0.	0.	17.919	17.919

TABLE B.2

MEAN HOUSEHOLD LABOR ALLOCATED TO SPREADING FERTILIZER EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.41463	1.4634	.73171	.97561 -1	2.8049	0.	0.	0.	0.	5.5122	5.5122
2	.14634	.36585	0.	0.	0.	0.	0.	0.	0.	.51220	.51220
3	0.	.24390 -1	0.	0.	0.	0.	0.	0.	0.	.24390 -1	.24390 -1
5	0.	.24390	0.	0.	.48780 -1	0.	0.	0.	0.	.29268	.29268
6	.29268	.19512	0.	.14634	0.	0.	0.	0.	0.	.63415	.63415
17	0.	.21951	0.	0.	0.	0.	0.	0.	0.	.21951	.21951
20	0.	0.	0.	0.	2.8780	0.	0.	0.	0.	2.8780	2.8780
21	0.	0.	0.	0.	2.5854	0.	0.	0.	0.	2.5854	2.5854
22	0.	.91057	0.	0.	2.0976	0.	0.	0.	0.	3.0081	3.0081
23	.63414	1.3089	0.	0.	3.3415	0.	0.	0.	0.	5.2845	5.2845
24	2.0000	2.4146	0.	0.	9.3658	0.	0.	0.	0.	13.780	13.780
25	1.1463	4.0650	.97560 -1	.48780	3.5203	.65040 -1	0.	0.	0.	9.3821	9.3821
26	2.3333	7.9349	.35772	.77236	9.7154	.22764	0.	0.	0.	21.341	21.341

TABLE B.3

MEAN HOUSEHOLD LABOR ALLOCATED TO SOWING EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	8.4309	47.715	1.4228	2.7805	60.919	2.0000	0.	.29268	0.	123.27	123.56
2	6.1057	50.317	2.8211	2.4146	44.390	3.1707	.26829	.43902	0.	109.22	109.93
3	3.6341	15.699	.92683	.80488	19.033	.17073	.24390 -1	.46341	0.	40.268	40.756
4	1.6098	10.976	0.	.97561	15.390	0.	0.	.41463	0.	28.951	29.366
5	.14634	4.2033	0.	0.	10.138	1.1057	2.1951	.97561	0.	15.593	18.764
6	.71545	4.3577	.29268	.36585	6.6911	.67479	0.	0.	0.	13.098	13.098
7	.11382	.33333	0.	0.	2.2276	0.	0.	0.	0.	2.6748	2.6748
8	0.	.32520 -1	0.	0.	.16260	0.	0.	0.	0.	.19512	.19512
11	0.	.97560 -1	0.	0.	0.	0.	0.	0.	0.	.97560 -1	.97560 -1
12	0.	.48780 -1	.36585	0.	0.	0.	0.	0.	0.	.41463	.41463
26	0.	.19512	.97560 -1	C.	.13008	.65040 -1	0.	0.	0.	.48780	.48780

TABLE B.4

MEAN HOUSEHOLD LABOR ALLOCATED TO WEEDING AND TRANSPLANTING EACH FORTNIGHT

FORTNIGHT	MALES			FEMALES			INVITED			TOTAL FAMILY	TOTAL HOUSEHOLD
	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED		
1	3.7561	25.358	3.7398	1.5610	21.650	2.0406	0.	0.	0.	58.106	58.106
2	11.553	68.390	10.650	5.9106	57.545	5.1301	0.	.14634	0.	159.18	159.33
3	18.789	108.48	14.805	6.3268	108.12	8.6585	2.6341	0.	0.	265.78	268.41
4	24.927	114.38	13.472	6.3984	139.67	8.9512	31.073	7.6585	0.	307.80	346.53
5	27.504	153.65	14.114	15.569	166.26	9.4878	39.935	8.9675	0.	386.59	435.49
6	34.122	156.75	14.691	20.374	173.05	10.220	42.919	3.0569	0.	409.20	455.18
7	27.740	154.77	11.317	18.870	172.59	9.7723	1.5854	.36585	0.	395.06	397.02
8	16.748	111.16	9.5528	13.098	116.28	7.2764	15.439	.12195	0.	274.12	289.68
9	8.5041	66.463	3.6829	5.1707	76.325	2.1463	24.634	1.0976	0.	162.29	188.02
10	2.7642	22.496	1.1707	.26829	25.967	0.	.36585	0.	0.	52.667	53.032
11	1.2032	13.707	.26016	.26016	10.138	0.	0.	0.	0.	25.569	25.569
12	.41463	12.211	.49593	.61780	2.6910	0.	.29268	0.	0.	16.431	16.724
13	1.4390	4.0569	0.	.85366	4.7805	0.	0.	0.	0.	11.130	11.130
14	0.	2.2276	0.	0.	0.	0.	0.	0.	0.	2.2276	2.2276
15	0.	2.1463	0.	0.	0.	0.	0.	0.	0.	2.1463	2.1463
16	.97561 -1	1.4065	0.	0.	0.	0.	0.	0.	0.	1.5041	1.5041
17	0.	.97561 -1	0.	0.	0.	0.	0.	0.	0.	.97561 -1	.97561 -1
18	.73171 -1	.68293	0.	0.	0.	0.	0.	0.	0.	.75610	.75610
19	.73171 -1	.95122	0.	0.	0.	0.	0.	0.	0.	1.0244	1.0244
20	0.	.12195	0.	0.	0.	0.	0.	0.	0.	.12195	.12195
21	0.	.63415	.97561 -1	0.	0.	0.	0.	0.	0.	.73171	.73171
22	0.	.97561 -1	0.	0.	0.	0.	0.	0.	0.	.97561 -1	.97561 -1
23	0.	.73171 -1	0.	0.	0.	0.	0.	0.	0.	.73171 -1	.73171 -1
25	0.	.97561 -1	0.	0.	0.	0.	0.	0.	0.	.97561 -1	.97561 -1

TABLE B.5

MEAN HOUSEHOLD LABOR ALLOCATED TO WATERING CROPS EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	1.6504	0.	0.	0.	0.	0.	0.	0.	1.6504	1.6504
2	.68293	2.1707	0.	.24390 -1	0.	0.	0.	0.	0.	2.8780	2.8780
3	.19512	.71545	0.	0.	1.7561	0.	0.	0.	0.	2.6667	2.6667
4	.65040 -1	.31707	0.	0.	0.	0.	0.	0.	0.	.38211	.38211
5	.32520 -1	.41463	0.	0.	0.	0.	0.	0.	0.	.44715	.44715
7	0.	0.	.81301	0.	0.	0.	0.	0.	0.	.81301	.81301
8	0.	.21951	.45528	0.	0.	0.	0.	0.	0.	.67479	.67479
9	0.	.78049	.87805	0.	0.	0.	0.	0.	0.	1.6585	1.6585
10	0.	1.5610	1.3171	0.	0.	0.	0.	0.	0.	2.8780	2.8780
11	0.	0.	.44715	0.	0.	0.	0.	0.	0.	.44715	.44715
12	0.	1.5772	1.6098	0.	.14634	0.	0.	0.	0.	3.3333	3.3333
13	0.	2.1951	1.1382	0.	0.	0.	0.	0.	0.	3.3333	3.3333
14	.39024	2.6992	1.1219	0.	0.	0.	0.	0.	0.	4.2114	4.2114
15	.39024	6.4797	.63414	0.	0.	0.	0.	0.	0.	7.5041	7.5041
16	.82927	18.602	.73171	0.	0.	0.	0.	0.	0.	20.163	20.163
17	5.5041	35.789	1.3740	.78049	0.	0.	0.	0.	0.	43.447	43.447
18	4.9593	36.496	1.9024	0.	.56098	0.	0.	0.	0.	43.919	43.919
19	3.2276	37.683	2.3740	0.	0.	0.	0.	0.	0.	43.284	43.284
20	3.5122	33.333	1.6667	0.	.51220	0.	0.	0.	0.	39.024	39.024
21	2.9756	29.520	2.5041	.39024	.73171	0.	0.	0.	0.	36.122	36.122
22	5.8943	34.382	.81301	0.	0.	0.	0.	0.	0.	41.069	41.069
23	3.4390	24.179	.97560 -1	0.	1.0488	0.	0.	0.	.14634	28.764	[illegible]
24	2.6098	26.276	.26016	.19512	1.0732	0.	0.	0.	0.	30.415	30.415
25	5.5366	18.569	1.3008	0.	0.	0.	0.	0.	0.	25.406	25.406
26	1.6585	3.8049	.41463	0.	0.	0.	0.	0.	0.	5.8780	5.8780

TABLE B.6

MEAN HOUSEHOLD LABOR ALLOCATED TO FENCING FIELDS EACH FORTNIGHT

	MALES			FEMALES			INVITED			TOTAL	TOTAL
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	FAMILY	HOUSEHOLD
2	0.	.14634	0.	0.	0.	0.	0.	0.	0.	.14634	.14634
7	0.	.73171 -1	0.	0.	0.	0.	0.	0.	0.	.73171 -1	.73171 -1
8	0.	.21951	0.	0.	0.	0.	0.	0.	0.	.21951	.21951
9	.14634	.48780	0.	0.	.43902	0.	0.	0.	0.	1.0732	1.0732
10	.87805	11.911	1.3333	0.	1.6098	0.	0.	0.	0.	15.732	15.732
11	.88618	22.553	1.4715	.24390	.97561	0.	.87805	0.	0.	26.130	27.008
12	.62602	13.000	.90244	.12195	.36585	0.	1.8293	0.	0.	15.016	16.846
13	.36585	2.8374	0.	0.	0.	0.	0.	0.	0.	3.2032	3.2032
14	0.	2.0163	0.	0.	0.	0.	0.	0.	0.	2.0163	2.0163
15	.14634	4.3902	.31707	0.	0.	0.	.43902	0.	0.	4.8537	5.2927
16	0.	4.8049	.12195	0.	.21138	0.	0.	0.	0.	5.1382	5.1382
17	1.9512	6.2683	.51220	0.	.81301	0.	0.	0.	0.	9.5447	9.5447
18	1.0244	4.6585	0.	.97561 -1	.19512	0.	0.	0.	0.	5.9756	5.9756
19	.36585	2.7073	.39024	0.	0.	0.	0.	0.	0.	3.4634	3.4634
20	0.	1.4146	.24390	0.	0.	0.	0.	0.	0.	1.6585	1.6585
21	0.	.14634	.19512	0.	0.	0.	0.	0.	0.	.34146	.34146
22	0.	.29268	0.	0.	0.	0.	0.	0.	0.	.29268	.29268
23	0.	.48780 -1	0.	0.	0.	0.	0.	0.	0.	.48780 -1	.48780 -1
24	0.	.14634	0.	0.	0.	0.	0.	0.	0.	.14634	.14634

TABLE B.7

MEAN HOUSEHOLD LABOR ALLOCATED TO GUARDING FIELDS EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	.12195	0.	0.	0.	0.	0.	0.	0.	.12195	.12195
2	0.	0.	.24390	0.	0.	0.	0.	0.	0.	.24390	.24390
3	0.	.14634	0.	0.	0.	0.	0.	0.	0.	.14634	.14634
4	0.	.19512	0.	0.	0.	0.	0.	0.	0.	.19512	.19512
6	0.	1.1707	0.	0.	.43902	0.	0.	0.	0.	1.6098	1.6098
9	0.	.48780 -1	0.	0.	0.	0.	0.	0.	0.	.48780 -1	.48780 -1
10	0.	.29268	0.	0.	0.	0.	0.	0.	0.	.29268	.29268
11	.48780	1.3659	0.	.97561 -1	.19512	0.	0.	0.	0.	2.1463	2.1463
12	.36585	.80488	.29268	0.	.97561 -1	0.	0.	0.	0.	1.5610	1.5610
13	.39024	.39024	0.	0.	.36585	0.	0.	0.	0.	1.1463	1.1463
14	0.	1.3984	0.	0.	0.	0.	0.	0.	0.	1.3984	1.3984
15	0.	.60162	0.	0.	0.	0.	0.	0.	0.	.60162	.60162
16	0.	1.5610	0.	0.	0.	0.	0.	0.	0.	1.5610	1.5610
24	.21951	.17073	0.	0.	0.	0.	0.	0.	0.	.39024	.39024
25	0.	.73171 -1	0.	0.	0.	0.	0.	0.	0.	.73171 -1	.73171 -1
26	0.	.19512	0.	0.	0.	0.	0.	0.	0.	.19512	.19512

TABLE B.8

MEAN HOUSEHOLD LABOR ALLOCATED TO TRAVEL BETWEEN FIELDS EACH FORTNIGHT

	MALES			FEMALES			INVITED			TOTAL	TOTAL
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	FAMILY	HOUSEHOLD
1	1.3902	6.6098	.31707	.68293	7.5366	.48780 -1	0.	0.	0.	16.585	16.585
2	.31707	3.0569	.24390	.48780 -1	4.1382	.41463	.24390 -1	.14634	0.	8.2195	8.3902
3	.80488	4.1138	.24390 -1	.97561 -1	3.8130	.29268	0.	0.	0.	9.1463	9.1463
4	1.3171	6.1951	0.	.21951	8.7805	0.	0.	0.	0.	16.512	16.512
5	1.7236	9.5610	.97561 -1	.48780	13.350	0.	0.	0.	0.	25.219	25.219
6	2.1463	7.7236	0.	.63414	11.545	0.	1.8293	0.	0.	22.049	23.878
7	1.2602	4.5854	0.	.46341	6.9837	0.	0.	0.	0.	13.293	13.293
8	1.4309	4.9431	0.	.24390	8.1951	0.	0.	.48780 -1	0.	14.813	14.862
9	2.9187	9.8049	0.	.38211	14.065	0.	3.6585	1.5854	0.	27.171	32.415
10	.66667	4.0650	0.	.37398	6.6667	0.	0.	0.	0.	11.772	11.772
11	.14634	.53659	0.	0.	.48780	0.	0.	0.	0.	1.1707	1.1707
12	0.	.13008	0.	0.	0.	0.	0.	0.	0.	.13008	.13008
13	.48780	2.5366	0.	.34146	5.5447	0.	0.	0.	0.	8.9106	8.9106
14	.39024	2.7154	0.	.39024	5.8211	0.	0.	0.	0.	9.3171	9.3171
15	.81300 -1	3.0976	0.	.48780 -1	5.0894	0.	0.	0.	0.	8.3171	8.3171
16	.40650	2.5203	0.	.97561 -1	7.8374	0.	0.	0.	0.	10.862	10.862
17	0.	0.	0.	0.	.58537	0.	0.	0.	0.	.58537	.58537
25	0.	.14634	0.	0.	.14634	0.	0.	0.	0.	.29268	.29268
26	0.	1.3659	0.	0.	.97561 -1	0.	0.	0.	0.	1.4634	1.4634

TABLE B.9

MEAN HOUSEHOLD LABOR ALLOCATED TO TIME SPENT ON AN AGRICULTURAL WORK INVITATION EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	.29268	0.	0.	.14634	0.	0.	0.	0.	.43902	.43902
2	0.	.31707	0.	0.	0.	0.	0.	0.	0.	.31707	.31707
3	0.	1.7561	0.	0.	.43902	0.	0.	0.	0.	2.1951	2.1951
4	.31707	7.2927	.21951	0.	.95122	0.	0.	0.	0.	8.7805	8.7805
5	.39024	12.374	.14634	0.	3.1138	0.	0.	0.	0.	16.024	16.024
6	.26829	12.691	.19512	0.	.20325	0.	0.	0.	0.	13.358	13.358
7	.21951	7.1301	.39024	0.	.53658	0.	0.	0.	0.	8.2764	8.2764
8	0.	8.6585	.19512	0.	.82114	0.	0.	0.	0.	9.6748	9.6748
9	.29268	10.171	.75610	0.	1.3984	0.	0.	0.	0.	12.618	12.618
10	.14634	5.4390	.29268	0.	1.1707	0.	0.	0.	0.	7.0488	7.0488
11	0.	2.0000	.34146	.97560 -1	1.1219	0.	0.	0.	0.	3.5610	3.5610
12	.97561 -1	5.3415	.24390	.34146	6.7073	0.	0.	0.	0.	12.732	12.732
13	.48780 -1	4.3496	0.	.19512	4.8293	0.	0.	0.	0.	9.4228	9.4228
14	0.	4.0732	0.	.43902	2.7236	0.	0.	0.	0.	7.2358	7.2358
15	0.	3.1870	.19512	0.	2.6016	0.	0.	0.	0.	5.9837	5.9837
16	0.	.63415	.73171 -1	0.	1.6260	0.	0.	0.	0.	2.3333	2.3333
17	0.	.65854	.19512	0.	0.	0.	0.	0.	0.	.85366	.85366
18	.58537	3.4146	.30894	0.	0.	0.	0.	0.	0.	4.3089	4.3089
19	.45528	6.5366	.22764	0.	.60976	0.	0.	0.	0.	7.8292	7.8292
20	1.3496	10.642	1.7561	0.	.92683	0.	0.	0.	0.	14.675	14.675
21	1.2520	19.764	1.1463	0.	1.4634	0.	0.	0.	0.	23.626	23.626
22	.74797	11.398	.19512	0.	0.	0.	0.	0.	0.	12.341	12.341
23	0.	1.1463	0.	0.	0.	0.	0.	0.	0.	1.1463	1.1463
25	0.	.19512	0.	0.	0.	0.	0.	0.	0.	.19512	.19512

TABLE B.10

MEAN HOUSEHOLD LABOR ALLOCATED TO HARVESTING EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
2	0.	.39024	0.	0.	.34146	0.	0.	0.	0.	.73171	.73171
8	.12195	.58537	0.	0.	.65854	0.	0.	0.	0.	1.3659	1.3659
9	.31707	1.8049	.32520 -1	0.	2.0244	0.	0.	0.	0.	4.1789	4.1789
10	4.0732	29.805	.89431	3.8293	37.016	.65854	.85366	2.4553	0.	76.276	79.585
11	1.0488	4.2195	0.	.43902	5.4472	.21951	.29268	.39837	0.	11.374	12.065
12	1.9268	14.780	.92683	1.6341	22.585	.65040 -1	4.3415	1.0732	0.	41.919	47.333
13	9.9512	55.439	3.7642	4.8618	74.764	3.3821	2.6098	9.5935	0.	152.16	164.37
14	7.0650	43.691	2.5284	4.9837	58.528	2.1301	1.5447	6.0650	0.	118.93	126.54
15	11.350	56.845	5.1057	6.5203	80.780	5.6911	2.9919	2.0000	0.	166.29	171.28
16	5.2683	33.268	1.3089	3.8049	43.707	1.6341	2.5854	1.0488	0.	88.992	92.626
17	.32520	3.7154	.12195	.39024	4.4634	0.	0.	.97561 -1	0.	9.0162	9.1138
18	.47967	1.9187	.27642	0.	.29268	0.	0.	0.	0.	2.9675	2.9675
19	.24390	2.2195	.11382	.19512	2.0488	0.	0.	0.	0.	4.8211	4.8211
20	.14634	1.1951	0.	0.	.24390	0.	0.	0.	0.	1.5854	1.5854
21	.24390 -1	.68293	0.	0.	.53659	0.	0.	0.	0.	1.2439	1.2439
22	.97561 -1	.80488	0.	0.	.53658	0.	0.	0.	0.	1.4390	1.4390
23	0.	0.	0.	0.	.48780 -1	0.	0.	0.	0.	.48780 -1	.48780 -1
24	.43902	1.3171	0.	0.	0.	0.	0.	0.	0.	1.7561	1.7561

TABLE B.11

MEAN HOUSEHOLD LABOR ALLOCATED TO PROCESSING OF HARVEST EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	.12195	0.	.29268	.60976	1.2439	0.	0.	0.	2.2683	2.2683
2	0.	.73171 -1	0.	0.	.48780	0.	0.	0.	0.	.56098	.56098
5	0.	.97561 -1	0.	0.	0.	0.	0.	0.	0.	.97561 -1	.97561 -1
6	0.	.21951	0.	0.	.48780 -1	0.	0.	0.	0.	.26829	.26829
7	0.	.73171 -1	0.	0.	.97561 -1	0.	0.	0.	0.	.17073	.17073
9	.24390	2.5122	.14634	.29268	2.8293	0.	0.	0.	0.	6.0244	6.0244
10	1.9919	8.4878	.63415	1.0732	8.5691	.34959	0.	.39024	0.	21.106	21.496
11	2.2114	8.4228	.21951	.29268	9.0163	.26016	0.	.73171 -1	0.	20.423	20.496
12	.57724	3.6585	0.	.14634	3.0976	0.	0.	0.	0.	7.4797	7.4797
13	0.	1.2846	0.	0.	2.8211	0.	0.	.14634	0.	4.1057	4.2520
14	.14634	1.1707	.56910 -1	0.	2.2764	0.	.51220	0.	0.	3.6504	4.1626
15	.82927	1.5854	.11382	0.	4.9024	0.	0.	0.	0.	7.4309	7.4309
16	.43902	3.0732	0.	.29268	8.0976	0.	.36585	0.	0.	11.902	12.268
17	.43902	1.1707	0.	.87805	8.2276	0.	0.	0.	0.	10.715	10.715
18	.17886	1.3089	0.	0.	9.7480	.19512	0.	0.	0.	11.431	11.431
19	2.9593	4.9837	.39024	1.3171	8.8862	.14634	0.	0.	0.	18.683	18.683
20	3.6667	10.886	.58536	1.5772	9.9024	.97561 -1	0.	0.	0.	26.715	26.715
21	.19512	3.0650	0.	.32520	5.6504	0.	0.	0.	0.	9.2358	9.2358
22	0.	1.3902	0.	.65854	4.0244	.97561 -1	2.4146	0.	0.	6.1707	8.5854
23	.29268	.48780	0.	0.	2.4634	.14634	0.	0.	0.	3.3902	3.3902
24	1.0732	.73171	0.	.24390	5.2033	0.	0.	0.	0.	7.2520	7.2520
25	.24390	0.	0.	.56098	11.691	0.	0.	0.	0.	12.496	12.496
26	.48780 -1	0.	0.	.48780	7.5447	0.	0.	0.	0.	8.0813	8.0813

TABLE B.12

MEAN HOUSEHOLD LABOR ALLOCATED TO GATHERING EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.73171 -1	.82927	0.	0.	1.7073	.26829	0.	0.	0.	2.8780	2.8780
2	.97561 -1	0.	0.	0.	.97561 -1	0.	0.	0.	0.	.19512	.19512
5	0.	0.	0.	0.	.24390	0.	0.	0.	0.	.24390	.24390
6	0.	0.	0.	0.	.21951	0.	0.	0.	0.	.21951	.21951
7	0.	0.	0.	0.	.97560 -1	0.	0.	0.	0.	.97560 -1	.97560 -1
8	0.	0.	0.	0.	.48780	0.	0.	0.	0.	.48780	.48780
9	0.	0.	0.	0.	.29268	0.	0.	0.	0.	.29268	.29268
10	0.	0.	0.	0.	.29268	0.	0.	0.	0.	.29268	.29268
12	0.	0.	0.	0.	2.6748	0.	0.	0.	0.	2.6748	2.6748
13	0.	0.	0.	0.	4.6911	0.	0.	0.	0.	4.6911	4.6911
14	0.	0.	0.	0.	1.1463	0.	0.	0.	0.	1.1463	1.1463
15	0.	0.	0.	0.	.68292	0.	0.	0.	0.	.68292	.68292
16	0.	0.	0.	0.	1.1707	0.	0.	0.	0.	1.1707	1.1707
17	0.	.90244	0.	0.	1.0244	0.	0.	0.	0.	1.9268	1.9268
18	0.	2.4634	0.	0.	1.2195	0.	0.	0.	0.	3.6829	3.6829
19	.24390	1.9024	0.	.29268	3.9675	0.	0.	0.	0.	6.4065	6.4065
20	4.9593	2.8049	0.	0.	2.0325	0.	0.	0.	0.	9.7967	9.7967
21	3.7805	0.	0.	0.	.48780	0.	0.	0.	0.	4.2683	4.2683
22	3.0894	.68293	0.	.48780 -1	0.	0.	0.	0.	0.	3.8211	3.8211
23	.17073	.75610	0.	0.	.26829	0.	0.	0.	.36585	1.1951	1.5610
24	0.	1.5122	0.	0.	0.	0.	0.	0.	0.	1.5122	1.5122
25	.43902	.78049	0.	.19512	1.1220	0.	0.	0.	0.	2.5366	2.5366
26	0.	3.9512	0.	0.	0.	0.	0.	0.	0.	3.9512	3.9512

TABLE B.13

MEAN HOUSEHOLD LABOR ALLOCATED TO POULTRY PRODUCTION EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.92683	.47154	.41463	1.6260	0.	.81300 -2	0.	0.	0.	3.4471	3.4471
2	1.0244	.96748	.66667	2.1789	0.	.16260 -1	0.	0.	0.	4.8537	4.8537
3	0.	.12195	.11382	0.	0.	0.	0.	0.	0.	.23577	.23577
8	0.	.19512	0.	0.	0.	0.	0.	0.	0.	.19512	.19512
10	0.	.82927	0.	0.	0.	0.	0.	0.	0.	.82927	.82927
11	0.	.19512	0.	0.	0.	0.	0.	0.	0.	.19512	.19512
14	0.	0.	.65040 -1	0.	0.	0.	0.	0.	0.	.65040 -1	.65040 -1
15	0.	.92683	.78049	0.	0.	0.	0.	0.	0.	1.7073	1.7073
16	0.	.78049	.73984	0.	0.	0.	0.	0.	0.	1.5203	1.5203
17	0.	.17073	.73171 -1	0.	0.	0.	0.	0.	0.	.24390	.24390
18	.14634	0.	.73171 -1	0.	0.	0.	0.	0.	0.	.21951	.21951
19	0.	.14634	0.	0.	0.	0.	0.	0.	0.	.14634	.14634
20	0.	0.	.14634	0.	0.	0.	0.	0.	0.	.14634	.14634
21	0.	.14634	0.	0.	0.	0.	0.	0.	0.	.14634	.14634
22	0.	.19512	0.	0.	0.	0.	0.	0.	0.	.19512	.19512
25	0.	0.	0.	0.	.14634	0.	0.	0.	0.	.14634	.14634

TABLE B.14

MEAN HOUSEHOLD LABOR ALLOCATED TO SMALL STOCK PRODUCTION EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	6.0976	1.5285	.14634	2.6992	.14634	0.	0.	0.	0.	10.618	10.618
2	15.756	1.4959	.19512	8.0732	.24390 -1	0.	0.	0.	0.	25.545	25.545
3	12.122	2.3577	.75610	9.3740	.63415	.73171 -1	0.	0.	0.	25.317	25.317
4	12.382	3.0163	.34146	5.3658	1.2520	0.	0.	0.	0.	22.358	22.358
5	13.285	2.5854	.17073	5.6260	1.6748	0.	0.	0.	0.	23.341	23.341
6	14.016	1.5041	.73171 -1	7.6179	1.3984	.48780	0.	0.	0.	25.098	25.098
7	14.854	2.4065	0.	5.8130	1.5935	.97561 -1	0.	0.	0.	24.764	24.764
8	14.041	1.8862	0.	7.0894	1.2033	0.	0.	0.	0.	24.219	24.219
9	9.2764	2.6341	.97560 -1	2.1707	3.7561	0.	0.	0.	0.	17.935	17.935
10	8.1463	5.2114	.98374	1.3659	1.5610	0.	0.	0.	0.	17.268	17.268
11	10.935	8.8780	.47967	1.6992	2.0081	0.	0.	0.	0.	24.000	24.000
12	12.244	13.000	.82927	1.6667	2.1138	.39024	0.	0.	0.	30.244	30.244
13	9.9024	11.748	1.1870	3.1220	1.6016	0.	0.	0.	0.	27.561	27.561
14	8.2439	15.106	1.6911	3.0000	2.5691	0.	0.	0.	0.	30.610	30.610
15	4.3821	5.3333	.34146	1.4878	.29268	0.	0.	0.	0.	11.837	11.837
16	7.9349	8.6992	.51219	.85366	0.	0.	0.	0.	0.	18.000	18.000
17	6.2195	7.4553	.84553	.53659	.12195	0.	0.	0.	0.	15.179	15.179
18	4.8618	6.4553	1.1789	.97561 -1	0.	0.	0.	0.	0.	12.593	12.593
19	4.3577	3.5285	.48780	.14634	.48780 -1	0.	0.	0.	0.	8.5691	8.5691
20	4.3089	.42276	.10569	0.	0.	0.	0.	0.	0.	4.8374	4.8374
21	3.4390	.45528	.13821	0.	0.	0.	0.	0.	0.	4.0325	4.0325
22	4.7073	1.0244	.24390	0.	0.	0.	0.	0.	0.	5.9756	5.9756
23	6.4146	.41463	0.	.14634	0.	0.	0.	0.	0.	6.9756	6.9756
24	4.6911	.43902	.58537	.39024	0.	0.	0.	0.	0.	6.1057	6.1057
25	6.0406	2.2683	.29268	1.3659	0.	0.	0.	0.	0.	9.9675	9.9675
26	3.5122	1.7317	0.	1.0732	0.	0.	0.	0.	0.	6.3171	6.3171

TABLE B.15

MEAN HOUSEHOLD LABOR ALLOCATED TO LARGE STOCK PRODUCTION EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.90244	1.3171	.14634	.58537	.29268	0.	0.	0.	0.	3.2439	3.2439
2	.68293	.36585	0.	.58537	0.	0.	0.	0.	0.	1.6341	1.6341
3	0.	.36585	0.	0.	0.	0.	0.	0.	0.	.36585	.36585
5	.73171 -1	.48780 -1	0.	0.	0.	0.	0.	0.	0.	.12195	.12195
6	0.	.97561 -1	0.	0.	0.	0.	0.	0.	0.	.97561 -1	.97561 -1
12	0.	.73171 -1	0.	0.	0.	0.	0.	0.	0.	.73171 -1	.73171 -1
13	1.2439	0.	0.	0.	0.	0.	0.	0.	0.	1.2439	1.2439
15	.56097	.17073	0.	0.	0.	0.	0.	0.	0.	.73171	.73171
16	.99187	2.0244	0.	0.	0.	0.	0.	0.	0.	3.0163	3.0163
17	1.7642	5.487[illegible]	0.	0.	.97561 -1	0.	0.	0.	0.	7.3496	7.3496
18	1.0732	7.2195	0.	0.	0.	0.	0.	0.	0.	8.2927	8.2927
19	1.6098	6.0732	0.	0.	0.	0.	0.	0.	0.	7.6829	7.6829
20	1.9024	5.6504	0.	0.	0.	0.	0.	0.	0.	7.5528	7.5528
21	1.2927	3.9106	0.	0.	.21951	0.	0.	0.	0.	5.4228	5.4228
22	0.	2.1463	0.	0.	.19512	0.	0.	0.	0.	2.3415	2.3415
23	0.	1.0000	0.	0.	0.	0.	0.	0.	0.	1.0000	1.0000
24	.65040 -1	1.2927	0.	0.	0.	0.	0.	0.	0.	1.3577	1.3577
25	.13008	1.0732	0.	0.	0.	0.	0.	0.	0.	1.2033	1.2033
26	0.	1.5366	0.	0.	0.	0.	0.	0.	0.	1.5366	1.5366

TABLE B.16

MEAN HOUSEHOLD LABOR ALLOCATED TO FETCHING WATER EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.44715	2.3252	.41463	.38211	4.0163	.15447	0.	0.	0.	7.7398	7.7398
2	.54472	4.7480	.91057	.86992	15.390	.86179	0.	0.	0.	23.325	23.325
3	.32520 -1	.14634	.65040 -1	.65040 -1	2.2764	.81300 -1	0.	.21951	0.	2.6667	2.8862
5	0.	0.	0.	0.	.58537	0.	0.	0.	0.	.58537	.58537
6	.65040 -1	0.	0.	0.	.68293	0.	0.	0.	0.	.74797	.74797
7	.13008	0.	0.	0.	.17073	0.	0.	0.	0.	.30081	.30081
8	0.	0.	0.	0.	.65854	0.	0.	0.	0.	.65854	.65854
9	0.	.89430 -1	0.	0.	1.3659	0.	0.	0.	0.	1.4553	1.4553
10	0.	.32520	0.	.26016	1.4146	0.	0.	0.	0.	2.0000	2.0000
11	0.	.13008	0.	1.4228	5.3496	.17886	0.	0.	0.	7.0813	7.0813
12	.21951	.30894	0.	.70732	7.3658	1.1951	.97561	0.	0.	9.7967	10.772
13	0.	1.7561	0.	.24390	6.6341	.65854	0.	0.	0.	9.2927	9.2927
14	0.	.73171 -1	0.	.73171	9.5935	1.0244	0.	0.	0.	11.423	11.423
15	.97561 -1	.29268	0.	.71545	5.5691	.58536	0.	0.	0.	7.2601	7.2601
16	.48780	1.3902	0.	3.0244	10.959	.78049	0.	0.	0.	16.642	16.642
17	.73171 -1	1.0244	0.	2.4146	9.9919	1.1220	0.	0.	0.	14.626	14.626
18	0.	.29268	0.	2.2764	10.325	1.1220	0.	0.	0.	14.016	14.016
19	.12195	2.4634	0.	2.5447	20.732	1.3089	0.	0.	0.	27.171	27.171
20	.22764	2.2927	0.	4.1463	18.659	1.7073	0.	0.	0.	27.032	27.032
21	.45528	.39024	0.	3.8943	17.683	1.4634	0.	0.	0.	23.886	23.886
22	.82927	1.6585	.29268	4.0813	18.813	1.1707	0.	0.	0.	26.846	26.846
23	0.	1.0244	0.	3.0976	18.203	.97561	0.	0.	0.	23.301	23.301
24	.68293	11.341	0.	4.4146	19.154	1.5122	0.	0.	0.	37.106	37.106
25	1.2683	5.4390	0.	5.3415	22.463	2.0406	0.	0.	0.	36.553	36.553
26	.97561	1.3659	.48780	4.9431	21.236	2.0488	0.	0.	0.	31.057	31.057

TABLE B.17

MEAN HOUSEHOLD LABOR ALLOCATED TO FETCHING WATER EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	0.	0.	.48780	4.0244	0.	0.	0.	0.	4.5122	4.5122
2	.63415	.48780 -1	0.	.14634	13.268	0.	0.	.21951	0.	14.098	14.317
3	0.	0.	0.	0.	1.8293	0.	0.	0.	0.	1.8293	1.8293
4	0.	0.	0.	.24390	3.9512	0.	0.	0.	0.	4.1951	4.1951
5	0.	.21951	0.	0.	5.5528	0.	0.	0.	0.	5.7724	5.7724
6	0.	0.	0.	0.	4.9919	0.	0.	0.	0.	4.9919	4.9919
7	.97561 -1	.24390	0.	0.	4.1951	0.	0.	0.	0.	4.5366	4.5366
8	.146[illegible]	1.2439	0.	0.	5.7723	0.	0.	0.	0.	7.1626	7.1626
9	0.	6.0244	.39024	.29268	5.5366	0.	0.	0.	0.	12.244	12.244
10	.12195	2.6098	0.	0.	3.9675	0.	0.	0.	0.	6.6992	6.6992
11	.58537	2.7073	0.	.48780	18.057	0.	0.	0.	0.	21.837	21.837
12	.41463	2.3659	0.	0.	17.463	0.	0.	0.	0.	20.244	20.244
13	.39024	2.6341	0.	0.	3.8537	0.	0.	0.	0.	6.8780	6.8780
14	.12195	2.3659	0.	0.	7.5122	0.	0.	0.	0.	10.000	10.000
15	.24390	1.2195	.97561 -1	0.	5.5610	0.	0.	0.	0.	7.1219	7.1219
16	.73170	3.2927	0.	0.	5.1463	0.	0.	0.	0.	9.1707	9.1707
17	1.3171	6.0732	0.	.19512	7.2195	.97561 -1	0.	0.	0.	14.902	14.902
18	1.1219	1.1707	0.	0.	6.8049	0.	0.	0.	0.	9.0976	9.0976
19	.97560	.48780	0.	0.	11.073	0.	0.	0.	0.	12.537	12.537
20	.19512	.58537	0.	.19512	22.951	0.	0.	0.	0.	23.927	23.927
21	0.	.87805	0.	.97560 -1	15.846	0.	0.	0.	0.	16.821	16.821
22	.36585	.51220	0.	.36585	13.699	.97561 -1	0.	0.	0.	15.041	15.041
23	0.	.29268	0.	.92683	23.415	0.	0.	0.	0.	24.634	24.634
24	.13008	3.1057	0.	0.	22.976	0.	0.	0.	0.	26.211	26.211
25	.26016	1.9187	0.	.24390	19.293	0.	0.	0.	0.	21.715	21.715
26	.51220	2.4878	0.	0.	7.9919	0.	0.	0.	0.	10.992	10.992

TABLE B.18

MEAN HOUSEHOLD LABOR ALLOCATED TO MEAL PREPARATION EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	.97561 -1	0.	1.2927	19.683	1.2439	0.	0.	0.	22.317	22.317
2	0.	.48780 -1	0.	3.0163	43.252	2.7317	0.	0.	0.	49.049	49.049
3	0.	0.	0.	.32520 -1	15.431	.97560 -1	0.	0.	0.	15.561	15.561
4	0.	0.	0.	0.	8.5366	0.	0.	0.	0.	8.5366	8.5366
5	0.	0.	0.	0.	5.4634	0.	2.4146	0.	0.	5.4634	7.8780
6	0.	0.	0.	0.	1.7317	0.	0.	0.	0.	1.7317	1.7317
7	0.	0.	0.	0.	2.1219	0.	0.	0.	0.	2.1219	2.1219
8	0.	0.	0.	0.	2.5610	0.	0.	0.	0.	2.5610	2.5610
9	0.	.29268	0.	.21951	2.4390	.19512	0.	0.	0.	3.1463	3.1463
10	.43902	1.6585	0.	1.8618	23.480	2.6341	0.	0.	0.	30.073	30.073
11	0.	0.	0.	.74797	19.756	1.0244	0.	0.	0.	21.528	21.528
12	0.	1.1707	0.	2.3415	29.341	1.8293	0.	0.	0.	34.683	34.683
13	0.	.58537	0.	2.4146	26.870	2.6585	0.	0.	0.	32.528	32.528
14	0.	.34146	0.	1.9024	27.219	2.7073	0.	0.	0.	32.171	32.171
15	.73171	.24390	0.	2.9512	27.732	3.6098	0.	0.	0.	35.268	35.268
16	0.	.39024	0.	3.8293	34.228	2.8780	0.	0.	0.	41.325	41.325
17	.97561 -1	1.6585	0.	5.4390	42.268	3.1707	0.	0.	0.	52.634	52.634
18	0.	0.	0.	4.5854	44.789	3.0732	0.	0.	0.	52.447	52.447
19	0.	0.	0.	4.1219	40.927	2.7805	0.	0.	0.	47.829	47.829
20	1.3171	3.0488	0.	4.6341	42.593	3.3252	0.	0.	0.	54.919	54.919
21	0.	1.3171	0.	3.9512	44.236	3.1382	0.	0.	0.	52.642	52.642
22	0.	.97561 -1	0.	5.6098	47.658	3.5854	0.	0.	0.	56.951	56.951
23	0.	.97561 -1	0.	5.9512	40.821	3.1301	0.	0.	0.	50.000	50.000
24	0.	.21951	0.	6.9024	41.658	2.8455	0.	0.	0.	51.626	51.626
25	0.	.29268	0.	6.7561	37.285	3.0976	0.	0.	0.	47.431	47.431
26	0.	0.	0.	5.9268	34.504	3.0732	0.	0.	0.	43.504	43.504

TABLE B.19

MEAN HOUSEHOLD LABOR ALLOCATED TO ATTENDING MEETING, RELIGIOUS RITES OR SCHOOL EACH FORTNIGHT

	MALES			FEMALES			INVITED			TOTAL	TOTAL
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	FAMILY	HOUSEHOLD
1	4.7317	7.0650	.79675	2.0488	4.9675	1.1707	0.	0.	0.	20.780	20.780
2	7.8618	16.089	1.5691	4.0081	11.545	2.5366	0.	0.	0.	43.610	43.610
3	11.894	33.309	1.4634	8.3821	38.325	1.4634	0.	0.	0.	94.837	94.837
4	8.2845	8.4228	0.	6.4146	7.1951	.29268	0.	0.	0.	30.610	30.610
5	7.4959	6.1138	.29268	5.5122	9.9675	0.	0.	0.	0.	29.382	29.382
6	1.1707	2.7317	.19512	0.	3.6829	0.	0.	0.	0.	7.7805	7.7805
7	2.8293	5.4959	0.	.39024	8.0731	0.	0.	0.	0.	16.789	16.789
8	1.0732	11.211	.58537	.78049	15.098	.29268	0.	0.	0.	29.041	29.041
9	0.	.87805	.19512	0.	1.5122	0.	0.	0.	0.	2.5854	2.5854
10	.26016	2.4959	0.	.26016	2.5610	0.	0.	0.	0.	5.5772	5.5772
11	9.7236	13.447	.24390 -1	2.9350	16.325	0.	0.	0.	0.	42.455	42.455
12	13.406	13.837	0.	5.9024	18.138	.58537	0.	0.	0.	51.870	51.870
13	9.4959	8.4553	1.1707	2.8130	4.9512	0.	0.	0.	0.	26.886	26.886
14	15.724	26.537	2.3415	4.7967	25.732	.58537	0.	0.	0.	75.715	75.715
15	17.626	17.301	0.	5.3089	23.073	.29268	0.	0.	0.	63.601	63.601
16	11.813	6.8049	.28455	3.4471	1.5122	.78049	0.	0.	0.	24.642	24.642
17	8.4471	8.6341	.37398	2.9106	4.1463	0.	0.	0.	0.	24.512	24.512
18	8.2683	3.8780	0.	3.5122	.82926	0.	0.	0.	0.	16.488	16.488
19	15.219	10.415	1.4634	6.3740	9.3577	1.4065	0.	0.	0.	44.236	44.236
20	12.520	5.5610	0.	4.3740	2.3008	.81300 -1	0.	0.	0.	24.837	24.837
21	11.691	4.0325	0.	3.0244	.65853	0.	0.	0.	0.	19.406	19.406
22	13.642	4.9837	.43902	3.8374	2.6179	.14634	0.	0.	0.	25.667	25.667
23	10.846	11.447	3.4390	5.3821	7.0163	.78049	0.	0.	0.	38.911	38.911
24	9.1870	6.9756	0.	2.6016	4.3902	0.	0.	0.	0.	23.154	23.154
25	12.935	9.5610	0.	5.5447	14.927	0.	0.	0.	0.	42.967	42.967
26	11.268	10.902	0.	5.1707	12.293	1.0732	0.	0.	0.	40.707	40.707

TABLE B.20

MEAN HOUSEHOLD LABOR ALLOCATED TO BEING ILL (1 DAY = 12 HOURS) EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.97561	4.2927	2.0244	0.	11.024	.39024	0.	0.	0.	18.707	18.707
2	0.	3.2683	.58537	1.1707	8.7805	.87805	0.	0.	0.	14.683	14.683
3	0.	2.6341	0.	3.2195	17.634	.29268	0.	0.	0.	23.780	23.780
4	.12195	4.1463	.29268	2.6341	13.902	0.	0.	0.	0.	21.098	21.098
5	0.	4.1951	0.	2.0488	11.081	.87805	0.	0.	0.	18.203	18.203
6	.24390	5.2601	.87805	.87805	15.756	1.4634	0.	0.	0.	24.480	24.480
7	1.6829	5.8374	0.	0.	17.285	1.1707	0.	0.	0.	25.976	25.976
8	1.1707	2.9268	0.	0.	17.073	0.	0.	0.	0.	21.171	21.171
9	.68292	3.0976	0.	0.	21.878	.87805	0.	0.	0.	26.537	26.537
10	.78048	4.9756	0.	0.	17.512	3.2195	0.	0.	0.	26.488	26.488
11	0.	3.0244	0.	0.	20.488	.87805	0.	0.	0.	24.390	24.390
12	2.0488	12.675	2.9268	0.	26.585	.87805	0.	0.	0.	45.114	45.114
13	1.6585	6.8618	2.0488	0.	21.098	1.1707	0.	0.	0.	32.837	32.837
14	1.5610	6.9268	0.	0.	36.000	0.	0.	0.	0.	44.488	44.488
15	.14634	10.976	0.	0.	22.732	0.	0.	0.	0.	33.854	33.854
16	0.	1.6098	0.	0.	23.366	0.	0.	0.	0.	24.976	24.976
17	0.	10.829	0.	0.	18.268	0.	0.	0.	0.	29.098	29.098
18	0.	7.6098	0.	0.	10.634	0.	0.	0.	0.	18.244	18.244
19	2.0488	10.537	.39024	0.	10.92[illegible]	0.	0.	0.	0.	23.902	23.902
20	0.	8.9268	2.5366	0.	8.1951	0.	0.	0.	0.	19.658	19.658
21	.87805	7.3658	2.4390	0.	9.3333	0.	0.	0.	0.	20.016	20.016
22	1.1707	10.049	2.0488	0.	8.2276	0.	0.	0.	0.	21.496	21.496
23	0.	8.4390	1.6585	0.	13.512	0.	0.	0.	0.	23.610	23.610
24	1.1707	8.7805	1.3171	0.	4.3902	0.	0.	0.	0.	15.659	15.659
25	0.	8.2927	1.0732	0.	6.7317	.87805	0.	0.	0.	16.976	16.976
26	0.	3.2195	1.2683	0.	8.0650	0.	0.	0.	0.	12.553	12.553

TABLE B.21

MEAN HOUSEHOLD LABOR ALLOCATED TO OTHER DOMESTIC WORK EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-69	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	1.1707	.20325	.17073	4.0488	6.6911	.45528	0.	0.	0.	12.740	12.740
2	2.6829	.13821	.24390 -1	6.8211	39.146	3.2195	0.	0.	0.	52.033	52.033
3	0.	0.	0.	2.2033	8.8699	1.9593	0.	0.	0.	13.033	13.033
4	.17073	0.	0.	0.	1.3902	2.1951	0.	0.	0.	3.7561	3.7561
5	.39024	.12195	0.	0.	4.6098	2.1951	0.	0.	0.	7.3171	7.3171
6	5.5854	0.	0.	.81300 -2	1.6585	.87805	0.	0.	0.	8.1301	8.1301
7	5.1951	.19512	0.	.16260 -1	3.0244	1.9512	0.	0.	0.	10.382	10.382
8	4.0976	0.	0.	1.1707	0.	1.1220	0.	0.	0.	6.3902	6.3902
9	3.7561	0.	0.	0.	.31707	.58536	0.	0.	0.	4.6585	4.6585
10	.36585	.97561 -1	0.	.24390	1.6098	1.3171	0.	0.	0.	3.6341	3.6341
11	1.2683	0.	0.	.65040	4.7073	1.5610	0.	0.	0.	8.1870	8.1870
12	0.	0.	2.0488	.91057	10.350	1.9512	0.	0.	0.	15.260	15.260
13	0.	.73171 -1	0.	.95122	14.114	2.0488	0.	0.	0.	17.187	17.187
14	.14634	.29268	0.	0.	11.748	2.3415	0.	0.	0.	14.528	14.528
15	1.0244	1.7561	0.	1.2683	25.886	2.0488	0.	0.	0.	31.984	31.984
16	.36585	0.	0.	1.7561	23.659	2.0488	0.	0.	0.	27.829	27.829
17	.26829	0.	0.	.39024	11.073	.43902	0.	0.	0.	12.171	12.171
18	1.1220	.19512	0.	2.9268	9.1789	2.9268	0.	0.	0.	16.350	16.350
19	0.	0.	0.	1.9756	15.699	1.4634	0.	0.	0.	19.138	19.138
20	0.	.14634	0.	2.4390	12.553	0.	0.	0.	0.	15.138	15.138
21	0.	0.	0.	2.0000	13.618	0.	0.	0.	0.	15.618	15.618
22	0.	0.	0.	2.2683	10.295	.58537	0.	0.	0.	13.146	13.146
23	0.	1.2032	.32520	3.9512	16.398	.26016	0.	0.	0.	22.138	22. 38
24	0.	.45528	.65040	4.2927	16.415	1.1057	0.	0.	0.	22.919	22.919
25	0.	0.	0.	2.6341	21.561	1.3171	0.	0.	0.	25.512	25.512
26	0.	.65854	0.	2.6829	20.187	1.0244	0.	0.	0.	24.553	24.553

TABLE B.22

MEAN HOUSEHOLD LABOR ALLOCATED TO STRAW WEAVING EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMLAE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.12195	.85366	0.	0.	.60976	0.	0.	0.	0.	1.5854	1.5854
2	.48780 -1	3.0000	.24390	0.	6.0000	0.	0.	0.	0.	9.2927	9.2927
3	0.	0.	.48780 -1	0.	0.	0.	0.	0.	0.	.48780 -1	.48780 -1
4	0.	.24390 -1	0.	0.	0.	0.	0.	0.	0.	.24390 -1	.24390 -1
6	0.	.24390 -1	0.	0.	0.	0.	0.	0.	0.	.24390 -1	.24390 -1
9	0.	.26829	0.	.63415	5.6341	2.0488	0.	0.	0.	8.5854	8.5854
10	.12195	1.1870	0.	0.	4.6585	2.6260	0.	0.	0.	8.5935	8.5935
11	0.	3.2602	.19512	0.	1.4878	.21642	0.	0.	0.	5.2195	5.2195
12	.24390	3.8211	0.	0.	1.2439	.65854	0.	0.	0.	5.9675	5.9675
13	.78049	7.1138	.14634	0.	.51220	1.0244	0.	0.	0.	9.5772	9.5772
14	2.7724	15.197	.79675	0.	2.8780	1.1220	.20325	0.	0.	22.756	22.959
15	6.5854	15.219	.52845	0.	1.1707	0.	.40650	0.	0.	23.504	23.911
16	5.5772	14.675	.77236	.78049	6.4797	1.1220	0.	0.	0.	29.406	29.406
17	2.2846	5.0000	.14634	.95122	7.2764	1.2439	0.	0.	0.	16.902	16.902
18	.92683	2.1220	0.	.87805	6.9024	1.4146	0.	0.	0.	12.244	12.244
19	.85366	3.1707	.24390	.21951	2.9024	1.5122	0.	0.	0.	8.9024	8.9024
20	.97560 -1	5.3252	0.	.43902	2.2602	1.4634	0.	0.	0.	9.5854	9.5854
21	3.4390	4.7480	.39024	.51220	1.7398	.51220	0.	0.	0.	11.341	11.341
22	5.0406	12.764	.63415	0.	2.0488	.87805	0.	0.	0.	21.366	21.366
23	10.691	19.984	.48780	.21951	1.0244	0.	0.	0.	0.	32.406	32.406
24	11.447	17.950	2.6992	.58537	1.4959	.92683	0.	0.	0.	34.504	34.504
25	8.2601	14.602	1.2276	.58537	1.7236	.58537	0.	0.	0.	26.984	26.984
26	6.4146	10.496	0.	0.	.21951	.43902	0.	0.	0.	17.569	17.569

TABLE B.23

MEAN HOUSEHOLD LABOR ALLOCATED TO HOUSE CONSTRUCTION & REPAIR EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.24390	2.4634	0.	0.	2.6098	.19512	0.	0.	0.	5.5122	5.5122
2	.97561 -1	1.3415	.14634	0.	.82927	0.	0.	0.	0.	2.4146	2.4146
3	0.	.21951	0.	0.	.24390 -1	0.	0.	0.	0.	.24390	.24390
4	0.	.97561 -1	0.	0.	.48780 -1	0.	0.	0.	0.	.14634	.14634
8	.24390 -1	.48780 -1	0.	0.	.73170 -1	0.	0.	0.	0.	.14634	.14634
9	.34146	.68293	0.	0.	.14634	0.	0.	0.	0.	1.1707	1.1707
10	.17073	.68293	0.	0.	0.	0.	0.	0.	0.	.85366	.85366
11	.24390	1.0000	0.	0.	0.	0.	.14634	0.	0.	1.2439	1.3902
12	.29268	.29268	0.	0.	0.	0.	0.	0.	0.	.58537	.58537
13	0.	.85366	0.	0.	0.	0.	0.	0.	0.	.85366	.85366
14	0.	.39837	0.	0.	0.	0.	0.	0.	0.	.39837	.39837
15	0.	1.0488	.34146	0.	.73171 -1	0.	0.	0.	0.	1.4634	1.4634
16	.58537	.57724	0.	.14634	.82927	0.	0.	0.	0.	2.1382	2.1382
17	0.	.34146	0.	0.	0.	0.	0.	0.	0.	.34146	.34146
18	.97561 -1	1.6098	0.	0.	0.	0.	0.	0.	0.	1.7073	1.7073
19	1.3171	6.3089	.97561 -1	0.	0.	0.	0.	0.	0.	7.7236	7.7236
20	0.	3.8943	0.	0.	.30081	0.	0.	0.	0.	4.1951	4.1951
21	1.9024	5.1789	.68293	.51220	2.7480	.14634	0.	0.	0.	11.171	11.171
22	1.6911	11.756	.78048	0.	10.390	0.	0.	0.	0.	24.618	24.618
23	2.4553	8.9756	1.8049	0.	7.7561	0.	0.	0.	0.	20.992	20.992
24	3.3089	14.008	1.2520	.19512	10.854	.14634	0.	0.	0.	29.764	29.764
25	3.2764	13.862	1.1219	0.	5.6748	0.	0.	0.	0.	23.935	23.935
26	2.0244	10.187	.55284	.14634	3.9837	0.	0.	0.	0.	16.894	16.894

TABLE B.24

MEAN HOUSEHOLD LABOR ALLOCATED TO METAL WORK EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
2	0.	.24390 -1	0.	0.	0.	0.	0.	0.	0.	.24390 -1	.24390 -1
4	0.	.48780 -1	0.	0.	0.	0.	0.	0.	0.	.48780 -1	.48780 -1
26	0.	.51220	0.	0.	0.	0.	0.	0.	0.	.51220	.51220

TABLE B.25

MEAN HOUSEHOLD LABOR ALLOCATED TO POTTERY WORK EACH FORTNIGHT

	MALES			FEMALES			INVITED			TOTAL	TOTAL
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	FAMILY	HOUSEHOLD
1	0.	.65854	0.	0.	0.	0.	0.	0.	0.	.65854	.65854
2	0.	.63415	0.	0.	0.	0.	0.	0.	0.	.63415	.63415
16	.21951	0.	0.	.33333	1.5610	.65040 -1	0.	0.	0.	2.1789	2.1789
17	1.0732	0.	0.	.44715	2.1463	.13008	0.	0.	0.	3.7967	3.7967
18	1.4146	0.	0.	.68293	2.0732	0.	0.	0.	0.	4.1707	4.1707
19	1.9024	1.1707	0.	.43902	2.0244	.97560 -1	0.	0.	0.	5.6341	5.6341
20	1.9756	1.4634	0.	.73170	4.3902	.51219	0.	0.	0.	9.0732	9.0732
21	3.4715	1.7561	0.	.92683	5.7073	1.0244	0.	0.	0.	12.886	12.886
22	3.1138	3.8455	1.5610	1.5610	5.3902	1.6829	0.	0.	0.	17.154	17.154
23	2.4146	6.6911	.36585	.92683	5.3333	1.0000	0.	0.	0.	16.732	16.732
24	2.2927	8.5203	1.0976	.58537	3.9187	1.3659	0.	0.	0.	17.780	17.780
25	3.0244	8.4797	1.2195	.95122	3.3089	.31707	0.	0.	0.	17.301	17.301
26	1.1707	3.3902	.63414	1.4634	4.1951	1.5122	0.	0.	0.	12.366	12.366

TABLE B.26

MEAN HOUSEHOLD LABOR ALLOCATED TO FABRIC AND SPINNING WORK EACH FORTNIGHT

	MALES			FEMALES			INVITED				
FORTNIGHT	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	1.6829	0.	.97561 -1	.45528	.35772	0.	0.	0.	2.5935	2.5935
2	0.	1.6098	0.	.19512	.20325	1.5691	0.	0.	0.	3.5772	3.5772
3	0.	.68293	0.	.97560 -1	.97561 -1	0.	0.	0.	0.	.87805	.87805
4	0.	.51220	0.	.73171 -1	.73171 -1	0.	0.	0.	0.	.65854	.65854
5	0.	.73171	0.	.48780 -1	0.	0.	0.	0.	0.	.78049	.78049
6	0.	.73171 -1	0.	.97560 -1	0.	0.	0.	0.	0.	.17073	.17073
7	0.	0.	0.	0.	.21951	0.	0.	0.	0.	.21951	.21951
8	0.	0.	0.	0.	.21951	0.	0.	0.	0.	.21951	.21951
10	0.	0.	0.	0.	.24390 -1	0.	0.	0.	0.	.24390 -1	.24390 -1
11	0.	1.6098	0.	0.	0.	0.	0.	0.	0.	1.6098	1.6098
12	0.	.14634	0.	0.	.31707	0.	0.	0.	0.	.46341	.46341
13	0.	.73171 -1	0.	0.	.73171 -1	0.	0.	0.	0.	.14634	.14634
14	0.	.97560 -1	0.	0.	.46341	0.	0.	0.	0.	.56097	.56097
15	0.	1.0000	0.	.36585	2.0406	0.	0.	0.	0.	3.4065	3.4065
16	0.	.90244	0.	.39024	16.732	0.	0.	0.	0.	18.024	18.024
17	0.	.92683	0.	1.2195	49.683	1.3415	0.	0.	0.	53.171	53.171
18	0.	2.1951	0.	2.1463	53.740	0.	0.	0.	0.	58.081	58.081
19	0.	2.8862	0.	1.8293	60.569	.73171	0.	0.	0.	66.016	66.016
20	0.	6.5041	0.	.97561	57.789	2.0000	0.	0.	0.	67.268	67.268
21	0.	8.3333	0.	.87805	51.154	2.6829	0.	0.	0.	63.049	63.049
22	.58537	9.5935	0.	.80488	54.878	1.7073	0.	0.	0.	67.569	67.569
23	0.	5.3415	0.	.82927	42.073	1.7317	0.	0.	0.	49.976	49.976
24	0.	7.6179	0.	0.	47.699	1.6098	0.	0.	0.	56.927	56.927
25	0.	7.1138	0.	0.	39.138	0.	0.	0.	0.	46.252	46.252
26	0.	3.8537	0.	0.	23.772	0.	0.	0.	0.	27.626	27.626

TABLE 8.27

MEAN HOUSEHOLD LABOR ALLOCATED TO NONAGRICULTURAL WORK INVITATION EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
2	.24390	0.	0.	0.	0.	0.	0.	0.	0.	.24390	.24390
3	1.2683	9.5528	.48780	1.2358	.67480	0.	0.	0.	0.	13.219	13.219
4	1.8780	31.472	1.0569	3.6098	1.4634	0.	0.	0.	0.	39.480	39.480
5	.82927	13.488	.69919	.66667	.12195	0.	0.	0.	0.	15.805	15.805
6	0.	.78048	0.	0.	.81300 -1	0.	0.	0.	0.	.86178	.86178
8	0.	.29268	.29268	0.	0.	0.	0.	0.	0.	.58537	.58537
9	0.	7.1220	.87805	0.	0.	0.	0.	0.	0.	8.0000	8.0000
11	0.	2.1707	0.	0.	0.	0.	0.	0.	0.	2.1707	2.1707
12	0.	.34146	0.	0.	0.	0.	0.	0.	0.	.34146	.34146
13	0.	.34146	0.	0.	0.	0.	0.	0.	0.	.34146	.34146
14	0.	.56910 -1	0.	0.	0.	0.	0.	0.	0.	.56910 -1	.56910 -1
15	.17073	.89431	0.	0.	.97561 -1	0.	0.	0.	0.	1.1626	1.1626
17	0.	0.	0.	0.	.97561 -1	0.	0.	0.	0.	.97561 -1	.97561 -1
19	0.	.19512	0.	0.	0.	0.	0.	0.	0.	.19512	.19512
20	0.	1.0976	.29268	0.	.21951	0.	0.	0.	0.	1.6098	1.6098
21	0.	1.0244	0.	0.	0.	0.	0.	0.	0.	1.0244	1.0244
22	.68293	6.8374	.14634	.19512	3.8049	0.	0.	0.	0.	11.667	11.667
23	.24390	4.5854	0.	0.	2.6341	0.	0.	0.	0.	7.4634	7.4634
24	0.	4.8618	.14634	0.	0.	0.	0.	0.	0.	5.0081	5.0081
25	0.	3.9431	0.	0.	0.	0.	0.	0.	0.	3.9431	3.9431
26	.12195	1.5772	0.	0.	0.	0.	0.	0.	0.	1.6992	1.6992

TABLE B.28

MEAN HOUSEHOLD LABOR ALLOCATED TO COMMERCIAL ACTIVITY EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	.17073	3.5528	.34146	.97561 -1	7.6667	0.	0.	0.	0.	11.829	11.829
2	.14634	5.1951	.63415	.41463	12.943	.48780 -1	0.	0.	0.	19.382	19.382
3	.17073	4.4959	.65040	0.	5.9431	0.	0.	0.	0.	11.260	11.260
4	.48780 -1	3.2195	1.1382	.24390	4.9187	.87805	0.	0.	0.	10.447	10.447
5	0.	3.1707	.35772	.24390 -1	3.2439	0.	0.	0.	0.	6.7967	6.7967
6	.97561 -1	3.4228	.29268	.26829	4.7236	0.	0.	0.	0.	8.8049	8.8049
7	0.	3.2195	0.	0.	4.1219	0.	0.	0.	0.	7.3415	7.3415
8	.48780 -1	3.2683	0.	0.	5.9268	1.7561	0.	0.	0.	11.000	11.000
9	.34146	5.3821	.32520 -1	.17073	10.439	.73171	0.	0.	0.	17.098	17.098
10	.34146	5.2114	.41463	.56910 -1	3.3171	0.	0.	0.	0.	9.3415	9.3415
11	.46341	2.8130	.26016	.43089	4.9431	.97561 -1	0.	0.	0.	9.0081	9.0081
12	2.1220	4.8618	.80488	0.	8.3658	.58537	0.	0.	0.	16.740	16.740
13	1.3171	6.0569	0.	.78049	7.3496	0.	0.	0.	0.	15.504	15.504
14	1.2439	6.5447	0.	0.	9.3496	.87805	0.	0.	0.	18.016	18.016
15	0.	3.6829	.73171 -1	1.0000	7.2032	0.	0.	0.	0.	11.959	11.959
16	0.	6.7398	0.	.48780	5.9106	.32520 -1	0.	0.	0.	13.171	13.171
17	.34146	8.1951	.12195	.48780	5.2358	.65040 -1	0.	0.	0.	14.447	14.447
18	.97560 -1	10.252	.73171 -1	0.	5.4228	.97561 -1	0.	0.	0.	15.943	15.943
19	.16260	11.033	0.	1.1301	11.919	.73171	0.	0.	0.	24.976	24.976
20	.17886	7.8862	.73171 -1	.65040 -1	3.5528	.73171 -1	0.	0.	0.	11.829	11.829
21	2.0244	9.1138	.24390	.36585	7.9024	.19512	0.	0.	0.	19.846	19.846
22	2.8293	10.138	0.	.24390	11.797	.73171 -1	0.	0.	0.	25.081	25.081
23	3.8618	8.4146	0.	1.0244	9.8293	.36585	0.	0.	0.	23.496	23.496
24	2.6260	8.5854	0.	.63415	14.195	0.	0.	0.	0.	26.041	26.041
25	1.2927	9.4309	0.	.19512	6.2439	0.	0.	0.	0.	17.163	17.163
26	.39024	9.0732	.24390	.58537	4.0732	.14634	0.	0.	0.	14.512	14.512

TABLE B.29

MEAN HOUSEHOLD LABOR ALLOCATED TO TRAVEL AWAY FROM VILLAGE OF A SOCIAL NATURE EACH FORTNIGHT

FORTNIGHT	MALES 8-14	MALES 15-60	MALES 61+	FEMALES 8-14	FEMALES 15-60	FEMALES 61+	INVITED MALE	INVITED FEMALE	HIRED	TOTAL FAMILY	TOTAL HOUSEHOLD
1	0.	1.8780	.48780 -1	0.	10.122	0.	0.	.24390 -1	0.	12.049	12.073
2	.29268	10.829	.29268	0.	22.732	.58537	0.	0.	0.	34.732	34.732
3	0.	3.3415	.58537	0.	10.634	0.	0.	0.	0.	14.561	14.561
4	.97561 -1	3.0000	1.2683	2.0976	15.293	.87805	0.	0.	0.	22.634	22.634
5	.58537	2.4146	.48780	0.	9.1220	1.1707	0.	0.	0.	13.780	13.780
6	.97560 -1	2.1463	.19512	0.	9.2439	0.	0.	0.	0.	11.683	11.683
7	.19512	2.3171	.97560 -1	0.	13.780	0.	0.	0.	0.	16.390	16.390
8	1.4634	5.6341	0.	.58537	20.488	0.	0.	0.	0.	28.171	28.171
9	.87805	8.5854	.87805	.87805	7.0488	1.1707	0.	0.	0.	19.439	19.439
10	.87805	11.285	0.	0.	10.439	0.	0.	0.	0.	22.602	22.602
11	0.	9.7398	0.	0.	5.0732	1.2683	0.	0.	0.	16.081	16.081
12	1.3984	26.390	.85366	0.	7.6585	.78048	0.	0.	0.	37.081	37.081
13	.74796	19.122	.87805	.87805	4.8293	0.	0.	0.	0.	26.455	26.455
14	0.	24.146	.39024	0.	14.683	0.	0.	0.	0.	39.219	39.219
15	.87805	19.780	.87804	1.1707	13.951	.87805	0.	0.	0.	37.537	37.537
16	0.	15.341	1.0732	1.2439	11.610	0.	0.	0.	0.	29.268	29.268
17	1.1707	23.415	0.	0.	7.6098	0.	0.	0.	0.	32.195	32.195
18	0.	17.976	.43902	0.	9.6585	0.	0.	0.	0.	28.073	28.073
19	0.	20.439	0.	0.	6.7317	0.	0.	0.	0.	27.171	27.171
20	0.	28.000	0.	0.	7.0244	0.	0.	0.	0.	35.024	35.024
21	0.	27.317	0.	0.	3.3171	0.	0.	0.	0.	30.634	30.634
22	0.	28.878	0.	1.1707	3.5122	0.	0.	0.	0.	33.561	33.561
23	.87805	40.732	0.	.87805	7.3171	0.	0.	0.	0.	49.805	49.805
24	0.	36.390	1.1220	0.	12.878	2.3415	0.	0.	0.	52.732	52.732
25	0.	37.268	0.	0.	6.4390	0.	0.	0.	0.	43.707	43.707
26	0.	38.585	1.7561	0.	2.3415	0.	0.	0.	0.	42.683	42.683

TABLE B.30

MEAN HOUSEHOLD LABOR ALLOCATED TO VISITING WITH FRIENDS, DRINKING MULLET BEER, ETC. EACH FORTNIGHT

FORTNIGHT	MALES			FEMALES			INVITED			TOTAL FAMILY	TOTAL HOUSEHOLD
	8-14	15-60	61+	8-14	15-60	61+	MALE	FEMALE	HIRED		
1	10.577	40.935	2.3577	6.0569	35.398	2.7886	0.	0.	0.	98.114	98.114
2	19.504	66.805	4.7805	13.447	49.480	3.3821	0.	0.	0.	157.40	157.40
3	22.211	54.480	3.9187	17.057	59.585	6.4878	0.	.70732	0.	163.74	164.45
4	23.244	56.455	5.4553	18.463	72.886	7.5854	.97561	.73171	0.	184.09	185.80
5	23.374	51.772	5.8293	22.374	67.252	6.6829	0.	0.	0.	177.28	177.28
6	27.008	56.423	7.6016	24.658	73.577	8.5366	0.	0.	0.	197.80	197.80
7	36.268	81.480	9.5772	27.496	96.406	9.5935	0.	0.	0.	260.82	260.82
8	50.317	116.95	13.309	32.008	135.25	14.138	0.	0.	0.	361.98	361.98
9	68.008	145.65	16.228	44.415	16[illegible].06	15.805	0.	1.6098	0.	474.16	475.77
10	71.097	158.46	15.984	45.813	189.59	12.073	1.2683	.60976	0.	493.02	494.89
11	50.114	141.40	12.106	36.748	184.42	10.626	0.	0.	0.	435.41	435.41
12	55.358	136.66	10.967	43.707	169.08	10.984	0.	0.	0.	426.76	426.76
13	51.577	119.55	11.098	57.569	134.56	8.5203	0.	0.	0.	362.88	362.88
14	47.577	102.86	10.431	37.000	118.41	9.2114	0.	0.	0.	324.68	324.68
15	48.130	106.37	11.106	34.593	111.45	8.7479	0.	0.	0.	320.39	320.39
16	53.431	134.67	13.528	38.837	123.27	11.634	0.	0.	0.	375.37	375.37
17	70.163	145.93	17.016	45.301	152.33	12.780	0.	0.	0.	443.51	443.51
18	56.886	132.38	17.504	43.041	126.57	12.439	0.	0.	0.	388.82	388.82
19	62.512	127.21	14.504	37.219	125.20	9.4309	0.	0.	0.	376.08	376.08
20	58.520	111.37	12.472	37.041	121.03	11.130	0.	0.	0.	351.57	351.57
21	56.016	110.29	11.967	35.650	106.86	10.789	0.	0.	0.	331.58	331.58
22	57.244	106.38	12.967	37.057	133.08	10.659	0.	0.	0.	357.39	357.39
23	51.756	105.03	11.187	34.837	111.34	11.805	0.	0.	.36585	325.96	26.32
24	60.032	105.08	12.041	38.911	112.90	10.098	0.	0.	0.	339.06	39.06
25	51.423	98.455	14.154	31.577	108.19	10.504	0.	0.	0.	314.30	314.36
26	46.097	77.984	12.854	30.187	81.618	9.7073	0.	0.	0.	258.45	258.45

TABLE B.31

CONVERSION OF UNITS OF VOLUME AT HARVEST INTO STORABLE KILOGRAMS TENKODOGO 1976

(Conversions are from Volumes of Freshly Harvested Produce in Form Specified to Weights of Dry Storable Produce in Form Specified)

Crop	Volume Form of Crop	Weight Form of Crop	"Plat"	Small Basket	Medium Basket	Large Basket	"Tine" (Used for Dry Storable Produce in Final Form)	"Sack" (Used for Dry Storable Produce in Final Form)
Millet	Ear	Grain	2.38	2.72	4.54	7.56	16.67	100[a]
White Sorghum	Ear	Grain	2.60	3.70	6.17	10.28	18.20	109.20[b]
Red Sorghum	Ear	Grain	2.75	4.77	8.18	12.95	19.25	115.50[b]
Maize	Ear	Grain	1.91	6.00[b]	10.00[b]	16.67[b]	13.33[b]	80.00[a]
Rice (Paddy)	Stem	Grain (Unshelled)	2.00[a]	14.51[b]	24.18	40.31[b]	14.00	25.00[a]
Cowpeas	Pod	Shelled	2.62	2.53[b]	4.22	7.03[b]	18.33	110.00[b]
Chick Peas	Shell	Shell	2.50	8.95	14.92	24.87	17.50	105.00[b]
Cassava	Tuber	Tuber	4.14	14.58	24.30	40.30[b]	29.00	-
Peanuts (Shell)	Stalk	Shell	1.24	7.40	12.34	20.57	8.65	51.90
Tobacco	Leaf	Leaf	0.06	1.95	3.25	5.42	-	-

NOTES: (a) By Definition

(b) Interpolated Values

TABLE B.32

MEAN NUMBER OF TRADITIONAL AGRICULTURAL IMPLEMENTS PRESENT IN EACH HOUSEHOLD, BY ETHNIC GROUP

Ethnic Group	Hoes (Daba)	Hatchets	Machetes	Sickles
Bisa n=30	6.9	1.9	1.5	3.4
Mossi n=28	5.1	.78	1.7	1.8
Bisa & Mossi combined n=57	6.1	1.4	1.6	2.7
Fulani n=14	4.64	.86	1.71	2.36

Source: Answers from questionnaire K, Appendix C.

TABLE B.33

AVERAGE ON-FARM CROP STORAGE FACILITIES, BY ETHNIC GROUP

Ethnic Group/Facility	Mud-brick Silos	Straw Silos	Earthenware Storage Jars
Bisa n=30	2.3	2.9	3.0
Mossi n=28	2.5	2.6	3.0
Bisa & Mossi combined n=58	2.4	2.8	3.0
Fulani n=14	1.5	1.9	1.6

Methodology: Means are taken over households.

APPENDIX C

RESEARCH MATERIALS

This appendix contains research materials generated by the author during the field study and referred to in the main body of the text. Their originality lies primarily in the fact that they permit a farm management survey in the British and American tradition in a Francophone area. Therefore the materials are copied in the original French form. They include an enumerator's manual for instructing field staff, the curriculum of the enumerator training workshop, and the set of questionnaires used to gather data. Each item is identified by a heading in English.

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Manuel d'Enquêteur pour le Projet de Recherche sur les Moyens de Production en Milieu Rural dans la Région de Tenkodogo, République de Haute-Volta

1ère Edition
Le 15 Avril 1976

Table de Matières

But et Importance de l'Etude

Le projet veut recueillir l'ensemble de moyens de production mis en oeuvre dans les villages de Loanga et de Ouegedo, pendant toute une année. La nouveauté, aussi bien que la valeur scientifique, de l'étude est que ces moyens peuvent compter le flux de travail humain aussi bien que le stock d'équipement et de terre. Par flux de travail humain, nous entendons le nombre d'heures passées par jour, chaque jour, sur différentes activités productives.

Les données recueillies doivent permettre de savoir combien de capitaux, de terres et d'heures de travail ont été combinés pour produire unkilogramme de chaque culture ou une unité de chaque produit vendu.

Ces données nous permettent de savoir les besoins en temps,capitaux et terres d'une unité de chaque culture. Ils permettent de comparer la rentabilité de différentes activités, par heure de travail aussi bien que par hectare. Finalement ces données nous permettent de constater, de façon rigoureuse, ce qu'on doit sacrifier si on veut réorienter les ressources rares (terre, capitaux, heures de travail pendant la saison des sarclages) d'une activité à une autre. C'est à dire, cet étude doit permettre le calcul des résultats de différentes stratégies de gestion au niveau du petit exploitant. Ces données sont jugées indispensables à la planification du développement rural, et ainsi leur existence facilite l'obtention d'une aide extérieure pour amorcer cet développement.

Le Rôle de l'Enquêteur

I - Généralités

En général, l'enquêteur sert de lien entre les villageois et le chercheur. Chaque enquêteur couvre un échantillon de quinze ménages.

La responsabilité principale de l'enquêteur est de maintenir d'excellents rapports de coopération avec les gens du village. Sans cette coopération, la réussite de l'étude est impossible.

Le travail d'un enquêteur (ou d'un chercheur) n'est pas un travail de bureau. Le projet nécessite que vous soyez sur place six jours sur sept. Certaines semaines il se pourrait que vous auriez plus de 40 heures de travail. D'autres semaines vous aurez certainement moins de 40 heures. Vous êtes engagés pour faire le travail - non pas pour accomplir un certain nombre d'heures par semaine au bureau.

II - Travaux à accomplir

1) Participation dans l'identification de l'échantillon de 30 ménages par village.

2) Prise de contact avec chaque ménage et effort pour établir des bases d'amitié et de coopération avec les membres de l'échantillon.

3) Administration des questionnaires A et B pour énumérer les membres de l'échantillon, leur âge et sexe et leurs champs.
Recopiez un exemplaire pour remettre au chercheur.

4) Visite de chaque champ et identification des champs par coloration des arbres s'il y a nécessité d'éviter une confusion. Vous devez faire ceci en compagnie du propriétaire du champ concerné.

5) Recueil, par visite sémi-hebdomadaire à chaque ménage, des données suivantes :

Enumerator's Manual p. 3

a) Heures de travail consacrées à toutes les tâches relatives à la production de cultures vivrières, industrielles et produits de l'élevage.

b) Heures de travail consacrées aux travaux non-agricoles: construction de maisons, recherche d'eau, etc...

c) Heuresde travail fournis par des invités, des visiteurs et des mains-d'oeuvre payées.

d) Tous les achats et ventes faits par les membres du ménage.

e) Toute utilisation d'un intrant à la production tel que femme, fertilisant inorganique , insecticide, etc...

De temps en temps, le chercheur vous demandera d'administrer des questionnaires supplémentaires.

Des exemples serraient : équipement à la disposition du ménage, taille des troupeaux, etc...

En plus/il vous sera demandé de faire d'autres travaux qui sont relatifs au projet : codification des questionnaires, mesure des surfaces de terrains étant les exemples principaux.

Il est souligné que vous êtes embauchés par le chercheur pour l'aider à accomplir son travail de recherche, tel qu'il le conçoit. Il ne faut pas revenir un jour dire : "On n'a pas été embauché pour ceci ou cela...".

III- Responsabilités de l'Enquêteur et Fautes Graves

Trois grandes catégories de délits sont jugés suffisamment graves pour mériter le licenciemment immédiat sans préavis.

1) - Fautes graves de comportement

a) - Bagarres avec villageois

b) - Rapports sexuels avec les filles du village

c) - Manque de respect flagrant pour les vieux du village.

La constatation d'une faute de ce genre revient au chef do village. Sur sa demande, l'enquêteur sera retiré immédiatement.

2) - Malhonnêtété dans l'obtention des données

La création des données fictives pour éviter l'effort de recueillir les données rentables apportera le licenciemont immédiat sans préavis.

3) - Manque d'assiduité au travail

Il est très important que l'enquêteur soit à son poste six jours chaque semaine pour 52 semaines. Des primes sont envisagées au lieu de vacances. Une absence du village non autorisé par le chercheur peut ammener le licenciement immédiat s'il juge la raison de l'absence non sérieuse.

En dehors de ces trois grandes catégories de délits, le chercheur réserve toujours son droit d'employer des gens qui l'aident dans son travail. Si, à l'avis du chercheur, un enquêteur nuit à son travail, pour raison qui sera seulement au chercheur de déterminer, et/si une faute grave n'a pas été commise, un préavis de licenciemment de 30 jours sera donné. Dans ce cas, tout le matériel de recherche fourni par le chercheur doit lui être rendu: bicyclette, lampe, lit, outils, etc...

L'UTILISATION DU QUESTIONNAIRE SEMI-HEBDOMADAIRE

(1) D'abord, remplissez le numéro du ménage en question dans la boîte marquer "ferme". Vérifiez que le numéro du ménage est composé de 2 chiffres. Ex.: ménage 2 est écrit "02".

(2) De même, remplissez le numéro de la semaine d'après la liste des dates. Il s'agit de la semaine de la visite de l'enquêteur. Semaine 2 est écrit "02".

(3) Remplissez le numéro du jour de l'interview. Si vous visitez le ménage un mardi, il faut écrire : "03". Le premier jour est dimanche et le dernier (7ème) est samedi.

(4) Remplissez les dates pour lesquelles les heures de travail sont recensées, dans la rubrique " Période".

(5) Remplissez les Noms de chaque membre du ménage dans les colonnes reservées à ce but.

(6) Demandez au Chef de ménage de se rappeler de ce qu'il a fait, en ordre chronologique, depuis le lever du soleil du premier jour recensé. Ensuite passez en deuxième et troisième jour, toujours dans l'ordre chronologique.

(7) Recueillir les mêmes données pour chaque membre du ménage.

(8) Indiquez s'il y a eu des visiteurs (codes 07 et 08) ou des mains-d'oeuvre embauchées pour l'argent.(Code 09). Essayer de recueillir le travail qu'ils ont fait sur chaque terrain. Vous devez prendre une grande colonne séparée pour visiteurs mâles et femelles, aussi bien qu'une colonne séparée pour mains-d'oeuvre embauchées.

(9) Si un des membres du ménage, un visiteur ou une main-d'oeuvre a récolté ou a utilisé de fertilisant ou d'insecticide, relevez les heures passées tout comme vous les auriez relevés pour une autre activité. Mais mettez un petit crochet dans la marge de la ligne en question.

(10) De même, si un des membres du ménage a fait un achat, notez le temps qu'il a fallu pour accomplir cette action (y compris le temps de déplacement). Mettez un petit crochet dans la marge.

(11) Lorsque vous notez le temps passé sur chaque activité, agissez de la manière suivante :

a) Notez le numéro de terrain (en deux chiffres) d'après la liste des terrains que vous avez fait pour ce ménage, s'il s'agit d'une activité se rapportant au terrain. Si non, laissez le terrain en blanc.

b) Ecrivez la culture, produit ou mélange des cultures dont il s'agit.

c) Ecrivez l'activité dont il s'agit.

d) Mettez les <u>heures</u> passées dans les colonnes correspondants aux jours en question.

e) Mettez les totaux des heures passées sur chaque activité par chaque personne.

f) Chez vous plus tard, remplissez les codes des cultures et des activités

(12) Pour une même activité, exercée sur le même terrain et culture, vous pouvez relever les heures de travail de différentes personnes sur la même ligne. Sinon, utilisez une ligne séparé pour chaque terrain et chaque activité.

(13) Après la relève de toutes les heures de travail, comptez le nombre de crochets que vous avez mis dans la marge. Vous avez maintenant besoin d'une ligne pour chaque ligne où il y a un crochet.

Vous écrivez la culture ou produit (et le numéro du terrain pour une récolte). Ecrivez l'unité de quantité ou de valeur dont il s'agit (ex. tines ou francs gagnés) dans la colonne des activités.
Vous indiquez le montant en centaines de francs ou en tines, etc. sous le jour en question dans une grande colonne codifié "99".

(14) Chez vous, mettez le code de la culture ou produit en question auquel on a ajouté 50, pour indiquer un achat, vente, récolte, fertilisation ou désinfectage. Dans l'espace réservé au code d'activité, écrivez le code qui correspond aux unités dans laquelle on calibre l'action dont il s'agit. (Exemple, pour un achat on mettrait le code correspondant à : " centaines de francs payés".

(15) Vérifiez que vous avez codifié correctement le questionnaire.

(16) Quelques exemples :
(Voir feuille de questionnaire attaché au manuel).

a) Moussa sarcle le petit mil et haricots dans son troisième champ (où les cultures sont mélangées) pour quatre heures le lundi et le mercredi. Sa femme Awa, fait la même chose pour deux heures le mardi.

b) Moussa récolte 4 paniers de Gros Mil (Sorgho Blanc) en 5 h. le lundi sur son 5eme champs.

c) Il prend 6 h. pour aller au marché vendre 3 tines de Gros Mil le Mardi. Il reçoit 1 540 F.

FERME 06 SEMAINE 03 JOUR 5

PERIODE DU ______ AU ______

AGE	65	64			
SEXE	M	F			
CODE	03	06	99		
NOM DU TRAVAILLEUR	Moussa	AWA	Récolte/vente		

TERRAIN		CULTURE	CODE	ACTIVITÉ	CODE		L	M_D	M_r		TOT	L	M_D	M_r		TOT	L	M_s	M_r		TOT
0	3	petit mil + haricots	25	Sarclage	1	0	4		4		08		2			02					
0	5	gros mil	02	récolte (en épis)	1	8	5				05										
				aller au marché	7	3		6			06										
0	5	gros mil	52	récolte en grands paniers	0	1											4				04
		gros mil	52	Vente en 100 Fs gagnés	1	2												15			15

Enumerator's Manual p. 6

CODES DES CULTURES, MELANGES ET PRODUITS

CROP, MIXTURE AND PRODUCT CODES

01 - Potit mil. PEARL MILLET

02 - Gros mil (sorgho blanc) consommation humainc.
WHITE SORGHUM FOR HUMAN CONSUMPTION

03 - mil rouge. RED SORGHUM

04 - Maïs. MAIZE

05 - Riz. RICE

06 - Haricot blanc. WHITE BEANS

07 - Poids do terre. COWPEAS

08 - Manioc. CASSAVA

09 - Patato. SWEET POTATOES

10 - Mil rouge + petit mil + Haricot + Arachido
RED SORGHUM, millet, beans and peanuts

11 - Fruits (Mangues, goyaves etc...)
Fuits (Mangoes, Guavas, etc...)

12 - Tomatos. Tomatoes

13 - Oignons. Oignons

14 - Sorgho rouge + riz. Red sorghum and rice

15 - Arachide + sorgho rouge. Peanuts and red sorghum

16 - Autres légumes (salade + choux etc...omettre tomates et oignons,gombo.)
Vegetables besides oignons, tomatoes and gumbo

17 - Piment (et autres épices + sel.) Red pepper, other spices, salt

18 - Arachides. Peanuts

19 - Coton. Cotton

20 - Tabac. Tabacco

21 - Sorgho rouge + Coton. Red sorghum and cotton

22 - Coton + Maïs. Cotton and Maize

23 - Maïs + tabac. Maize and tabacco

24 - Gros mil + Haricot blanc. White sorghum and beans

25 - Petit mil + Haricot blanc. Millet and beans

26 - Sorgho rouge + Haricot blanc. Red Sorghum and beans

27 - Gros mil + petit mil + Haricot blanc.
White sorghum, millet and beans

28 - Piments + Tomates. Pepper and tomatoes

29 - Piments + Oignons + Tomates. Pepper, oignons and tomatoes

30 - Gros mil + sorgho rouge. White and red sorghum

31 - Objet en terre cuite (canaris etc...)
Objects in baked earth (pots and jugs).

32 - Grand bétail - Large livestock (cattle)

33 - Beurre de karité, autres produits de cueillette(exple. Néré)
Sheanut butter uther gatherings

34 - Objets en bois (manche de daba, mortiers, cuvettes, etc...).
Wooden objects (hoe handles, etc.)

35 - Objets en paille tressée (séco, panier, natte...)
Straw objects (mats, etc.)

36 - Objets en métal (daba, couteau, pioche....)
Metal objects (hoe blades, etc)

37 - Produits chimiques (savon, marchandises etc...)
Chemical products (soap) and other merchandise

38 - Huiles   Eddible oils

39 - Tissus et vêtements   cloth and clothes

40 - Machines électriques (Radios, Machines à coudre.
Electrical machines

41 - Bicyclettes + Mobylettes. Bicycles and mopeds

42 - Dolo . Millet Beer

43 - Viande. Meat

44 - Petit bétail, moutons, chèvres, poulets, pintades
Small Livestock and fowl

45 - Pétrôle. Kerosene

46 - Sorgho rouge + petit mil + Haricot. Red sorghum, millet and beans

47 - Sorgho rouge + petit mil + haricot + coton.
Red Sorghum, Millet, Beans and Cotton

48 - Sorgho blanc + Coton + Haricot.
White sorghum Cotton and Beans

49 - Arachide + Pois de terre. Peanuts and cowpeas

CODES DES ACTIVITES
ACTIVITY CODES

(a) CODES POUR TRAVAUX DES CHAMPS
FIELD WORK CODES

01 – Débroussage : 03 Déracinage (Pessingo) Bush clearing
02 – Brulure (N'yobo) Burning
03 – Déracinage = 01 Débroussage (Pessingo) Same as 01
04 – Nivellement : 06 Labour – Hersage (Bougboug) Leveling, Ploughing
05 – Binage (3ème Sarclage-Butage) Ridging (3 rd weeding)
06 – Labour – Hersage – Ameublissement : 04 Nivellement (Bougboug) Same AS 04.
07 Fumure (Pondo) Fertilizing
08 – Semailles (D'Bo) Sowing
09 – Démariage=11 Transplantation (Wosgo) Separating and transplanting
10 – Sarclage Weeding
11 – Transplantation = 09 Démariage (Selbo) Same AS 09
12 – Drainage Draining
13 – Irrigation = 81 Arrosage Irrigating, Watering
14 – Désinfectage (Spraying insecticide)
15 – Clôture (N'yangbo) Fencing
16 – Surveillance des champs (Gounbou) Guarding Fields
17 – Récolte-couper les tiges (Kehbo) Harvesting : cutting the stalks
18 – Récolte – couper les épis (Kenbego) Harvesting: Cutting the heads of grain
19 – Récolte – Battage (Ki-Pantré Kâ-wedo) Threshing
20 – Séchage (yedegré) Drying
21 – Vente des récoltes (Kohsgo) selling harvest
22 – Travail agricole (aide sollicitée) (ko-Poussogho) Providing cabor help in neighbors fields
23 – Transport des produits agricoles (Ka- Woukré) Transportation of agricultural products

b) CODES POUR TRAVAUX D'ELEVAGE
STUCKRAISING WORK CODES

24 – Balayer le poulailler + vendre la volaille – Sweeping the coop, selling chickens
25 – Ramasser les oeufs Gathering Eggs
26 – Donner à boire aux volailles Fetching water for fowl
27 – Recherche des termites pour les volailles Fetching termites fur fowl
28 – Donner à manger aux volailles feeding fowl
29 – Donner à boire au petit bétail watering small stock
30 – Couper de l'herbe cutting grass for feed

31 - Gardor petit bétail herding small stock

32 - S'occuper des porcs Taking care of pigs

33 - Donner à boire au gros bétail Watering Largestock

34 - Entrainer les chevaux - Training and exercising horses

35 - Construction d'étable - Building stables

36 - Récherche d'un animal égaré Looking for a lost animal

37 - Amener les boeufs lécher le sel Taking Cattle For Salt lick

38 - Traire le lait de vache Milking cows

39 - Soin sanitaire des animaux - Health care of animals

- CODES POUR CHASSE ET CUEILLETTE
HUNTING AND GATHERING CODES

40 - Pêche (y compris construction de Matériel)
Fishing activities

41 - Chasse (y compris construction de matériel)
Hunting activities

42 - Cueillette de noix de karité Gathoring shea nut

43 - Cueillette autres produits (Néré - Pain de singe - Tamarin)
All other Gathering of wild fruits, roots, etc...

c) - CODES POUR TRAVAUX D'ENTRETIEN
UPKEEP OF MATERIAL ACTIVITY CODES

44 - Réparation des outils de culture. Repairing Agricultural Tools

45 - Fabrication de manche de daba.
Making Tool Handles

46 - Recherche de fertilisants, semences, insecticides.
Gathering Fertilizer, Fetching Seeds

47 - Nettoyage des produits. Cleaning of agricultural produce

48 - Triage . Sorting of produce.

d) CODES POUR TRAVAUX DOMESTIQUES
HOUSEHOLD CHORE CODES

49 - Réparation - confection - lavage des habits. Sewing and washing clothes

50 - Recharche de l'eau. Fetc ing water for household use

51 - Recherche du bois. Fetching wood for fuel

52 - Ecraser les céréales (mil - Riz - Sorgho) avec meule
Shelling cereals with mechanical mill

53 - Ecraser les céréales (mil - Riz - Sorgho) avec Moulin
Shelling cereals with mortar

54 - Piler le céréale avec mortier. Grind flour with morter

55 - Piler le céréale avec Moulin
Grind flour with mill

56 - Préparation de repas (omettre piler et écraser)
Preparation of meal other than making flour

57 – Autres travaux de ménages (balayer la cour, laver les assiettes gardiennage d'enfants).
Other Houseaold chores

58 – Aller au dispensaire + soins médicaux + être malade + accouchement
Go to dispensary, being immobilized due to physical condition

1 jour = 12 heures.

a) – CODES POUR TRAVAUX NON AGRICOLES

NON-AGRICULTURAL LABOR CODE

59 – Réparation et construction de puits. Repair and construction of wells

60 – Tressage de nates, corbeilles, Paniers, cordes, châpeaux, autres produits artisanals + Paille.
Straw weaving handicraft work

61 – Tressage de secos. Weaving hut construction materials (mats, walls, roofs)

62 – Recherche de pailles (pour artisanats + construction).
Gathering straw for weaving and construction.

63 – Construction + Réparation de maison, de hangar, Réparation des toîts.
Construction and repair of buldings

64 – Travaux des métaux. Métal work

65 – Fabrication des canaris Fabrication of earthenware

66 – Réparation de machines (Bicyclette – Radios, etc...
Repair of machines, bicycles etc...

67 – Activités commerciales au village (Vente piles, galettes, dolo)
Commercial activity in village (selling)

68 – Fabrication dolo, galettes, autres pour vendre –
Preparing food for sale

69 – Fabrication de briques Making Bricks

70 – Autres travaux non agricoles faits au village pour de l'argent
Other non-agricultural work in village for money

71 – Autres travaux non-agricoles faits en déhors du village pour de l'argent – Other non-agricultural activity outside village for money

72 – Travaux non agricoles sollicités (aide au voisin, au chef)
Non-agricultural labor help supplied to neighbor

73 – Aller au marché Go to Market

74 – Transport des produits non agricoles
Transport of non agricultural products

b) – AUTRES CODES ET ADDITIONS

OTHER CODES AND ADDITIONS

75 – Aller au marigot pour se laver – Bathing in watercourse

76 – Distraction (boire du dolo, écouter la radio, jouer un instrument de musique, rien faire + Repos aux champs)
Distraction, leisure activies, drinking millet beer

77 – Réunion Attending non-religions meeting

78 – Fêtes + Funérailles + manifestation Réligieuse.
Religions and customary activities

79 - Aller à l'école. Go to school

80 - Aller et venir des champs. Travel To and Between Fields

81 - Arrosage des jardins. Watering gardens

82 - Etre parti en voyage 1 jour = 12 heures. Being away on a trip (I day 12 hours)

83 - Décorticage (Néré - Arachide) Shelling Peanuts and other non-cereals)

84 - Egréner le coton, kapok. Seeding cotton and kapok

85 - Tisser + Filer. Weaving and spinning

CODES DES UNITES DE MESURE
UNIT MEASUREMENT CODES

01 - Grand panier. Large Basket
02 - Panier moyen. Average Basket
03 - Petit panier. Small Basket
04 - Kg. Kilograms
05 - Plat. Dish (Local Measurement)
06 - Tine. Tin grain measuring can (local measurement)
07 - Sac. Grain sack
08 - Litre. Litre
09 - Calebasse. Gourd
10 - Grands canaris. Large pot
11 - Canaris moyens . Average pot
12 - Centaines de Francs gagnés Hundreds of cfa france earned
13 - Centaines de Francs payés· Hundreds of cfa francs paid
14 - Tas (coton) = 1 kg. de coton . Pile (local measurement)

PERSONNELS APPARTENANT AU MENAGE
MEMBERS OF HOUSE HOLD CODES

Catégorie Category in years	code
Mâle 7-14 ans MALE	01
15-60 ans	02
61 + .. ans	03
Femelle 7-14 ans Female	04
15-60 ans	05
61 - ans	06

Invitation de travail, enfants rentrés pour les grandes vacances scolaires
Invited labor, visitors, school childen home on vacation older than 14

Catégorie	code
Male	07
Femelle	08

Main d'oeuvre embauchée pour de l'argent

Hired Labor

CODE 09

Enumerator's Manual p. 14

La Mesure du Temps à Loanga (Bisa)

6 h.	) Hounsou Harlé (domelé)
7 h.	)
8 h.	)
9 h.	)
10 h.	} Hounsou Malé
11 h	}
12 h.	} Simbir
13 h.	}
14 h.	) Zafara
15 h.	) Yillé
16 h.	} Lassara
17 h.	}
18 h.	) Hounsou Lékedalé

La Mesure du Temps à Oueguedo (Mossi)

6 heures	Winding-Poukri - Yibé-mansga
7 "	SOMME
8 "	"
9 "	"
10 "	
11 "	Sonkègga
12 "	Wito-Suka
13 "	
14	Winkaoré
15 "	
16 "	Zãbré
17 "	
18 "	Wind-Luigna

La Mesure des Surfaces des Champs

I - La Mesure des Surfaces

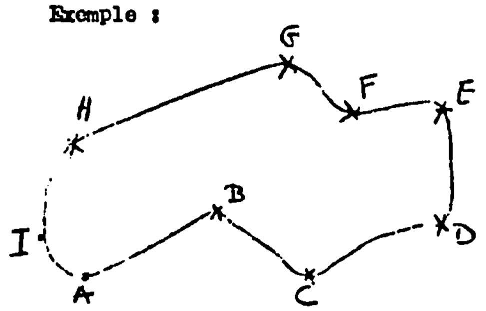
Pour mesurer des surfaces, nous avons besoin de reproduire les caractéristiques du champ sur un croquis très exact tracé à l'échelle.

Pour faire ce croquis, vous devez savoir :

- la longueur des côtés
- la direction des côtés vis à vis du Nord.

Pour procéder, il faut d'abord marcher autour du champ pour vous donner une idée de la forme du champ. Vous creusez des trous avec un daba pour démarquer chaque station, relevez les stations sur un croquis approximatif, vérifiez que le nombre de stations creusés correspondent au nombre sur le croquis.

Exemple :

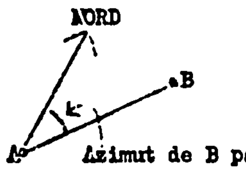


Donnez une lettre à chaque station.

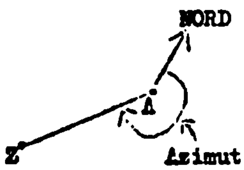
II - L'Utilisation de la Boussole

La boussole nous indique la direction que suit une ligne par rapport au Nord magnétique. Nous appelons cette direction le gisement ou l'azimut de la ligne. C'est toujours mesuré dans le sens des aiguilles d'une montre, à partir du Nord.

Exemple :



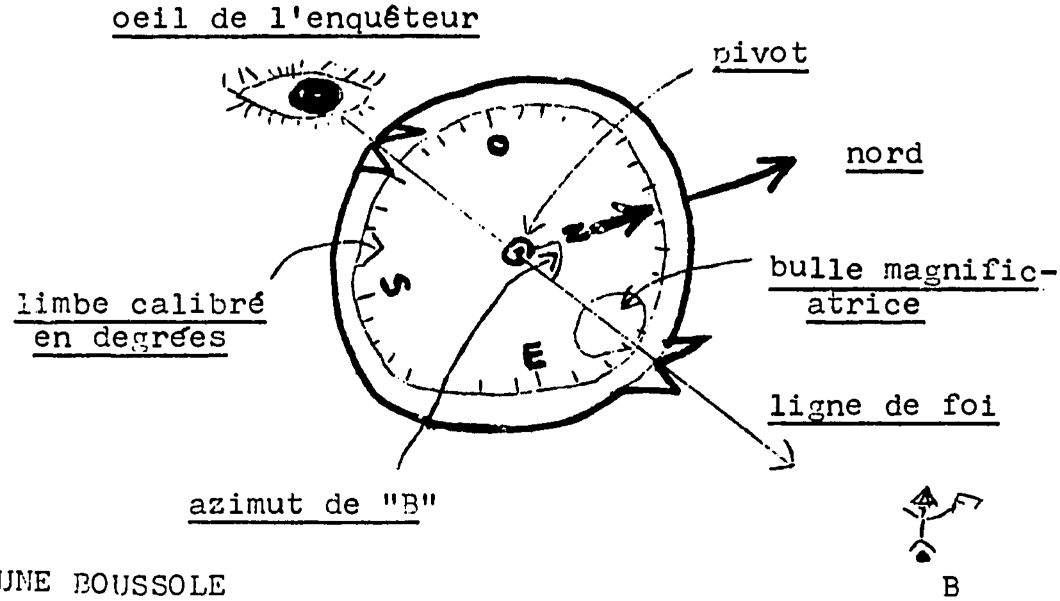
Azimut de B partant de A



Azimut de Z, partant de A

.../...

· ~~Debout sur la station,~~ visez la station prochaine avec la ligne de foi sur la boussole.



UNE BOUSSOLE

Donc vous pouvez toujours mesurer les azimuts de chaque station par rapport au nord. Ceci nous suffit comme mesure de direction.

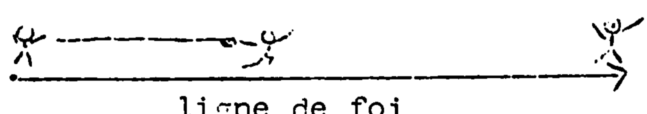
Ayant mesuré l'azimut de B en partant de A, nous devons mesuré la distance de A en B.

III - L'Utilisation de l'Arpenteur

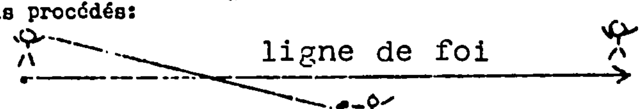
L'Arpenteur est un ruban de métal gradué en mètres qui nous permet de mesurer des distances. Pour des petites distances, un enquêteur et un aide-opérateur suffit. Pour des grandes distances, il vaut mieux avoir trois personnes.

En partant de A, vous mesurez 30 mètres. Un aide reste sur le point A pour tenir le bout du ruban. Un deuxième aide reste sur la station B, pour vérifier que l'enquêteur reste toujours en ligne droite.

Bons procédés :

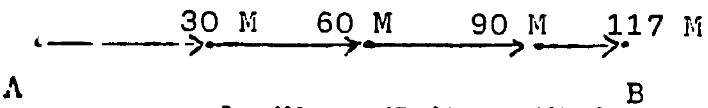


Mauvais procédés:



Ramassez un caillou chaque fois que vous mesurez 30 mètres sur une seule ligne, pour vous souvenir du nombre de fois que vous avez mesuré 30 mètres.

Exemple :



3 cailloux + 17 mètres = 117 mètres.

Comme ceci vous pouvez trouvé la distance de chaque station à son voisin. Ne jamais tirer le ruban de l'arpenteur au délà de 30 mètres. En ramassant le ruban sur la bobine, essayez d'évité le grincement du côté gradué.

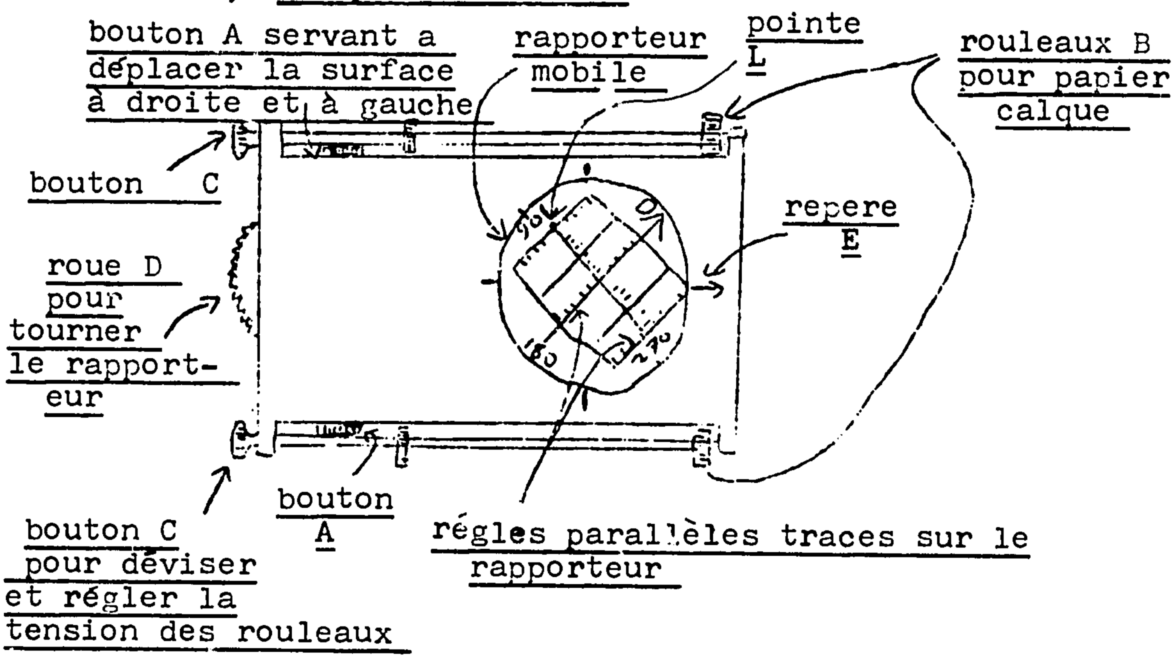
IV - Rapportage des distances et angles sur le papier calque : utilisation de la Planchette.

1) - Notion d'Echelle

Il faut trouver un rapport constant entre les distances mesurés en mètres et les traits sur le croquis mesurés en millimètres. Une échelle de 1/1000 ou "un millième" veut dire que un millimètre sur le papier correspond à un mètre sur le terrain.

Echelle	Sur le papier	Sur le terrain
1/500	1 mm	1/2 mètre (500 mm)
1/2000	1 mm	2 mètres
1/5000	1mm	5 mètres (5000 mm)

2) - Description de la Planchette



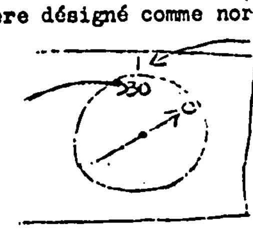
3) Utilisation de la Planchette

a) - Mettez le rouleau de papier calque. Verrifiez qu'il est posé sans jeu contre la surface de la planchette. Les boutons "C" peuvent être divisé pour la mise en place du rouleau et le réglage de tension.

b) - Mettez votre première station au-dessus du pivot du rapporteur, mais faites attention de choisir votre première station de façon à ne pas sortir du papier calque lorsque vous allez dessiner le champs sur la planchette.

c) - En choisissant un des points de repère "E" comme "Nord", tournez le rapporteur à l'aide de la roue "D" de façon à ce que l'azimut du station Y, visé du station "X" soit en face du repère désigné comme nord. (voir croquis).

azimut de Y vise de X



repere choisie comme nord

d) - Maintenant, vous tracez la distance de "X" à "Y" le long de la grande flêche sur le rapporteur, en faisant une tracée en millimètres qui correspond à la distance mesurée, démultipliée par l'échelle choisie.

Exemple:

Si l'échelle est de 1/2000 et la distance mesurée est de 36 mètres, on fait une ligne sur le calque, dans la direction indiquée par la flêche, de 18 millimètres (1/2000 veut dire que 1 millimètre = 2 mètres).

e) Notez que si vous avez mis la station "X" sur, par exemple, le point "L" du rapporteur, vous auriez pû tracé la distance de "X" à "Y" le long de la règle qui passe par "L", puisque cette règle est parrallèle à la grande flêche de direction, donc elle a la direction voulue.

f) Maintenant, mettez la station "Y" au-dessus du pivot du rapporteur (ou au-dessus d'un point comme "L" si c'est plus commode) et recommencez la tracée de "Y" à "Z" en tournant le rapporteur utilisant le même "Nord" qu'avant) pour que l'azimut de "Z", visé de "Y" soit en face du repère choisi comme "Nord" sur la planchette.

g) Tracez la distance de "Y" à "Z" utilisant la même échelle qu'avant.

h) Quand vous avez complété le croquis : si vous avez la chance, vous êtes revenu au point "X" de départ. En tout cas, l'erreur de clôture ne do pas être très grand, sinon il faudrait mesurer le champs.

4) - La mesure des surfaces.

Maintenant nous avons un croquis d'un champ fait à l'échelle. sur papier calque.

Marquez soigneusement de quel champ il s'agit (N° du Ménage, n° du terrain), directement sur le calque, à côté du dessin. La surface peut être recupérée par le chercheur à l'aide d'un planimètre ou par vous avec du papier millimètré.

5) - L'Utilisation du papier millimètré.

Vous mettez le calque au-dessus du papier millimètré. Ensuite vous contez tous les petits carreaux contenus dans l'enceinte du croquis du champ . Si l'échelle est 1/2000, on sait que 1 mm = 2 mètres, donc 1 mm au carré = 4m2. Donc chaque petit carreau = 4m2.

-o-o-o-o-o-o-o-o-o-o-o-o-o-o-

Christopher DELGADO
ECOLE SUPERIEURE DE SCIENCES ECONOMIQUES

Enumerator Training Workshop p. 1

STAGE DE FORMATION DES ENQUETEURS POUR LE PROJET DE RECHERCHE

Du 2 AU 13 AVRIL 1976

Vendredi 2 Avril	Samedi 3 Avril	Dimanche 4 Avril
8 h. - 12 h. 30	8 h.-12 h. 30	
RENDEZ-VOUS A L'E.S.S.EC. - Enregistrement et Introduction de personnel. - Exposé des termes de l'emploi - Exposé sur le But et l'Etendu de la Recherche. - Contrôle de la compréhension du But de la Recherche	- Contrôle de la compréhension du rôle de l'enquêteur dans la recherche. - Exposé des questionnaires à passages répetés. - Son But - Son utilisation	
15 h. - 17 h. 30	15 h. - 17 h. 30	
- Exposé sur le rôle de l'enquêteur dans le projet et de ses responsabilités envers le chercheur. - Exposé sur l'utilisation des données, les conséquences des données fausses.	- Exercice d'application du questionnaire à passages répétés au sein du groupe de recherche. - Commentaires des enquêteurs sur la composition du questionnaire.	

Lundi 5 Avril	Mardi 6 Avril	Mercredi 7 Avril
8 h. - 12 h.30	8 h. - 10 h. 30	8 h. - 10 h. 30
- Travail de Groupe : Le salarié dans le cadre du village-problème à éviter : - Dépouillement et discussion - Travail de Groupe : problèmes associés avec l'utilisation du questionnaire à passages répétés.	- Contrôle écrite de l'expression : rédaction sur un thème à préciser.	- Contrôle Ecrite de l'Aptitude mathématique. - Quelques exercices de calcul et d'algèbre.
	10 h. - 12 h. 30	10 h. 30 - 12 h. 30
	- Travail de Groupe : Les activités en milieu rural - Dépouillement d'une liste d'activités.	- Travail de Groupe : La mesure du temps en milieu rural.
15 h. - 17 h. 30	15 h. - 17 h. 30	15 h. 17 h. 30
- Exposé sur le dépouillement et la codification des questionnaires à passage répétés. - Exercice Pratique.	- Codification de la liste des activités avec avis du chercheur.	- Etablissement d'un barême pour convertir les mesures de temps locaux en heures.

Jeudi 8 Avril	Vendredi 9 Avril	Samedi 10 Avril
8 h. - 12 h. 30	8 h. - 12 h. 30	8 h. - 12 h. 30
- Travail de Groupe : La période des récoltes et les mesures de rendements en milieu rural. - Procédé pour convertir les mesures locales en kg.	- Travail de Groupe sur l'obtention de la coopération des paysans dans le fournissement des données. - Le problème des données "sensibles".	- Intervention d'un expert de l'O.R.S.T.O.M. sur l'utilisation de la Boussole et l'Arpenteur sur le terrain.
15 h. - 17 h.30	15 h. - 17 h. 30	15 h. - 17 h. 30
- Exercice d'application : Conversion d'une liste de mesures "traditionnelles" en heures, kilogrammes et mètres	- Exposé sur les problèmes associés avec la mesure des surfaces en milieu rural.	- Application pratique : Calcul de la surface de quelques champs.

Dimanche 11 Avril	Lundi 12 Avril	Mardi 13 Avril
8 h. - 12 h. 30	8 h. - 12 h. 30	Exercice Pratique
	- Contrôle des connaissances des techniques de mesurer les surfaces. - L'utilisation du papier millimétré. - Les questionnaires à passage unique : - Son but - Son utilisation	- Utilisation d'un questionnaire à passage unique chez soi. 10 h. 30 - 12 h. 30 - Dépouillement des résultats
	15 h. - 17 h. 30	15 h. - 17 h. 30
	- Exemple des questionnaires à passage unique. - Etablissement d'un questionnaire pour obtenir des informations sur : Le stock d'intrants à la production autres que le travail et la terre.	- Exposé sur: La remise des données au chercheur; La coopération avec le chercheur. - Le bilan du travail accompli. - Le calendrier du travail à faire.

A

Household Census Questionnaire (A)

No. de Ménage	Village	Chef de Ménage	No. de Fiche

no.	Nom-Prénom	Sexe	Age	Code	Lien de parenté	sit. M.	activité	Observ.

B

1976 Field Survey Questionnaire (B)

No. de Ménage | Village | Chef de Ménage | No. de Fiche

No.	Propriétaire du champs	Cultures	Code	Surf. Est.	Proximité de la case	Identi-fication	Observations

Detail From Twice-Weekly Questionnaire (C)

C

Enqueteur:

MENAGE 47 SEMAINE 29 JOUR 5

Periode du: 16.11.76 au: 18.11.76

Champs	Culture		Activite		39 M 02 MINOUNGOU MARCEL: M1	M2	S		TOTAL	40 F 05 SORGHO MARIA: M1	M2	S		TOTAL
02	Petit mil	01	couper les épis	18	8				08	7				07
			Voyages entre champs	80	1				01					
			S'occuper des Porcs	32	3	3	3		09					
02	Petit mil	51	récolte en Paniers moyens	02										
01	Petit mil	01	couper les tiges	17			4		04					
01	Petit mil	01	couper les épis	18								6		06
01	Petit mil		récolte en Paniers moyens	02										
			écraser le mil germé	52							5			05
			préparation du repas	68							2			02
			Détente	76	-	9	5		14	5	5	6		16

The full Questionnaire (C) has nine columns and twenty four lines for entering data.

D

Market Price Questionnaire (D)
(Similar to one used by Tenkodogo O.R.D.)

Produit	Code	Unite de Mesure	Equivalence en Kg.	Prix par unité de mesure	Prix par Kg.	Observations
Petit Mil						
Sorgho Blanc						
Sorgho Rouge						
Mais						
Riz (Paddy)						
Riz (Net)						
Haricot Blanc						
Pois de Terre						
Manioc						
Patates						
Tomates						
Oignions						
Pommes de Terre						
Salade						
Piment						
Arachide Coque						
Cotton						
Tabac						
Amande de Karite						
Noix de Nere						
Niebe						

E | RENDEMENTS DES PARCELLES

Yield Plot Questionnaire (E)

SIGNIFIEZ PAR X SI LE CHAMPS EST ENTIEREMENT RECOLTE

! !

MENAGE:

CHAMPS:

CULTURE 1 = ______

CULTURE 2 = ______

CULTURE 3 = ______

RECOLTE PAR HA EN KG CULTURE 1

RECOLTE PAR HA EN KG CULTURE 2

RECOLTE PAR HA EN KG CULTURE 3

DATE RELEVEE	DATE RECOLTEE	CULTURE	UNITE DE MESURE	UNITE EN KG	CULTURE 1 REC. EN KG	CULTURE 2 REC. EN KG	CULTURE 3 REC. EN KG	ENQUETEUR

(1) SURFACE CHAMPS EN HA

TOTAL : (3)

H₁

Livestock Census Questionnaire (H) p. 1

INVENTAIRE DES TROUPEAUX

Ménage Nº

Nom du Chef de Ménage :

Date de l'Interview :

(1) Animaux Actuellement Possédés pour l'ensemble du Ménage.

Bovins ________ Moutons ________

Chèvres ________ Chevaux ________

Anes ________ Porcs ________

(2) Historique des Troupeaux.

(Nombre d'Animaux gardés par la famille pendant l'hivernage de chaque année).

Année	Bovins	Moutons	Chèvres	Chevaux	Anes	Porcs	Genre des Pertes
1976							
1975							
1974							
1973							
1972							
1971							

(3) Explication du Changement de la Taille des Troupeaux entre l'hivernage 1975 et le

	Bovins	Moutons	Chèvres	Chevaux	Anes	Porcs
Dons (+)						
Achats (+)						
Naissances(+)						
Ventes (-)						
Egarés -						
Morts -						
Changement Total						

(4) Problèmes de la Santé

Notez les 3 maladies (en ordre d'importance) qui, selon l'enquêté, sont les plus graves pour l'élevage (toutes espèces).

(a) ________

(b) ________

(c) ________

H. Livestock Census Questionnaire (H) p. 2

(5) Age des Bovins

Actuellement, l'Age des Bovins se décomposent de la façon suivante :

	Male	Femelle
1 - 2 ANS	______	______
3 - 4 ANS	______	______
5 - 6 ANS	______	______
Plus de 6 ANS	______	______

Est-ce-qu'il y a des Boeufs de Trait ?

Leur nombre ______

Leur âge ______

Age des Ovins — Moutons et Chèvres male et femelle

Moins d'un AN ______

Entre 1 et 2 ANS ______

Entre 2 et 3 ANS ______

Plus de 3 ANS ______

I₁

Livestock Management Questionnaire (I) p. 1

GESTION DES TROUPEAUX

Nom du Chef de Ménage ______________________

Date de l'Interview ____________________

N° de Ménage
: : :
: : :
: : :

(1) Combien d'animaux sont confiés par le ménage à des bergers ?

Bovins (Male ________ (Femelle ______

Moutons __________

Chèvres __________

(2) Combien d'animaux sont gardés par la famille ?

Bovins (Male ________ (Femelle ________

Moutons __________

Chèvres __________

Est-ce qu'ils sont gardés tout l'année par la famille : Oui Non

Si non , expliquez : ______________________________________

____

(3) Où est-ce qu'on a pâturé (gardé) les animaux pendant la saison sèche de 1976 ?

Bovins ____

Moutons et chèvres ____

(4) Où est-ce qu'on a pâturé (gardé) les animaux pendant la saison pluvieuse de 1976 ?

Bovins : ____

Moutons et Chèvres : ______________________________________

(5) Qu'est-ce-que les animaux mangent pendant la saison sèche ?

Bovins ____

Moutons et Chèvres ____

(6) Qu'est-ce qu'on fait de la "terre noire" produite par les animaux appartenant à la maison ?

des animaux gardés par la famille : ________________________

..des animaux gardés par les bergers : ______________________

I₂

Livestock Management Questionnaire (I) p. 2

Est-ce-que le Chef du ménage a utilisé des engrais naturels pendant la saison agricole 1976 (Rayer les mentions inutiles).

Pas du tout Un Peu Beaucoup.

(8) Qulle quantité de lait ou de viande a été donné au Chef de ménage pendant 1976 par son berger ?

Lait _______ _________ (Ex.: Une calebasse tous les mois).

Vidande ______________ (Ex.: Un gigot tous les trois mois).

(9) Quelle quantité de nourriture ou d'argent a été donné au berger par le Chef de ménage pendant 1976 ?

Espèce de nourriture ______________

Quantité ______________

Argent (Quantité) ______________

(10) Est-ce-que le Chef de ménage a cédé des petits des animaux aux bergers pendant les deux dernières années ? OUI NON.

Si Oui, le Chef de Ménage cède un veau au berger après combien de temps de garde ? ____________________________

(11) Le Chef de ménage visite ses troupeaux tous les :

semaines mois 3 mois 6 mois.

AN 2 AN S

(Rayer les Mentions inutiles)

Mois et année de la dernière visite ______________________

J1

Field History Questionnaire (J) p. 1

LES CHAMPS

Nom du Chef de Ménage : ____________________

Ménage [| |]

ENQUETEUR: ____________________

Champs [| |]

Cultures pratiquées pendant 1976 dans ce champs :

Culture (1) ____________________
Culture (2) ____________________
Culture (3) ____________________
Culture (4) ____________________

(1) PROPRIETE: A qui appartient ce champs ?
(Ex. femme du Chef de Ménage:) ____________________

(2) DUREE DE LA PROPRIETE: Ce champs lui appartient depuis combien d'annees? ____________________

(3) APPARTENANCE ANTERIEURE: Avant d'appartenir à cette personne, le champs appartenait à qui ? : (ex.: la brousse, le père, la mère ?).

(4) DUREE DE LA CULTIVATION: Depuis combien d'années est-ce-que le champs est cultivé ? ____________________

(5) SOLS: (ex.:bas-fond, plateau, sable, laterite).
____

(6) DISTANCE DE LA CASE (ESTIMEE) ____________________

(7) HISTOIRE DES CULTURES: Indiquez les cultures pratiqués dans ce champs les années précédentes :

ANNEE	CULTURES	RECOLTE ESTIMEE (Ex. 3 GP de Mil)
1975	______	______
1974	______	______
1973	______	______
1972	______	______
1971	______	______
1970	______	______
1960-69	______	______

(8) JACHERE : Quelle est la dernière année que le champs a été laissé en

J₂

Field History Questionnaire (J) p. 2

(9) SEMENCES 1976.

CULTURE	DATE (APPROX.)	QUANTITE
____	____	____
____	____	____
____	____	____
____	____	____
____	____	____
____	____	____
____	____	____
____	____	____
____	____	____
____	____	____

(10) SARCLAGES :

Nombre de sarclages ____________

Dates ____________ ____________ ____________
(Approx.)

(11) FUMIER :

(a) Quantité de fumier (répondre par le paysan sur ce champs: (ex 3 charettes).

____

(b) Est-ce qu'il y a eu une "invitation de paturage" sur ce champs pendant 1975 ?

OUI NON

Si Oui, combien de boeufs ont paturé sur le champs ?

1, 2-5, 6-12, 12-20 PLUS QUE 20

(RAYER LES MENTIONS INUTILES).

Si oui, combien de jours est-ce que les boeufs ont paturé ?

____

Si oui, qu'est-ce que le chef de ménage a donné aux peulhs pour ammener les boeufs sur son terrain ?

J3

(12) ACCROCHAGES AVEC ELEVEURS :

Est-ce que des animaux ont gâtés une porportion de ce champs pendant

	MOIS	ESPECE D'ANIMAUX
Hivernage 1976	____________	____________
	____________	____________
1975	____________	____________
	____________	____________
1974	____________	____________

Est-ce qu'un jugement a été fait suite à ces problèmes :

ANNEE	PERSONNE FAISANT LE CONSTAT (ex. ORD),Chef)	Montant du Jugement
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

(13) OBSERVATION DE L'ENQUETEUR :

K1

Capital Goods Inventory Questionnaire (K) p. 1

LES BIENS DE PRODUCTION

Nom du Chef de Ménage : ____________

Ménage : | | |

Enquêteur : ____________ Date : ____________

(1) LES BIENS DE TRANSPORT :

Mettez le nombre d'engins dont dispose le ménage.

Bicyclettes : ____________ Mobylettes : ____________

Charettes : ____________ Anes : ____________

Boeufs de Trait : ____________

(2) OUTILS DE PRODUCTION :

Mettez le nombre d'engins dont dispose le ménage :

Charrues : ____________ (Précisez si Asine ou Bovine

Rayonneuses : ____________ Haches : ____________

Dabas : ____________ Machetes : ____________

Faucilles : ____________ Fléaux : ____________

Autre : (Précisez) : ____________

(3) SEMENCES destinées à être utilisé pour 1977 :

Estimez la quantité en sacs

(ex. sacs de 100 kgs pour le Mil)

Petits Mils : ____________ Sacs

Sorgho Rouge : ____________ Sacs

Sorgho Blanc : ____________ Sacs

Arachides: ____________ Sacs

Riz : ____________ Sacs

Haricots : ____________ Sacs

Pois de Terre : ____________ Sacs.

K2

Capital Goods Inventory Questionnaire (K) p. 2

* Est-ce-que le Chef de ménage compte utiliser des semences fournies par l'O.R.D. ?

OUI NON

* Si oui, Précisez les cultures concernées et la quantité désirée.

CULTURE	QUANTITE
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________

(Soyez précis avec le paysan - ceci n'est pas une commande de semences auprès de l'O.R.D.) .

(4) OBJETS DE STOCKAGE: Total (pour tous les membres du ménage individuellement et collectivement)

Nombre de Greniers en Banco : ____________

de Greniers en Seco : ____________

de Jars de Stockage des produits : ____________

De Grands Paniers : ____________

De Petit et moyens paniers: ____________

(5) Autres Objets Industriels :

____

Nombre de Poste Radios : ____________

Nombre de Lampes à Pétrole : ____________

Nombre de Torches : ____________

L₁

Christopher L. Delgado
Ecole Supérieure de Sciences Economiques
Université de Ouagadougou

(L)

Janvier 1977

Enquête auprès des Eleveurs Peuhls, Tenkodogo, Haute-Volta

Enquêteur:

Nom de l'enquêté:

Domicile de l'enquêté:

Enquêteur introduit par qui?

UNITE DE PRODUCTION

(1) L'éleveur est responsable pour combien de parcs? S'il y en a plus d'un, expliquez.

(2) Il y a combien de personnes dans la famille pour s'occuper des animaux (donnez leur âge, sexe et tâche)?

(3) Le troupeau a combien de propriétaires:
Paysans: ________ Peuhls: ________

(4) Le propriétaire sédentaire a combien de boeufs, en moyenne?

(5) Le propriétaire sédentaire visite ses boeufs tous les:
mois XX trois mois XX six mois XX un an XX deux ans ?

(6) La famille est installée depuis quand:
a) dans la région: ________________?
b) dans le camp où se déroule l'entretien: ________________?

TRANSHUMANCE

(7) Où est le troupeau entre:
Octobre et Décembre:
Janvier et Mars:
Avril, Mai:
Juin et Septembre:
Expliquez pourquoi les boeufs se trouvent dans des régions différentes à des moments différents.

L₂

Fulani Herdsmen Survey Questionnaire (L) p. 2

(8) L'éleveur prend-il toujours la même route de transhumance? Laquelle? (utilisez les noms des villages les plus proches.) S'il y a plusieurs routes, donnez les toutes. Qu'est-ce qui fait que l'éleveur choisit une route plutôt qu'une autre?

(9) Pendant la saison sèche, au village (teng'pugin), est-ce-qu'on observe une carence de pâturage, ou bien d'eau? Laquelle vient d'abord?

(10) Pendant la saison sèche, en brousse, est-ce-qu'on observe une carence de pâturage, ou bien d'eau? Laquelle vient d'abord?

(11) Pendant la saison sèche, les boeufs trouvent-ils de l'eau au puits, au marigot, ou bien au barrage? Dans le cas des puits, par qui est fait le puits, à quel moment et à quel profondeur?

(12) Pendant la saison sèche, les éleveurs qui suivent les troupeaux se nourrissent de quelle façon? Cù est-ce que les femmes obtiennent le mil?

(13) A quel moment de l'année est-ce qu'on perd le plus de boeufs à cause de la maladie?

(14) Quels groupes, par âge et sexe, meurent les premiers en cas de maladie?

(15) Quelles maladies (en Moré) sont les plus graves?

UTILISATION DE L'ENGRAIS

(16) Est-ce-que l'éleveur a participé à une invitation de pâturage pendant l'année précédente?
Si oui,
Combien de boeufs?
Combien de jours? Sur combien de terrains?
A quelle époque?

(17) Quels problèmes ont été rencontrés pendant les invitations de pâturage?

(18) Lorsque le troupeau est au village (teng'pugin), où sont les boeufs:
La nuit?
Le matin?
L'après-midi?

(19) Qu'est ce qu'on fait de la fumure:

Pendant: Utilisation:	Ramassé par:	Au bénéfice de:
Oct. à Dec.		
Jan. à Mars/Avril		
Avril, Mai		
Juin à Sept.		

(20) Les paysans offrent-ils de l'argent ou de la nourriture pour une invitation de pâturage?

(21) On trait le lait des vaches combien de mois après la naissance d'un petit?

REMUNERATION

(22) Quelle quantité de lait est remise aux propriétaires des vaches, tous les trois mois?

(23) Qu'est-ce que les propriétaires donnent aux Peuhls:

	Nourriture	Genre et Quantité	Argent
de 1 à 2 (bovins)?			
2 à 5 "			
6 à 12 "			
+ 12 "			

La rémunération est-elle plus grande pour les mâles ou pour les femelles?

PRIX

(24) En quelle saison les prix sont les plus élevés? les moins élevés?

(25) D'où viennent les acheteurs? Qui conduit les boeufs au marché de la ville? Est-ce que ce sont les agents des bouchers?

(26) Donnez les prix par saison et par catégorie (8 réponses):
Avril/Mai 1976: Jeune Femelle, Jeune Mâle, Vieille Femelle, Vieux Mâle
Septembre 1976: mêmes catégories

LA DIVISION DU TRAVAIL

(27) Qui, dans la famille, trait le lait des vaches? (Est-ce-que des hommes aident les femmes parfois? pourquoi?)

(28) Est-ce-que des membres du ménage ont vendu du lait ou du beurre pendant le mois précédent? Où? Souvent? Quelle quantité? Est-ce-qu'on en vend plus pendant une saison donnée? Est-ce que les prix changent avec la saison?

L₄

(29) Qui garde les bêtes pendant le jour? la nuit?
a) pendant l'hivernage
b) d'Octobre à Décembre
c) de Janvier à Mars
d) d'Avril à Juin

(30) Qui sarcle le mil pendant l'hivernage?

(31) Qui débrousse et fume les champs? (à part le pâturage des animaux sur les champs)

(32) Qui coupe les tiges de mil à la récolte? Qui coupe les épis?

(33) Qui file le coton?

(34) Qui tisse?

(35) Qui va chercher du bois?

(36) Qui contruit et répare les maisons? (est-ce qu'on doit faire appel aux paysans sédentaires pour ça?)

(37) Est-ce-qu'on embauche de la main-d'oeuvre rémunérée pour cultiver? Qui? Pour combien de temps? Pour quelle rémunération?

(38) Est-ce-qu'on embauche de la main-d'oeuvre pour garder les troupeaux? Qui? Pour combien de temps? Pour quelle rémunération?

(39) Est-ce-qu'on a confié des bovins à d'autres bergers peuhls?

(40) Qui dispose de la récolte de mil, d'arachide, de maïs, de coton, etc... Qui peut la vendre? Comment est-ce que la récolte est distribuée entre les membres de la famille?

(41) Qui va chercher l'herbe pour les veaux?

(42) Pendant l'hivernage, quand est-ce qu'une femme ou un fils peut travailler sur son propre champs, ou bien gagner de l'argent pour soi? (Quel moment de la journée ou de la semaine?)

LA COOPERATION ENTRE LES VOISINS EN MATIERE DE TRAVAIL

(43) Est-ce-que des membres du ménage ont participé à un battage de mil chez des voisins Mossi ou Bisa cette année? (Combien de fois? Combien de membres du ménage?)

L_5

Fulani Herdsmen Survey Questionnaire (L) p. 5

(44) Est-ce-que des Mossi ou Bisa ont aidé le chef de ménage à battre son mil cette année? (ou bien l'année passée, s'il n'a pas encore battu son mil.)

(45) Est-ce-que les membres du ménage aident les propriétaires Mossi ou Bisa des boeufs qui sont dans leurs troupeaux à battre leur mil?

(46) Est-ce-que le Chef de ménage a fait d'autres invitations de travail chez lui dans les douze mois précédents?
Si oui, qui est venu (nombre, éthnie)?

(47) Est-ce que des membres du ménage sont partis dans les douze mois précédents, chez des voisins Peuls, pour les aider dans le travail
a) chez des parents
b) chez des non-apparentés

(48) Est-ce-qu'un membre du ménage a eu un emploi (traditionnel ou "moderne") rémunéré par de l'argent, dans les douze mois précédents, qui l'a obligé à vivre en dehors de la concession pendant un certain temps?
a) Qui?
b) Quel emploi? (Ex.: berger conducteur de boeufs)
c) Pour combien de temps?
d) En quel lieu? Ex.: Côte d'Ivoire

(49) Est-ce-qu'un membre du ménage a récemment (12 mois) répondu à une convocation de travail du:
a) Chef Peul local (Oueguedo ou Pouswaka)
b) Feu le chef Peul de Tenkodogo
c) Chef de Canton de Oueguedo
d) Chef de Tenkodogo
e) Une autre autorité traditionnelle ou moderne (laquelle)? Précisez quel genre de travail et à quel moment.

RENDEMENTS

(50) Estimez les rendements agricoles obtenus cette année, en paniers correspondant à ceux utilisés par l'enquête chez les sédentaires.

Champs No.	Culture	Nombre de paniers	Genre de paniers	Equiv.en Kg.

L₆

(51) Est-ce-que vous avez été obligés d'acheter du Petit Mil en 1975? en 1976? Cette année? Combien?

(52) A votre avis, est-ce-que la plupart des Peuls de cette région doivent acheter du Mil, même pendant une année de bonne récolte?

DECISIONS DE GESTION

(53) Est-ce que vous devez informer les propriétaires des boeufs qui vous sont confiés, si:
- (a) Vous partez en transhumance? (Peut-il refuser?)
- (b) Vous faites vacciner les boeufs? (Qui paie?)
- (c) Vous amenez un bovin chez le vétérinaire?
- (d) Vous soignez un bovin malade vous-même, sans qu'il soit en danger de mort?
- (e) Vous commencez à traire une vache?
- (f) Vous pensez qu'il est mieux de vendre un boeuf (en cas d'urgence, le propriétaire est informé avant ou après la vente?)

(54) Est-ce-que d'autres Peuls vous ont confié des boeufs? Combien de Peuls (j'entends Peuls d'en dehors de la concession)? Combien de boeufs? Qu'est-ce-qu'ils vous donnent pour ceci?

(55) Qu'est-ce-qui fait qu'un paysan Mossi vous a confié des boeufs à vous, plutôt qu'à un autre éleveur?

(56) L'année dernière (début hivernage 1976 -- début hivernage 1977) dans votre troupeau, il y a eu:
- (a) Combien de naissances?
- (b) Combien de morts? (ou animaux mourants vendus à 5000F)
- (c) Combien de ventes? (ou animaux donnés ou consommés)

(57) S'il y a eu des ventes, pourquoi est-ce-que l'éleveur a vendu?

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LIST OF ABBREVIATIONS USED IN REFERENCES

CILSS	Commission Inter-Etats de Lutte Contre la Sécheresse au Sahel
CIRES	Centre Ivoirien de Recherches Economiques et Sociales
CNRS	Centre National de la Recherche Scientifique (France)
CVRS	Centre Voltaïque de la Recherche Scientifique
FAO	Food and Agriculture Organization (United Nations)
IBRD	International Bank for Reconstruction and Development (World Bank)
IEMVT	Institut d'Elèvage et de Médecine Vetèrinaire des Pays Tropicaux
INSEE	Institut National de la Statistique et des Etudes Economiques (France)
IRAT	Institut de Recherches Agronomiques Tropicales et des Cultures Vivriéres
OFNACER	Office National des Céréales (Upper Volta)
ORD	Regional Development Authority
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
REDSO/WA	Regional Economic Development Services Organization/West Africa (USAID)
RHV-MDR	République de Haute-Volta - Ministère du Développement Rural
SEDES	Société d'Etudes pour le Développement Economique et Social
UNDP	United Nations Development Program
USAID	United States Agency for International Development