LABOR IN THE RURAL HOUSEHOLD ECONOMY OF THE ZAIRIAN BASIN

Tshikala B. Tshibaka
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LABOR IN THE RURAL HOUSEHOLD ECONOMY OF THE ZAIRIAN BASIN

Tshikala B. Tshibaka

Research Report 90
International Food Policy Research Institute
## CONTENTS

- Foreword
- 1. Summary 9
- 2. Introduction 11
- 3. The Study Area 15
- 4. Division and Allocation of Household Labor Time 21
- 5. Determinants of Household Labor Time Allocation 30
- 6. Allocation and Use of Agricultural Labor Time 39
- 7. Labor and Cultivated Area 45
- 8. Labor and Agricultural Output 50
- 9. Policy Implications and Conclusions 58

Bibliography 62
# TABLES

1. Practicability of roads and navigability of rivers, 1982/83
2. Sample population in the study area
3. Division of household activities by gender
4. Allocation of labor among household activities, 1982/83
5. Statistical description of variables for labor time allocated to agriculture and nonagriculture
6. Determinants of shares of household labor time allocated to farm and nonfarm activities
7. Division and allocation of labor by farm operations, 1982/83
8. Regression results for the determinants of intensity of labor use per hectare of cultivated area
9. Statistical description of variables for cultivated area, labor for land preparation, and capital
10. Determinants of cultivated area
11. Statistical description of variables for total output, labor, and capital
12. Regression results for the farm production function
13. Average and marginal products of labor input, 1982/83
14. Comparison of intensity and productivity of labor allocated to farming in Zairian Basin with other areas of Sub-Saharan Africa
15. Effect of timing on household farm output and labor productivity, 1982/83

18  20  23  24  36  37  41  44  46  48  51  52  53  55  57
ILLUSTRATIONS

1. Map of Zaire 14
2. Monthly allocation of male labor time to income-generating activities, 1982/83 26
3. Monthly allocation of male labor time to non-income-generating activities, 1982/83 26
4. Monthly allocation of female labor time to income-generating activities, 1982/83 27
5. Monthly allocation of female labor time to non-income-generating activities, 1982/83 27
6. Monthly allocation of male labor time to farm and nonfarm income-generating activities, 1982/83 28
7. Monthly allocation of female labor time to farm and nonfarm income-generating activities, 1982/83 29
FOREWORD

The deterioration of the food sector in Sub-Saharan Africa, combined with rapid population growth and the degradation of the environment, continues to present a challenge to policymakers in both Africa and the donor community. The agricultural and other policies that have been followed have failed to reverse the trend. One reason for this failure has been lack of data on the workings of the rural household economy, which is the main food producer in the Sub-Saharan region.

This study attempts to address this gap by examining various aspects of labor in the rural household economy. It identifies main determinants of labor use and allocation, assesses factors that affect labor productivity, and makes some recommendations on how the productivity of labor can be enhanced in the farm sector. The need to increase the productivity of labor allocated to agriculture is central from the standpoint of both growth and equity. Labor input accounts for more than 70 percent of the agricultural output of Sub-Saharan Africa.

The study is conducted in the Zaïrian Basin, a rain forest zone that is among the least-studied areas of the developing world. Thus this research report by Tshikala B. Tshibaka represents a major contribution to our understanding of the rural household economy in this part of the world and provides useful information to policymakers.

The report is a follow-up study based on the survey that led to the publication of IFPRI Research Report 74 by the same author. That survey, conducted in collaboration with the Institut Facultaire des Sciences Agronomiques (IFA), Yangambi, Zaïre, was partially funded by the International Development Research Centre of Canada (IDRC). IFPRI and IFA reiterate their gratitude to IDRC for its support.

Just Faaland
Washington, D.C.
ACKNOWLEDGMENTS

The data used for this study are taken from a survey undertaken during the 1982/83 crop year in collaboration with the Institut Facultaire des Sciences Agronomiques (IFA), Yangambi, Zaire. This effort was partially funded by the International Development Research Centre (IDRC) of Canada, to whom the author wishes to express his sincere appreciation.

The author is grateful to Raisuddin Ahmed for suggesting this analysis and to Just Faaland for his advice and comments. Stephen Vosti, Dayanatha Jha, and Behjat Hojjati gave thoughtful, constructive comments on the first draft that were helpful in revising the manuscript. Hojjati was also instrumental in data processing and analysis. The author also acknowledges the comments by anonymous reviewers.
SUMMARY

Most agricultural labor studies conducted in Sub-Saharan Africa have tended to concentrate on describing the division of labor, estimating the amount of labor input allocated to agriculture and to other household activities, examining the seasonality of labor time allocated to agriculture, and estimating the productivity of this resource and its contribution to agricultural output. In addition to these aspects, this study attempts to identify the key economic and other variables that affect the use and productivity of labor in the small-farm sector of the rural household economy, thus contributing to an understanding of the rural household economy in the Zairian Basin, one of the least-known areas of the developing world.

The 1982/83 survey on which the study is based indicates a clear gender division of household labor, with men relatively more involved in income-generating activities and women relatively more engaged in non-income-generating activities. Male household members spent about 24.3 percent of the potential 12 hours of daily working time on income-generating activities, of which 5.9 percent was expended on farming and 18.4 percent on nonfarming activities. Females allocated 19.8 percent of the potential working time to income-generating activities, of which 6.2 percent was devoted to farming and 13.6 percent to nonfarming activities. Of the 75.7 percent of potential male working time allocated to non-income-generating activities, 15.6 percent was used for domestic activities and 50.1 percent for sociocultural and leisure activities. Females allocated 80.2 percent of their potential working time to non-income-generating activities, of which 25.9 percent was for housework and 54.3 percent for sociocultural and leisure activities. Overall, household members allocated 6.1 percent of their potential working time to agriculture, 15.7 percent to nonagricultural income-generating activities, 21.3 percent to domestic activities, and 56.9 percent to sociocultural and leisure activities.

The allocation of labor time in the study area presents different seasonal patterns for men and women. However, it is important to emphasize that no male or female household member spent more than 50 percent of his or her available monthly time on income-generating (farming and nonfarming) activities during the entire year of the survey. This implies that the observed pattern of labor use does not suggest any seasonal labor shortages in the study area.

The analysis of the determinants of labor allocation to farming and nonfarming reveals that the farmgate terms of trade between farm and nonfarm products, the level of household capital (tools and seeds) input per working unit (adult-equivalent), and the state of infrastructure are the key factors explaining the share of household labor time allocated to either farm or nonfarm income-generating activities in the Zairian Basin. The elasticity estimate of the share of household labor time allocated to agriculture is about 0.27 with respect to farmgate terms of trade between farm and nonfarm products, 0.26 with respect to household capital input per working unit, and 0.23 with respect to the state of infrastructure. For other income-generating activities,
the elasticity estimate of the share of household labor time allocated to this group of activities is about −0.22 with respect to farmgate terms of trade between farm and nonfarm products, 0.10 with respect to capital input per working unit, and 0.21 with respect to the state of infrastructure.

Labor time allocated to agriculture by both men and women in the Zairian Basin is primarily used in the production of cassava, rice, maize, and plantain. The amount of labor use per hectare of cultivated area in this tropical rain forest zone was estimated at 1,717.1 adult-equivalent hours in the 1982/83 crop year. This high labor use per hectare was found to be significantly affected by the timing of farm operations. The study estimated that a 1.00 percent increase in the number of households observing the timing of farm operations recommended by the extension service would be associated with a 0.51 percent decrease in the amount of labor use per hectare of cultivated area.

In addition, the analysis shows that male labor time allocated to land preparation and the timing of this farm operation are the main determinants of the size of cultivated area in the Zairian Basin. The study also found that a 1.00 percent increase in the number of households observing the correct timing of farm operations would lead to a 0.47 percent upward shift in the production function curve, while a 1.00 percent increase in the number of households using a rice-maize crop mix would be associated with a 0.42 percent downward shift in the agricultural production curve. Compared with cassava and plantain, rice and maize are biologically less productive in terms of energy per unit of land and time.

Furthermore, the average and marginal products of male labor are estimated at 6.9 and 3.0 kilograms of cereal-equivalents per hour of work, respectively, and those for female labor time are 5.1 and 1.7 kilograms of cereal-equivalents per hour of work. The overall average and marginal products of labor amount to 2.6 and 2.0 kilograms of cereal-equivalents per hour of work, respectively. These estimates of labor productivity vary by a factor of about 6 across households.

The analysis also indicates that the households that did not observe the correct timing of farm operations could have achieved about a 60.0 percent increase in their labor productivity if they had, and the entire sample would have increased its labor productivity by about 14.0 percent. The sample data indicate that 32.6 percent of the 132 study households did not observe the recommended agricultural calendar.

The study underscores the importance of the farmgate terms of trade, household capital input, and infrastructure in the process of labor allocation among farming, nonfarming, and other household activities carried out in the Zairian Basin. It also reveals that an appropriate timing of farm operations has a positive and significant effect on farm output and labor productivity. It concludes that, in the long run, development of capital (credit) markets and improvement and expansion of the road network and marketing channels need to be pursued. And for the short or medium term, the extension service should consider educating farmers to observe the recommended agricultural calendar. Therefore, efforts to improve research, extension, and weather forecasting need to be undertaken.
INTRODUCTION

Labor input accounts for more than 70 percent of agricultural output in most of the Sub-Saharan region. Therefore the need to increase the productivity of labor input allocated to agriculture is central from the standpoint of both growth and equity in this region (Eicher and Staatz 1984; Mellor, Delgado, and Blackie 1987; Delgado and Tshibaka 1990).

Despite the paramount importance of labor, the amount of time spent on farming by most African farmers over a year is generally low even during seasonal peak periods. In the Toro area of Uganda, an average household was found to spend one hour per person per day in farming (Pudsey 1967). In the Uboma area of Nigeria, Oluwasanmi et al. (1966) found that a male household member spent an average of 3.4 hours per day on farming, while his female counterpart devoted 2.4 hours per day to farm work during the cropping season. However, Massell and Johnson (1968) found in their study of smallholder farmers in Zimbabwe that farmers worked from 4.5 to 7.0 hours per day.

The allocation of labor to farming in Sub-Saharan Africa was also found to be affected by the traditional consideration of many farm operations as being age- and gender-specific. Thus the extent of specialization in labor use by gender has received particular attention. In Sierra Leone, Spencer (1976) reported that women spent 900 hours per year in farming, compared with 1,450 hours for men. In northwest Tanzania, Shapiro (1978) observed that women contributed more than 28 percent of the total hours worked. In northern Nigeria, where Moslem social customs prevail, farm work is carried out almost exclusively by men (Luning 1967; Matlon et al. 1979). In some areas, men concentrate on the production of cash crops, while women take sole responsibility for production of food. In general, the heavy tasks are carried out by men, with women weeding and harvesting the fields (Cleave 1974; Niang 1980). Several reports indicate that traditional divisions of labor are breaking down in many areas. Heyer (1966) noted that in Kenya the traditional labor organization is disappearing, and both men and women participate during plowing time and weeding season.

Cleave (1974) argued that although seasonality of agriculture partly explains the low labor use in farming in Africa, it is common for adult family members to work on the land only 20-40 hours a week during the peak periods. Norman, Pryor, and Gibbs (1979) found that more than 50 percent of the time allocated to farming in Hausaland in Northern Nigeria was concentrated in four months. However, Ruthenberg (1980) indicates that seasonal labor peaks are more acute in a permanent cultivation system than in a fallow system. Furthermore, in subhumid and semi-arid areas of Sub-Saharan Africa, the distribution of rainfall imposes a pattern of labor use and allocation to farming that results in seasonal labor shortages during peak periods. These shortages do not occur in humid areas of the Sub-Saharan region because the distribution of rainfall there allows for farming all year round (Tshibaka 1989).
It is clear from this survey of literature that previous labor studies conducted in Sub-Saharan Africa have tended to concentrate mostly on describing the division of labor, estimating the amount of labor allocated to agriculture and other household activities, examining the seasonality of labor time spent on agriculture, and estimating the productivity of labor input and the contribution of this input to farm output. It is critically important to note that these studies have overlooked two other significant aspects of labor allocation and use in Sub-Saharan agriculture. First, they failed to pay enough attention to the effects of economic variables on labor use and allocation. Second, they failed to examine the effect of timing of different farm operations on the amount of labor used and on the productivity of this input.

In his work on X-efficiency, Leibenstein (1966) explicitly recognizes that “the inputs may have a fixed specification but yield a variable performance depending on the exact nature of their employment.” This implies that when and how resources are used in the production process affect the level of technical efficiency and consequently the level of resource productivity. Following Leibenstein, the timing of different farm operations and the way these operations are carried out have a significant impact not only on labor use but also on the productivity of this and other farm inputs. In a study conducted in Sarawak and Sabah states of Malaysia, where shifting cultivation is still prevalent, Cramb (1989) also concluded that timing is an important factor leading to higher returns to labor. Timing affects the effectiveness of burning, and good burning results in a reduced labor requirement (for clearing, planting, and weeding) and increased farm output per unit of labor and land.

Furthermore, the extent to which the timing of agricultural labor use reflects the recommended agricultural calendar is a strong indication of the effectiveness of the extension services. This variable also provides some indication of the managerial and technical skills of the farmers, which constitute an important indicator of the stock of human capital available in the area. The timing of agricultural labor use has serious implications for the productivity of labor and other agricultural inputs.

Finally, it is important to stress that the rural household economy in the Zairian Basin has received little research attention to date. In fact, to most development economists and other social scientists, the area as a whole is among the least-known areas of the developing world.

Objectives of the Study

This study attempts to document the labor issues discussed above in order to fill some gaps in the understanding of the rural household economy in the Zairian Basin. More precisely, it describes the division of household labor time between males and females, examines the structure and seasonality in labor allocation among different household activities, and identifies key factors that determine the allocation of this resource. In addition, the study conducts a detailed analysis of labor use in the small-farm sector of the rural household economy by examining the structure of labor allocation among different farm operations, estimating the intensity of labor use, and assessing its determinants.

Furthermore, the study establishes the relationship between labor input and cultivated area, estimates the contribution of male and female labor to cultivated area, and examines the effect of timing on the size of cultivated area. The study also derives
the relationship between the amount of labor input, the timing of farm operations, and the level of farm output, and from this relationship it estimates the contribution of male and female labor to farm output, computes the productivity of male and female labor, and appraises the effect of timing on both farm output and labor productivity. Finally, some policy implications and conclusions are drawn.

Data Sources and Limitations

The data used in this research report were derived from a household survey conducted during the 1982/83 crop year by the author in the rural communities of Turumbu, Mongandjo, and Bomaneh located in Isangi and Basoko zones, Tshibop District. This district is located in the rain forest part of Haut-Zaïre Province (see Figure 1). To form the study area, six subareas were selected on the basis of the level of development of the road network system (Tshibaka 1989). A sample of 132 households was studied. These households were chosen following a proportionate, stratified sampling procedure. First, a number of villages were randomly drawn in each subarea. Second, taking account of the population of selected individual villages, a number of households were randomly drawn in each selected village.

One enumerator and an aid were posted in each subarea for one crop year. Two research assistants were allocated to the project to help supervise the survey. Selected households were visited by enumerators four times a week for one crop year, and two techniques of data collection were used: interview and direct measurement. Data were collected on population, infrastructure, input, output, and prices. Enumerators measured perimeters and angles of land under crops using tape measures, compasses, and pickets, and cultivated area was estimated by the triangulation method. The most serious difficulty during this survey was the assessment of time spent on different activities, which is affected by farmers’ own judgment and that of the enumerators. With regard to capital, farmers do not easily recall the monetary value of their tools or the date of acquisition. These limitations are hard to avoid in a situation where most farmers are illiterate or do not keep records. A statistical method proposed by the Institut National des Statistiques et d’Études Economiques de France was adopted to estimate the cultivated area allocated to individual crops. The proposed method, notwithstanding its limitations, provides estimates that are useful when studying a mixed-crop farming system. (For details about the data see Tshibaka 1989.)

The allocation of time spent on nonspecific farm operations such as land preparation and weeding among individual crops was made on the basis of area shares of individual crops. For capital tools—mainly hoes, cutlasses, and hatchets—the labor time allocated to each of the four major crops (cassava, rice, maize, and plantain), expressed as a fraction of total labor time devoted to farming, was used as a weight to calculate the depreciation (in zaires) of capital tools used in the production of each crop. Since most of the tools used in the area are hand-held, their use is highly correlated with labor input per crop.
Figure 1—Map of Zaire

THE STUDY AREA

Ecology

The study area, located in Tshopo District, Haut-Zaïre Province, is made up of three communities: Turumbu people in the administrative zone of Isangi; Basoo people in Bomaneh, Bomenge Rural Community; and Bangelima people in Mongandoj Community in the administrative zone of Basoko. This area belongs to the Zaïrian Basin, which covers almost 40 percent of the total land area of Zaïre. The tropical rain forest that covers the Zaïrian Basin is a very rich biocenosis with a large number of species of trees, birds, animals, insects, and microorganisms. Some of these organisms constitute a major environmental constraint to agricultural production in this area.

Rainfall exhibits a bimodal distribution pattern and averages 1,800 millimeters a year. There are two rainy seasons, one between March and May and the other between August and November, and two dry seasons, one between January and February and the other between June and July. The area receives an average of 1,972 hours of sunlight per year, representing 45 percent of the days of possible sunshine. Most of this sunshine is concentrated during the dry seasons of the year. Temperature and humidity average respectively 25.5°C and 90 percent a year (Crabbe 1970).

Soils are leached and have a pH varying between 4 and 6. High surface heat and hard, frequent rains lead to a rapid breakdown in organic soil materials. The organic matter content of these soils varies between 1 and 2 percent (Sanchez 1976). As a result, fertility is low. Once land is cleared and put under cultivation with annual crops, soils are rapidly depleted. This low soil fertility forces farmers, in the absence of inputs to improve soil fertility, to clear new plots of land every cropping season. This shifting cultivation mode of production is becoming increasingly unsustainable with rapid population growth and, above all, constitutes a wasteful use of forest resources.

Rural Household Economy

The rural household economy of the study area evolves around two major sectors: the small-farm and nonagricultural sectors. The small-farm sector relies mostly on household labor, which is the main determinant of production. The capital input is composed largely of hand tools and seeds from previous crops. Land is abundant and freely accessible to every household. In 1982/83 the area cultivated by each household ranged from 0.25 to 1.09 hectares. Traditional techniques of production are still in use, and technological change occurs so slowly in the small-farm sector that it is hardly noticeable. The slash-and-burn method continues to be the mode of production. The major crops produced in the small-farm sector are food crops including rice, maize, cassava, and plantain. Rice and maize are primarily produced as cash crops, while cassava and plantain are mostly grown for subsistence.
The nonagricultural sector includes several activities that can be classified as food-producing or non-food-producing. Living in a very rich biocenosis, households engage extensively in hunting, fishing, and gathering to produce the bulk of the protein-based foods consumed in the area. These activities are also an important source of cash income for most of the households in the area. Non-food-producing activities are handicrafts, petty trade, and production of alcoholic beverages.

The area also has a plantation sector owned mainly by large foreign-owned corporations. This sector depends on paid inputs—labor and capital—and produces entirely for markets. The bulk of its output includes coffee, cocoa, rubber, and palm oil. The plantation sector sells very little to the smallholder sector. The smallholder sector sells food and nonfood products as well as a limited amount of labor to the plantation sector. There has not been any competition for land between these plantations and the local communities, even during the period of rapid expansion of the plantation sector (Jurion and Henry 1967). Since the 1960s, this sector has been contracting because of a number of inappropriate policies and poor management of the economy (Tshibaka 1986).

Historically, the establishment of this plantation agriculture was achieved with labor supplied mainly by the rural households in the study area. Over the years, the plantations have succeeded in reproducing most of their own labor force. That is, the children of the people who migrated from a rural household economy into the plantation economy were and still are the primary source of labor used by the plantation sector. None of the study household members were found to be engaged in plantation agriculture during the survey. The linkages between the two sectors are primarily limited to the flow of food, other household products, and a limited labor force from the smallholder sector to this large-scale agriculture. In fact, the plantation and the smallholder sectors constitute two distinct socioeconomic entities.¹

Basic Infrastructure

The Zairian Basin is the least developed region in the country, as is reflected in the poor state of the road network and consequently of the transportation system. Most villages in the region are isolated or poorly connected to major markets and urban centers. There are differences from one group of villages to another in the physical condition of the roads and in distances to rural markets or urban centers, making some villages more accessible than others. Most Turumbu villages are served by the Zaire River and the Isangi-Yangambi-Kisangani road. Local traders provide the sole means of transportation on the river, the traditional canoe. The traders are Lokele people, who play an important role in the distribution and marketing of farm and nonfarm commodities produced by Turumbu farmers. Although canoes are used all year round, the volume of goods transported remains small and the risk of accident high.

¹This is also the case for the mining sector in Zaire. The plantation and mining sectors are economic entities that have succeeded in creating their own identity. This anthropological aspect of the relationship between the rural household economy and the plantation agriculture is beyond the scope of this study.
The Isangi-Yangambi-Kisangani road, considered to be a major national road, is unpaved. Even during relatively dry periods of the year, the use of this road by vehicles is limited. Covering the 97 kilometers that separate Yangambi and Kisangani may take three hours in the best of weather conditions. During wet periods, the road is seldom used by vehicles. The high level of precipitation in the Zairian Basin makes the use of unpaved roads by vehicles difficult during most of the year. As a result, Turumbu villages along this axis are poorly connected to Yangambi and Lotokila—the major local markets in the community—and to Kisangani, the major urban center. Farmers living along this road usually walk 4-23 kilometers, depending on the location of their village, to reach a rural marketplace.

A second group of Turumbu villages, even more isolated, includes Weko and Yambaw in the remote forest. The road connecting these villages to Yangambi has deteriorated to such an extent that it is no longer used by vehicles at all. Farmers bring their produce twice a week to a local marketplace (which is 1 kilometer from Weko and 12 kilometers from Yambaw) for sale to traders, most of whom come from Yangambi by foot or bicycle. The distance from this local market to Yangambi is about 42 kilometers.

In the Mongandjo Community, farm households are served by the Aruwimi River and two feeder roads. The 42-kilometer road connecting Bolikango to Basoko is the best maintained in the entire study area. It was in fair condition for seven months of the survey year, in poor condition for three months, and in very poor condition for two months. Farmers walk 5-23 kilometers to reach three rural marketplaces: Longote, Bokote, and Baonde. The first two are along the Aruwimi River, while the third is at the point where the Basoko-Baonde route crosses the Aruwimi River. Farm and nonfarm products sold there are transported by traditional canoes or vehicles to Basoko, an important river port and marketplace.

The 190-kilometer road connecting Babendja in Mongandjo Community to Basoko is the second-best road in the area. This road was in fair condition for five months and in poor condition for the rest of the 1982/83 crop year. Babendja farmers walk 4-13 kilometers to reach a local market, where farm and nonfarm products are sold and then transported to Basoko either by road or by the Aruwimi River. The Aruwimi is used all year round by small boats and canoes. The distance by water from Babendja to Basoko is about 105 kilometers.

The 21-kilometer road connecting Bomaneh to Basoko in Bomenge Community is no longer practicable for vehicles, and it is now left entirely to those on foot. Only the Aruwimi River connects Bomaneh farmers to the two marketplaces—Baonde, 23 kilometers away, and Basoko, 24 kilometers. Canoes and small boats are the means of transportation used by farmers to reach these rural markets.

Data on the condition of the roads and the navigability of rivers in the area are summarized in Table 1. The table shows that Mongandjo and Bomaneh (Bomenge) farmers are in a somewhat better position than Turumbu farmers. The negative impact of this poor road network on the development of local marketing channels cannot be overemphasized. In all, the transportation system in the study area is grossly inadequate. For this and other reasons, few plantations are now operating in the study area.

**Labor Force**

The population of the study area was estimated at 49,103 people in 1981 (Zaire 1983). This population is growing at an annual rate of 1.2 percent, substantially lower
## Table 1 — Practicability of roads and navigability of rivers, 1982/83

<table>
<thead>
<tr>
<th>Transport Route Destinations</th>
<th>Condition of Road or River</th>
<th>Distance from Primary (Local) to Secondary Markets (months)</th>
<th>Community Served</th>
<th>Villages Served</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yangambi-Kisangani (road)</td>
<td>Fair 0</td>
<td>97</td>
<td>Turumbu</td>
<td>Villages along the Yangambi-Kisangani road</td>
</tr>
<tr>
<td></td>
<td>Poor 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Poor 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yangambi-Weko (road)</td>
<td>Fair 0</td>
<td>42</td>
<td>Turumbu</td>
<td>Villages in remote forest (Weko and Yambaw)</td>
</tr>
<tr>
<td></td>
<td>Poor 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Poor 12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yangambi-Isangi (road)</td>
<td>Fair 0</td>
<td>97</td>
<td>Turumbu</td>
<td>Villages along the Yangambi-Isangi road</td>
</tr>
<tr>
<td></td>
<td>Poor 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Poor 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basoko-Baonde (road)</td>
<td>Fair 7</td>
<td>47</td>
<td>Mongandjo</td>
<td>Bolikango</td>
</tr>
<tr>
<td></td>
<td>Poor 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Poor 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basoko-Mongandjo (Aruwimi River)</td>
<td>Fair 8</td>
<td>105</td>
<td>Mongandjo</td>
<td>Babendja</td>
</tr>
<tr>
<td></td>
<td>Poor 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Poor 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basoko-Bomaneh (Aruwimi River)</td>
<td>Fair 8</td>
<td>24</td>
<td>Bomenge</td>
<td>Bomaneh</td>
</tr>
<tr>
<td></td>
<td>Poor 4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Very Poor 0</td>
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</tbody>
</table>

than the national average growth rate of 2.8 percent a year. The sample population data in Table 2 are drawn from 132 households, of which 53 are in Turumbu Community, 53 in Mongandjo, and 26 in Bomenge. The sample population consists of 885 people, of whom 48 percent are males and 52 percent are females.

Considering the age bracket of 20-55 years as the most productive group, the survey data reveal that this group of people accounts for 16.5 percent of the males and 22.7 percent of the females. The group in the age bracket of 15-19 years—those who will enter the set of the most productive people in the near future—includes 4.1 percent of the males and 3.4 percent of the females. The group of those more than 55 years of age accounts for 6.0 percent of the males and 5.3 percent of the females.²

A large proportion of the sample population—about 42 percent—is under 15 years of age. The youthful character of the study population is further portrayed by a relatively low median age of 19. Demographically, a large proportion of people under 15 means that much momentum for future growth in the labor force in the study area is already built into the population. Another interesting feature of the sample population is the relatively small fraction of people in the 20-49 age bracket. This seems to suggest a substantial age- and gender-specific migration out of the study area, in addition to a relatively high death rate.³

In a subsistence-oriented economy, young adults are engaged in economic, social, and cultural activities in varying degrees. The definition of economically active people or the work force, that is, the group in the 15-64 age bracket, needs to be modified to show that even children below 15 and adults of 65 and above contribute to the household labor force in the peasant economy. There is recognition among researchers that due to labor division along gender lines, adult men and women in the 20-55 age bracket are equally efficient in performing specific tasks—for example, land preparation for men and planting, weeding, and harvesting for women; collection of palm nuts for men and processing of these nuts for women (Spencer 1976; Dodge 1977). On this basis, one adult man or woman is equivalent to one working unit. The same researchers seem to accept that female children work harder than their male counterparts.

The structure of the labor force is shown in Table 2. The sample population of 885 people represents 491.2 working units made up of 44.3 percent males and 55.7 percent females. The most productive group (20-55 age bracket) accounts for 70.6 percent, made up of 29.7 percent males and 40.9 percent females. In all, the data show that the share of females in the household labor force is, on average, relatively larger than that of males. The average household labor force in the study area is about 3.7 working units, of which 1.6 are males and 2.1 females.⁴

²In Zaire, farmers more than 55 years of age are considered retired farmers.
³Life expectancy in Zaire as a whole was about 45 years of age at the time of the survey. It is possible that this age may have dropped as a result of persistent socioeconomic crisis.
⁴The following conversion factors adopted from Collinson (1972) were used after adjustment for female children: 0.25 for males in the 10-14 age bracket, 0.67 for males in the 15-19 age bracket or more than 55 years of age, 0.37 for females in the 10-14 age bracket, and 0.75 for females in the 15-19 age bracket or more than 55 years of age.
Table 2—Sample population in the study area

<table>
<thead>
<tr>
<th>Sex/Age</th>
<th>Number of People</th>
<th>Percent of Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4</td>
<td>74</td>
<td>8.36</td>
</tr>
<tr>
<td>5-9</td>
<td>69</td>
<td>7.80</td>
</tr>
<tr>
<td>10-14</td>
<td>48</td>
<td>5.42</td>
</tr>
<tr>
<td>15-19</td>
<td>36</td>
<td>4.07</td>
</tr>
<tr>
<td>20-24</td>
<td>26</td>
<td>2.94</td>
</tr>
<tr>
<td>25-29</td>
<td>31</td>
<td>3.50</td>
</tr>
<tr>
<td>30-34</td>
<td>19</td>
<td>2.15</td>
</tr>
<tr>
<td>35-39</td>
<td>15</td>
<td>1.69</td>
</tr>
<tr>
<td>40-44</td>
<td>11</td>
<td>1.24</td>
</tr>
<tr>
<td>45-49</td>
<td>19</td>
<td>2.15</td>
</tr>
<tr>
<td>50-55</td>
<td>25</td>
<td>2.82</td>
</tr>
<tr>
<td>More than 55 years old</td>
<td>53</td>
<td>5.99</td>
</tr>
<tr>
<td>Total males</td>
<td>426</td>
<td>48.14</td>
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<tr>
<td>Average males per household</td>
<td>3</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Female</th>
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</thead>
<tbody>
<tr>
<td>0-4</td>
<td>75</td>
<td>8.47</td>
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<td>5-9</td>
<td>66</td>
<td>7.46</td>
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<td>10-14</td>
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<td>4.52</td>
</tr>
<tr>
<td>15-19</td>
<td>30</td>
<td>3.39</td>
</tr>
<tr>
<td>20-24</td>
<td>45</td>
<td>4.86</td>
</tr>
<tr>
<td>25-29</td>
<td>28</td>
<td>3.16</td>
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<td>30-34</td>
<td>26</td>
<td>2.94</td>
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<td>40-44</td>
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<tr>
<td>45-49</td>
<td>26</td>
<td>2.94</td>
</tr>
<tr>
<td>50-55</td>
<td>27</td>
<td>3.04</td>
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<tr>
<td>More than 55 years old</td>
<td>47</td>
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<tr>
<td>Total females</td>
<td>459</td>
<td>51.86</td>
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<tr>
<td>Average females per household</td>
<td>3</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Males and female</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>0-4</td>
<td>149</td>
<td>16.83</td>
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<tr>
<td>5-9</td>
<td>135</td>
<td>15.26</td>
</tr>
<tr>
<td>10-14</td>
<td>88</td>
<td>9.94</td>
</tr>
<tr>
<td>15-19</td>
<td>66</td>
<td>7.46</td>
</tr>
<tr>
<td>20-24</td>
<td>69</td>
<td>7.80</td>
</tr>
<tr>
<td>25-29</td>
<td>59</td>
<td>6.67</td>
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<tr>
<td>30-34</td>
<td>45</td>
<td>5.08</td>
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<td>35-39</td>
<td>44</td>
<td>4.97</td>
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<td>40-44</td>
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<td>3.73</td>
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<tr>
<td>45-49</td>
<td>45</td>
<td>5.08</td>
</tr>
<tr>
<td>50-55</td>
<td>52</td>
<td>5.88</td>
</tr>
<tr>
<td>More than 55 years old</td>
<td>100</td>
<td>11.30</td>
</tr>
<tr>
<td>Total males and females</td>
<td>888</td>
<td>100.00</td>
</tr>
<tr>
<td>Average per household</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

DIVISION AND ALLOCATION OF HOUSEHOLD LABOR TIME

Description of Household Activities

All the activities carried out in rural households in the Zairian Basin can be conveniently grouped into two broad categories: income-generating and non-income-generating. Income-generating activities include farm and nonfarm activities. Farming in the area is undertaken in the slash-and-burn fallow mode of production in which simple hand tools, on-farm crop seeds, household labor time, and land are the productive inputs. Land is abundant and freely accessible to all the households. The four major food crops are cassava, rice, maize, and plantain—all energy-rich foods (Tshibaka 1989).

Nonfarm activities can be divided into food-producing, non-food-producing, and service activities. Nonfarm food-producing activities consist of fishing; gathering edible wild fruits, leaves, mushrooms, insects, and honey in the forest; and the extraction of oil from wild palm nuts. These activities provide most of the protein-, mineral-, and vitamin-rich foods consumed in the Zairian Basin. Nonfood commodities and services include handicrafts, processing of maize into alcohol, extraction of wine from wild palm trees, and petty trade.

Non-income-generating activities include a wide variety that can be grouped into domestic and other activities. Domestic activities include building and maintaining houses; cooking; dishwashing; fetching water and firewood; health care; taking care of children; washing, mending, and ironing clothes; and so on. Other non-income-generating activities include sociocultural activities and leisure. Sickness and disease are also included in this group. Sociocultural activities are made up of schooling; attending political meetings, church services, parties, traditional dances, and festivals; and visiting friends and relatives. These activities are often viewed as non-economic, as they generally carry no monetary remuneration. It should be emphasized, however, that they are essential functions that ensure the reproduction and maintenance of human resources for the household and the nation.

Division of Household Activities

In most societies, the division of different activities performed in the household follow, to varying degrees, age and gender lines. The survey shows that high-energy and risky tasks are mainly reserved for adult male members of the household, while lighter and less risky tasks are primarily handled by adult women. The same pattern of labor division applies to children. Male children are coached by men, while female children are trained by women.
In relation to farming activities, the survey data indicate that slashing of forest or fallow and burning are mainly carried out by males, while clearing, planting, weeding, harvesting, processing, transporting, and marketing are primarily responsibilities of females. As for nonfarm activities, hunting, fishing, gathering wild palm nuts, extracting palm wine, and making handicrafts are mainly done by males, while collecting food items such as mushrooms, insects, and wild edible leaves, extracting oil from wild palm nuts, processing maize into alcohol, and marketing are primarily performed by females. Petty trade is handled by both males and females.

Most domestic activities are the responsibility of females, except for gardening, building and maintaining houses, and sociocultural activities, which are performed by both males and females. Nevertheless, it should be pointed out that some sociocultural activities such as traditional festivals and secret initiations are reserved either to males or females. The whole picture of labor division along gender lines in the study area is summarized in Table 3.

**Labor Time Allocation among Household Activities**

Labor data were collected only during daylight hours, and the observations covered the 365 days of the 1982/83 crop year. Labor time allocated during the 12 hours of daylight to each activity by individual household members aged at least 10 years was aggregated for each household using some conversion factors to account for age and gender differences (Collinson 1972; Spencer 1972; Dodge 1977).

It is important to note that this study, like most time-allocation studies confined to daylight hours, is likely to contain selective biases. Activities requiring daylight to accomplish (such as farming and house construction) are overrepresented, while those that can be practiced at night (such as visiting and rituals) are underrepresented. However, the bulk of income-generating and non-income-generating activities are carried out in the Zairian Basin during daylight hours. The structure of daylight time allocation between these two groups of activities is shown in Table 4.

The data show that household members allocated, on average, 21.8 percent of their annual labor time to income-generating activities, of which 6.1 percent was spent on farming and 15.7 percent on nonfarm activities. This finding clearly indicates that, in the Zairian Basin, nonfarm income-generating activities—hunting, fishing, gathering, handicrafts, and production of alcoholic drinks—are the leading economic activities. Although vital as a major source of food for the household, farming remains of secondary importance as an economic activity in the study area.

A survey conducted in 1974/75 on a small sample of households in Yalibwa, Turumbu Community (Kilumba 1975), revealed that the contribution of nonfarm activities to household cash income (after taking account of home consumption) was larger than that of farming. The surplus from these activities contributed about 62 percent.

---

5 Nighttime is assumed to be a period of time after 7:00 p.m. and before 6:00 a.m. Daytime (daylight) is assumed to be a period of time after 6:00 a.m. and before 7:00 p.m. The Zairian Basin extends north and south of the equator.
Table 3—Division of household activities by gender in the study area

<table>
<thead>
<tr>
<th>Activities</th>
<th>Males</th>
<th>Period of the Year</th>
<th>Females</th>
<th>Period of the Year</th>
<th>Males and Females</th>
<th>Period of the Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income-generating</td>
<td>Land preparation (slashing, burning) January through April</td>
<td></td>
<td>Planting, sewing, weeding, harvesting, processing, transporting, and marketing January through December</td>
<td>Land clearing</td>
<td></td>
<td>March through April</td>
</tr>
<tr>
<td>Farming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonfarming</td>
<td>Hunting, fishing, gathering nuts from wild palm trees, extracting and marketing wine from wild palm trees, and handicrafts January through December</td>
<td></td>
<td>Gathering different food products in the forest, extracting oil from wild palm nuts and marketing oil, processing maize into beer and alcohol and marketing them, and crafts January through December</td>
<td>Petty trade</td>
<td></td>
<td>January through December</td>
</tr>
<tr>
<td>Non-income-generating Domestic</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Other</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Table 4—Allocation of labor among household activities, 1982/83

<table>
<thead>
<tr>
<th>Activities</th>
<th>Males</th>
<th>Females</th>
<th>Males and Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours per Working Unit*</td>
<td>Percent of Hours</td>
<td>Hours per Working Unit*</td>
</tr>
<tr>
<td>Income-generating</td>
<td>1,063.85</td>
<td>24.29</td>
<td>868.75</td>
</tr>
<tr>
<td>Farming</td>
<td>258.53</td>
<td>5.90</td>
<td>272.26</td>
</tr>
<tr>
<td>Nonfarming</td>
<td>805.32</td>
<td>18.39</td>
<td>596.49</td>
</tr>
<tr>
<td>Non-income-generating</td>
<td>3,316.15</td>
<td>75.71</td>
<td>3,511.25</td>
</tr>
<tr>
<td>Domestic</td>
<td>682.01</td>
<td>15.57</td>
<td>1,133.46</td>
</tr>
<tr>
<td>Otherb</td>
<td>2,634.14</td>
<td>60.04</td>
<td>2,377.79</td>
</tr>
<tr>
<td>Total annual</td>
<td>4,380.00</td>
<td>100.00</td>
<td>4,380.00</td>
</tr>
</tbody>
</table>


Note: The potential time per working unit is estimated at 4,380 hours a year on the basis of 12 hours of daytime and 365 days a year. Daytime (daylight) is assumed to be a period of time after 6:00 a.m. and before 7:00 p.m.

*aA working unit is defined as an adult-equivalent.

*bOther includes non-income-generating activities such as sociocultural activities and leisure.

of household cash income as opposed to 36 percent from farm products. The remaining 2 percent of household cash income was provided by gifts and other donations.

The observation of the same data along gender lines reveals that male household members spent more time on income-generating activities than their female counterparts (Table 4). Males devoted 24.3 percent of their working time to these activities, compared with 19.8 percent for females. Non-income-generating activities claimed 78.2 percent of total labor time, of which 21.3 percent was devoted to domestic activities and 56.9 percent to other non-income-generating activities. Males allocated about 75.7 percent of their working time to this group of activities, of which 15.6 percent was spent on domestic activities and 60.1 percent on other non-income-generating activities. Females spent about 80.2 percent of their working time on the same activities, of which 25.9 percent was allocated to domestic activities and 54.3 percent to other non-income-generating activities.

Looking at the contribution of each member to the household work load during the study year, the analysis indicates that an average male member of the household contributed about 22.5 percent more labor than his female counterpart to income-generating activities. The disaggregation of these activities into farming and nonfarming indicates that an average female devoted 5.3 percent more time to farming and 35.0 percent less time to nonfarm income-generating activities than her male counterpart. With regard to non-income-generating activities, an average female devoted 5.9 percent more labor than an average male to this group of activities. The disaggregation of these activities into domestic and other activities, reveals that an average female spent about 66.2 percent more labor time than her male counterpart on domestic activities, while an average male allocated 10.8 percent more time than his female counterpart to other non-income-generating activities during the study year.
This survey confirms the findings of previous studies conducted in Sub-Saharan Africa that men spend relatively more time on income-generating activities and less time on non-income-generating work than women. The study also reveals that on average in the Zaïre Basin, women do not spend significantly more time on farming than men. This finding is supported by many other labor studies conducted in the Sub-Saharan region (Oluwasanmi et al. 1966; Luming 1967; Spencer 1976; and Matlon et al. 1979).

In sum, this analysis finds that both male and female members of the household allocate relatively less labor time to income-generating (farming and nonfarming) activities than to non-income-generating activities, and that farming receives only a relatively small fraction of household labor time allocated to income-generating activities. Therefore, an assessment of the key determinants of labor time allocation between income-generating and non-income-generating activities is called for to help in policymaking. That analysis is taken up in Chapter 5.

Seasonality in Labor Time Allocation

In a subsistence-oriented economy, rural household activities generally exhibit a certain degree of seasonality that reflects changes in the rainfall distribution pattern and other environmental conditions. These changes determine farming, hunting, fishing, and gathering periods, and consequently impose on the rural households a seasonal pattern of labor time allocation to both income-generating and non-income-generating activities. It is therefore important to examine this seasonality of labor use and allocation in order to pinpoint when labor shortages occur and whether these shortages occur during peak periods. This is particularly critical for farm operations such as land preparation, planting, weeding, and harvesting. In addition, it is useful to explore whether this seasonality in time allocation differs by gender in order to establish whether some policy recommendations related to labor use and allocation need to be gender specific.

The monthly allocation of male labor to income-generating and non-income-generating activities shows a seasonal trend (Figures 2 and 3). From November to April, male labor time allocated to income-generating activities does not show any discernible trend. From April to July, male labor time devoted to these activities exhibits an increasing trend, while from July to October, it shows a declining trend. With respect to the amount of male labor time spent on non-income-generating activities, three periods are identified: from November to April, an increasing trend; from April to August, a decreasing trend, and from August to October, an increasing trend. The trend in the monthly allocation of female labor time to income-generating activities declines from November to April, increases from April to August, and decreases from August to November (Figure 4). The situation is reversed for non-income-generating activities (Figure 5).

A further disaggregation of income-generating activities into farming and non-farming reveals a seasonal pattern in the allocation of labor time to these activities. The allocation of male labor time to farming shows an increasing trend from December to February and a decreasing trend from February to December (Figure 6). The slashing of forest or fallow is mostly carried out during the December-February period. During February-April, burning and clearing are undertaken by most rural households. From April to December, other farm operations such as planting, weed-
Figure 2—Monthly allocation of male labor time to income-generating activities, 1982/83


Figure 3—Monthly allocation of male labor time to non-income-generating activities, 1982/83

Figure 4—Monthly allocation of female labor time to income-generating activities, 1982/83


Figure 5—Monthly allocation of female labor time to non-income-generating activities, 1982/83

Figure 6—Monthly allocation of male labor time to farm and nonfarm income-generating activities, 1982/83


ing, harvesting, processing, and marketing are performed. Male labor time spent on nonfarm activities displays a declining trend in December-March, increasing in March-August, declining in August-October, and increasing in October-December.

The monthly allocation of female labor time to farming shows a decreasing trend in November-February, increasing in February-July, declining in July-September, and increasing in September-November (Figure 7). From November to February, most females are engaged in processing and marketing farm produce. From February to July, they are generally clearing, planting, and weeding. From September to November they are harvesting (cassava and plantain), processing, and marketing. The monthly female labor allocation to nonfarm activities exhibits an increasing trend in December-February, declining in February-May, increasing in May-August, and decreasing in August-December.

This analysis shows that the allocation of labor time has different seasonal patterns for men and women. The time allocated to income-generating activities by an average male is greater than that of his female counterpart throughout the year except for August, when their monthly allocation of labor time to these activities is practically the same. The reverse holds for non-income-generating activities. In addition, the pattern of labor time allocation over the years reveals that forest or fallow slashing and burning are almost entirely carried out by men, while clearing, planting, weeding, harvesting, processing, and marketing are mainly performed by women, with substantial help from men.
Figure 7—Monthly allocation of female labor time to farm and nonfarm income-generating activities, 1982/83


Furthermore, the survey reveals that no male or female household member spent more than 50 percent of his or her available monthly labor time on income-generating activities during the entire 1982/83 year. Thus the observed pattern of labor use and allocation does not suggest any seasonal labor shortages in the study area. Moreover, given a bimodal distribution pattern of rainfall that allows for two cropping seasons a year, it is plausible to suggest that the limited labor allocated to farming during the survey year can hardly be attributed to seasonal variations in rainfall distribution—a major factor constraining labor use, particularly in the subhumid and semi-arid areas of Sub-Saharan Africa (Tshibaka 1989)—but rather to other factors this study attempts to identify in subsequent chapters.
DETERMINANTS OF HOUSEHOLD LABOR TIME ALLOCATION

Estimations of the amount of household labor time (expressed in adult-equivalent hours) allocated to different groups of household activities were given in Chapter 4. Next, the study attempts to identify key factors that determine the allocation of this labor time among these groups of activities, that is, the factors that determine how this labor input is shared among agricultural, non-agricultural, and other household (non-income-generating) activities. This assessment provides information on how to change the observed pattern of household labor allocation to enhance a specific group of activities—for example, income-generating activities including farming.

The Singh-Squire-Strauss Model

This section is an exposition of the existing SSS model (Singh, Squire, and Strauss 1986). The SSS model is used in an attempt to examine the key determinants of labor allocation among different household activities. Given the division of labor along gender lines and the high degree of interdependency between household members of both genders in this subsistence-oriented society, it is plausible to assume that the decisionmaking unit is the household and not the individual. For example, the amount of labor time female members allocate to farming is partly determined by the size of the cultivated area, which is primarily determined by the amount of labor males devote to land preparation. Since subsequent farm operations (planting, weeding, harvesting, transporting, processing, and marketing) are primarily performed by females, one may assume that during land preparation (slashing and burning), men will take into account the available household female labor force.

With regard to nonfarm activities—for example, production of oil from wild palm trees—amounts of labor that males allocate to gathering palm nuts will be affected by the availability of the female labor needed in the processing and marketing of palm oil. This strong interdependency is exacerbated by the lack of a labor market in the area. Thus the household, rather than the individual member, should be considered as the decisionmaking unit.

It should be stressed that the model attempts to identify key demographic, environmental, economic, and sociocultural factors that enter the household’s decisionmaking process related to allocation of the available labor time among different groups of activities including income-generating (farming and nonfarming) and non-income-generating (domestic and other) activities carried out in the rural household.
Before the model is postulated, it is important to note the following assumptions:

- The rural household in the Zairian Basin is assumed to be a utility-maximizing unit that tries to approximate the profit-maximizing solution.
- The production is competitive and subject to a homogeneous production function of degree one, exhibiting constant returns to scale.
- The resources available to the household are limited and fully employed. These inputs are labor and capital. Since land is abundant and freely available to each household, it is not a binding constraint to production.
- The production of farm products requires land, labor, and capital, and that of nonfarm products requires primarily labor and capital, while non-income-generating activities demand mainly labor.
- Labor is mobile between farming, nonfarming, and non-income-generating activities. Land is specific to agriculture, and capital is mobile between farming and nonfarming.

For any production cycle, the household is assumed to maximize a utility function:

$$U = U(V_a, V_n, V_m, V_o),$$

where

- $V_a$ = set of household's own agricultural goods consumed,
- $V_n$ = set of household's own nonagricultural products consumed,
- $V_m$ = set of market goods purchased by the household, and
- $V_o$ = set of non-income-generating activities.

The household utility function is maximized, subject to a cash-income constraint:

$$P_a V_a + P_n (Q_n - V_n) - w (L_a - H_a) - w (L_n - H_n) - r (K_a + K_n),$$

where

- $P_m$ = set of prices of purchased goods,
- $P_a$ = set of prices of farm products produced in the household,
- $P_n$ = set of prices of nonfarm products produced in the household,
- $Q_a$ = set of household's farm outputs (so that $Q_a - V_a$ is the set of its marketed farm surplus),
- $Q_n$ = set of household's nonfarm outputs (so that $Q_n - V_n$ is the set of its marketed nonfarm surplus),
- $w$ = market wage,
- $L_a$ = total labor input allocated to agriculture,
- $H_a$ = household labor input allocated to agriculture,
- $L_n$ = total labor input allocated to nonagriculture,
- $H_n$ = household labor input allocated to nonagriculture,
- $r$ = cost per unit of household capital input,
- $K_a$ = household capital input allocated to agriculture, and
- $K_n$ = household capital input allocated to nonagriculture.

Note that $K_a + K_n = K$, which is the stock of household capital available during the production cycle. Note also that if labor was hired, then $L_a > H_a$ and $L_n > H_n$: hence
\( L_a - H_a > 0 \) and \( L_n - H_n > 0 \). If, on the contrary, some household labor is sold out, then the reverse holds. The household also faces a time constraint, so that

\[
H_a + H_n + H_o = T, \tag{3}
\]

where \( H_o \) is the household labor allocated to non-income-generating activities, and \( T \) is the stock of household labor time.

The transformation of the household's resources into farm and nonfarm products is constrained by the production technology that depicts the relationship between the set of the household's inputs and the set of its outputs. The aggregate farm and nonfarm production functions could be given as functions of labor and capital inputs:

\[
Q_a = f(L_a, K_a), \quad \text{and} \tag{4}
\]

\[
Q_n = f(L_n, K_n). \tag{5}
\]

This formulation is made on the basis that the volume of farm and nonfarm output in a land-surplus, labor-scarce economy is primarily determined by the amount of labor and secondarily by capital input allocated to farming and nonfarming (Tshibaka 1989). Since land is plentiful and freely available in the Zairian Basin, it is not a binding constraint to farm production and is therefore omitted from the aggregate agricultural production function.

Furthermore, the production of both farm and nonfarm goods is assumed to be riskless, and the household is assumed to be a price-taker. The three basic constraints of the model—cash, labor, and production—can be combined into a single constraint. Substituting the production constraint into the cash-income constraint for \( Q_a \) and \( Q_n \) and substituting the time constraint into the cash-income constraint for \( H_a \) and \( H_n \) yields a single constraint of the form

\[
P_m V_m + P_a V_a + P_n V_n + wH_o = wT + \pi, \tag{6}
\]

where \( \pi = P_a f(L_a, K_a) + P_n f(L_n, K_n) - w(L_a + L_n) - r(K_a + K_n) \). In equation (6), the left-hand side shows total household expenditure on four groups of items—market-purchased goods, the household's purchase of its own farm output, the household's purchase of its own nonfarm output, and the household's purchase of its own time in non-income-generating activities (sociocultural and leisure). The right-hand side is a development of Becker's concept of full income, in which the value of the stock of household labor time is explicitly recorded. The extension for rural households includes a measure of household profits, \( \pi = (P_a Q_a + P_n Q_n) - w(L_a + L_n) - r(K_a + K_n) \), with all labor valued at the market price, this being a consequence of the assumption of price-taking behavior in the labor market.

It follows from equation (6) that the household can choose the levels of consumption for the four groups of commodities and the amount of total labor for agricultural and nonagricultural production. Now consider the first-order conditions for maximizing agricultural and nonagricultural output with respect to labor:

\[
P_a \frac{\partial Q_a}{\partial L_a} = w, \quad \text{and} \tag{7}
\]

\[
P_n \frac{\partial Q_n}{\partial L_n} = w. \tag{8}
\]
That is, the household will equate the value of the marginal product of labor in farm production and that of labor in nonfarming with the market wage rate. It is important to see that each of these equations contains only one endogenous variable, L. The other endogenous variables—V, Vₜₙ, Vₛₙ, and Hₜₙ—do not appear and therefore do not influence the household’s choice of the amount of labor time to be allocated to agricultural and nonagricultural activities.

Accordingly, equations can be solved for L as a function of prices \( P_a, P_n, w \) and the stock of capital input. Let the solution for L be

\[
L_a = f(w, P_a, P_n, K_a), \quad \text{and} \tag{9}
\]

\[
L_n = f(w, P_a, P_n, K_n). \tag{10}
\]

Since it was observed during the survey that the household had a fixed stock of labor time and that no labor was hired or sold out, labor allocated to farming and nonfarming \( (s_a, s_n) \) can be expressed as shares of the stock of household labor time. Equations (9) and (10) become

\[
s_a = f(P_a, P_n, w, K_a), \quad \text{and} \tag{11}
\]

\[
s_n = f(P_a, P_n, w, K_n), \tag{12}
\]

so that \( s_a + s_n + s_o = 1 \), where \( s_o \) is the share of non-income-generating activities in the stock of household labor time. It follows that the labor-allocation-share constraint makes the labor equation for non-income-generating activities redundant and it need not be estimated.

**Regression Equations**

The above theoretical model was based on the assumption that the production is competitive. This assumption implies, among other things, that the economic environment is the same for all households in the study area. The survey conducted in the six locations that form the study area does not support this assumption. These locations were not found to display the same level of infrastructural development (road network, transportation system, distribution system, and markets). This observation calls for the inclusion of the infrastructure in the analysis.

As shown above, the prices of farm and nonfarm products produced in the household and the household capital input affect the allocation of labor between farming and nonfarming. The prices of farm and nonfarm products are, in turn, affected by the level of infrastructural development facing each location. Therefore, the prices will be highly correlated with the infrastructure variable. But the terms of trade between agricultural and nonagricultural products will be neutral with respect to this variable. Thus the infrastructure and the terms of trade are expected to independently affect the level of labor input allocated to farm and nonfarm activities. In fact, in the process of labor allocation between farming and nonfarming, farmers tend to think in terms of relative prices between farm and nonfarm products. Therefore, the terms of trade between farm and nonfarm activities is the most appropriate
price variable to include in the analysis. Because the capital input available to the household is mostly made up of simple tools such as cutlasses, hatchets, and knives that are used for both farm and nonfarm activities, the study found it more appropriate to consider the amount of household capital available to all the income-generating activities per working unit as a good proxy of the capital input allocated to either type of income-generating activity. This variable is expected to positively affect the amount of labor time allocated to agriculture and nonagriculture.

Since the study households are primarily subsistence-oriented, and given that only household labor is used, two demographic variables to introduce in the analysis in order to account for these two household characteristics are the dependency ratio and the gender composition of the household labor force. The dependency ratio variable is expected to affect positively the amount of labor allocated to farming—the primary source of food for the household. But this demographic variable is expected to affect negatively the amount of labor allocated to nonfarming. Output from nonfarm activities such as fishing, hunting, and gathering is not predictable. Therefore, as the number of dependents is high, farmers will tend to put a low premium on these activities. Regarding the gender composition of the labor force, it was observed that males tend to spend more labor time on nonfarm activities than females, while females tend to allocate more labor time to farming than males. Hence, the gender composition of the labor force, expressed as the share of women in the household labor force, is expected to affect positively the amount of labor time spent on farming, and negatively the amount of labor time devoted to nonfarming.

Furthermore, a key variable that is not introduced in this empirical model is the market wage rate. It should be recalled that during the survey, labor was not hired or sold out. This suggests that the labor market in the study area was almost nonexistent. Therefore the market wage rate is considered to be zero. Under this situation, the household demand for labor is equal to the supply of its own labor (Singh, Squire, and Strauss 1986).

Thus the regression equations to be estimated include the infrastructure, the terms of trade between farming and nonfarming, the household capital input per working unit, the dependency ratio, and the gender composition of the labor force. These equations can be expressed as

\[ s_a = f(I, T_{an}, K/W, D_r, C_g, e) \], and
\[ s_n = f(I, T_{an}, K/W, D_r, C_g, e) \],

where

- \( s_a \) = share of labor allocated to farming,
- \( s_n \) = share of labor allocated to nonfarming,
- \( I \) = infrastructure variable,
- \( T_{an} \) = terms of trade between farming and nonfarming,
- \( K/W \) = household capital per working unit,
- \( D_r \) = household dependency ratio,
- \( C_g \) = gender composition of the household labor force, and
- \( e \) = error term.
It is worth noting that a similar empirical model was used by Bardhan (1984) in his analysis of the peasant labor supply in India. It is also important to note that this model attempts to examine cross-section variations in the labor supply by focusing on factors specific to the household units as well as on factors that describe the economic environment within which these households operate.

**Definition of Variables**

As specified above, the empirical model includes the following variables: household dependency ratio, gender composition of the household labor force, capital input per working unit, infrastructure, and terms of trade between farming and nonfarming. The dependency ratio is defined as the ratio of the number of household consuming units over the number of household working units. This variable indicates the number of people (expressed in adult-equivalents) one working unit must support.\(^6\)

The gender composition of the household labor force is defined as the ratio of the number of working units ascribed to females over the total number of working units in the household. Due to a lack of data on household capital (tools and seeds) input available for productive purposes, the capital input allocated to farming was used as a proxy. This capital input is expressed in zaires per working unit. This variable was introduced in the model to account for the effect of productive household assets on labor use.

The practicability of roads, navigability of rivers, and size of the markets in the study locations are used as a proxy to express the state of infrastructure in the study area. On the basis of these data the six study locations were divided into two groups. A dummy displaying a value of one was used for any location with a relatively adequate state of infrastructure and a value of zero for any other location.

The preplanting weighted farmgate prices for maize, cassava, rice, and plantain were computed to represent the price of farm products. The share of each crop in the cultivated area was used as a weight, while the preplanting producer price of palm wine was used as a proxy for the price of nonfarm products produced in the household. These average prices were computed from monthly farmgate price data collected from September 1982 to March 1983. These prices were used to estimate the terms of trade between farm and nonfarm activities. Finally, Table 5 presents some statistics describing the dependent variables (shares of labor time allocated to agriculture and nonagriculture, respectively) and the explanatory variables specified above.

**Regression Results**

A least squares method applied to the survey data gives the regression results summarized in Table 6. For the share of household labor time allocated to farming, the regression equation shows that the fit is fair and the F-statistics are highly significant at the 1 percent level. As expected, the coefficients for the preplanting

\(^6\)The conversion factors proposed by Collinson (1972) were used to compute the number of consuming units for each household. One working unit equals one adult-equivalent.
Table 5—Statistical description of variables for labor time allocated to agriculture and nonagriculture

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_n$</td>
<td>0.07</td>
<td>0.04</td>
<td>57.14</td>
<td>Share of household labor allocated to farming</td>
</tr>
<tr>
<td>$z_n$</td>
<td>0.17</td>
<td>0.10</td>
<td>58.82</td>
<td>Share of household labor allocated to nonfarming</td>
</tr>
<tr>
<td>$T_{an}$</td>
<td>1.88</td>
<td>0.84</td>
<td>44.68</td>
<td>Farmgate terms of trade between farming and nonfarming</td>
</tr>
<tr>
<td>$K/W$</td>
<td>32.06</td>
<td>24.45</td>
<td>76.26</td>
<td>Household capital input (in zaires per working unit)</td>
</tr>
<tr>
<td>$D_t$</td>
<td>1.59</td>
<td>0.38</td>
<td>25.15</td>
<td>Household dependency ratio</td>
</tr>
<tr>
<td>$C_g$</td>
<td>0.55</td>
<td>0.13</td>
<td>23.64</td>
<td>Gender composition of household labor force</td>
</tr>
</tbody>
</table>


Farmgate terms of trade between farming and nonfarming activities ($T_{an}$), the amount of capital input per working unit ($K/W$), and the state of infrastructure ($I$) are positive and significantly different from zero at the 1 percent level. This implies that these variables are key determinants of the share of household labor time devoted to farming in the Zairian Basin. The degree of dependency ($D_t$)—introduced in the equation on the assumption that large household size would generate pressure to allocate more labor time to farming in order to produce more food crops—and the gender composition of the labor force (expressed as the share of women in the household labor force) do not explain the share of household labor time spent on farming.

With respect to the share of household time allocated to other income-generating activities, the analysis indicates that the fit is fair and the F-statistic is highly significant at the 1 percent level. All the variables display the expected signs. These variables are statistically different from zero. This suggests that these factors explain the share of labor time spent on nonfarm income-generating activities.

The elasticity estimate of the share of household labor allocated to agriculture with respect to the preplanting farmgate terms of trade is 0.27, that with respect to capital input per working unit is 0.26, and that with respect to the state of infrastructure is 0.23. These results can be interpreted as follows with regard to the share of household labor time allocated to agriculture: a 1.00 percent increase in preplanting farmgate terms of trade between agricultural and nonagricultural activities will be associated with an increase of about 0.27 percent; a 1.00 percent increase in capital input per working unit will lead to about a 0.26 percent increase; and a 1.00 percent improvement in the state of infrastructure will be associated with about a 0.23 percent increase.
<table>
<thead>
<tr>
<th>Explanatory Variables and Important Statistics</th>
<th>Shares of Household Labor Time Allocation</th>
<th>Nonfarm Time Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Farming ( \left( e_a \right) )</td>
<td>Nonfarming ( \left( e_a \right) )</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.23 (0.70)</td>
<td>21.55 (4.52)***</td>
</tr>
<tr>
<td>( T_{fn} )</td>
<td>1.02 (3.27)***</td>
<td>-1.74 (-1.91)**</td>
</tr>
<tr>
<td>( K/W )</td>
<td>0.06 (5.09)***</td>
<td>0.05 (1.47)*</td>
</tr>
<tr>
<td>I</td>
<td>3.55 (6.06)***</td>
<td>8.67 (5.07)***</td>
</tr>
<tr>
<td>( C_g )</td>
<td>-1.10 (-0.61)</td>
<td>-7.78 (-1.50)*</td>
</tr>
<tr>
<td>( D_T )</td>
<td>0.65 (1.01)</td>
<td>-1.52 (-0.81)</td>
</tr>
<tr>
<td>( R )</td>
<td>0.43</td>
<td>0.33</td>
</tr>
<tr>
<td>F</td>
<td>20.79</td>
<td>14.13</td>
</tr>
<tr>
<td>n</td>
<td>132</td>
<td>132</td>
</tr>
</tbody>
</table>


Notes: The numbers in parentheses are t-values. \( T_{fn} \) is the farmgate terms of trade between farm and nonfarm activities, \( K/W \) is capital input per working unit, I is the state of infrastructure, \( C_g \) is the gender composition of the household labor force, and \( D_T \) is the degree of dependency.

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

The elasticity estimate of the share of household labor time spent on other income-generating activities with respect to the preplanting farmgate terms of trade between agriculture and nonagriculture is -0.22, that with respect to capital input is 0.10, and that with respect to the state of infrastructure is 0.21. This suggests that a 1.00 percent increase in the farmgate terms of trade between agriculture and nonagriculture will lead to about a 0.22 percent decline in the share of household labor time spent on nonagricultural activities, while a 1.00 percent increase in household capital input available per working unit will be associated with a 0.10 percent increase in the share of household labor time allocated to nonfarming. A 1.00 percent improvement in the state of infrastructure will lead to a 0.21 percent increase in the share of household labor time allocated to nonagricultural activities.\(^7\)

\(^7\)The elasticity estimates are computed at the mean values of variables.
These findings suggest that policy actions to improve the state of infrastructure and to develop the rural capital and product markets need to be considered if rural households in the Zairian Basin are to divert more of their labor time to farming and other income-generating activities. In the medium term, there is a need to improve the practicability of the existing road network and the navigability of the rivers and to stimulate the trucking, distribution, and marketing of farm implements and products. In the long run, actions to develop rural capital and credit markets should be initiated. These actions should be associated with policy measures designed to generate and promote the diffusion of appropriate agricultural technologies. This will help to improve the volume and the composition of agricultural capital input available to households.
ALLOCATION AND USE OF AGRICULTURAL LABOR TIME

The survey shows that the nonagricultural sector, which is the main sector of the rural economy in the Zairian Basin, claimed 75.7 percent of labor time expended on the production of goods and services, while agriculture received only 24.3 percent. The nonagricultural sector produces a variety of goods including game meat, fish, nuts, oil, fruits, leaves, insects, mushrooms, honey, and crafts. Collecting output data on most of these products during the survey proved to be a difficult task. Most of these goods are food commodities, and a substantial fraction of their output is quickly consumed as soon as they arrive in the home. Farmers in the area do not weigh their products. Because of this limitation, the remaining chapters of the study are restricted to labor division, allocation, and use in the farm sector of the rural household economy of the Zairian Basin.

More specifically, this chapter describes the division of agricultural labor between male and female members of the household and examines the pattern of labor allocation between different farm operations in order to delineate these operations on the basis of their claim on male and female labor time allocated to agriculture. This exercise is important on several grounds. First, it will help, in the process of mechanization of the farm sector, to direct effort toward those farm operations that are more labor-consuming and likely to suffer from labor shortages in this land-surplus, labor-scarce economy. Second, it will indicate, for each specific type of mechanization, the target household members. That is, for farm operations predominantly performed by males, efforts to mechanize these operations will be directed to this group and likewise for those operations handled mainly by females. Third, the analysis will also help in the diffusion of improved agricultural techniques for land preparation, planting, fertilizer use, weeding, harvesting, transporting, processing, storage, and marketing of farm produce by targeting the appropriate household members.

Finally, an assessment is made of the intensity of labor use per hectare of cultivated area in the Zairian Basin, and the determinants of this intensity of labor use are identified. This analysis has serious policy relevancy, as the productivity of labor is affected not only by crop yield but also by the intensity of labor use per hectare of cultivated area.

Main Farm Activity in the Study Area

In the Zairian Basin, shifting cultivation of cassava, plantain, rice, and maize is the main farm activity. However, this does not mean that all the labor and other inputs allocated to agriculture in this area are used for this purpose; minor crops such as vegetables and fruits are also produced. For the purpose of the study, it is assumed
that labor and other productive inputs allocated to farming are used up in the production of the four major crops.

Cassava is the main staple food consumed by farm households in the study area. Plantain is sold to the Lokele, an ethnic group who specialize in fishing and commerce and whose staple food is plantain. Maize is mostly produced as a raw material used in the production of alcoholic drinks. The survey found that 93.5 percent of the study households who produced maize transformed most of it into alcohol, while 6.5 percent of these households did not process their maize output into alcohol at all. Farmers affirmed that the production of alcohol allows them to turn maize production into a more profitable activity.8 Rice is mainly produced for sale.

As to the contribution of each crop to total food-crop output, in 1982/83 cassava accounted for 85.0 percent (expressed in kilograms of cereal-equivalents), rice for 7.7 percent, maize for 5.2 percent, and plantain for 2.1 percent. Clearly, the smallholder sector in the Zairian Basin is a cassava-based system.

Division and Allocation of Labor among Farm Operations

In the Zairian Basin, smallholder agriculture is characterized, among other things, by a net division of agricultural labor between male and female members of the household. During land preparation, slashing and burning are primarily performed by men, with a negligible contribution from women, while clearing is mainly undertaken by women, with a substantial contribution from men. During production operations, planting and weeding are handled mostly by females, with a limited contribution from males, whereas the protection of rice from birds is almost solely performed by males. Postproduction operations, including harvesting, transporting, and marketing, are primarily done by women, with a very limited contribution from men.

The allocation of labor time among different farm operations by both male and female household members in the Zairian Basin in 1982/83 is shown in Table 7. The data indicate that most of the male workload was concentrated on land preparation. About 66.5 percent of male labor time devoted to agriculture was allocated to this operation, compared with 5.8 percent of female labor. As for production operations, males allocated 23.1 percent of their farm labor to these operations, compared with 42.1 percent for females. Postproduction operations accounted for only 10.4 percent of male farm labor, whereas females allocated 52.1 percent of their farm labor to the same operations.

This analysis shows that the contribution of male members of the household to agricultural labor time is substantial. This contribution is especially critical in the Zairian Basin, where the size of cultivated area, which is the main determinant for volume of agricultural output, is primarily determined by the amount of male labor time allocated to land preparation.9 Hence, males in the study area cannot be consid-

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8The production of alcoholic drinks at the household level is prohibited by law in Zaire, but this prohibition is not effectively enforced.

9This is true because the area has abundant land, and the use of yield-increasing technologies is not known (Tshibaka 1989).
Table 7—Division and allocation of labor by farm operations, 1982/83

<table>
<thead>
<tr>
<th>Farm Operations</th>
<th>Males Hours per Working Unit*</th>
<th>Males Percent</th>
<th>Females Hours per Working Unit*</th>
<th>Females Percent</th>
<th>Average for Males and Females Hours per Working Unit*</th>
<th>Average Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation</td>
<td>171.82</td>
<td>66.46</td>
<td>15.81</td>
<td>5.81</td>
<td>84.70</td>
<td>31.82</td>
</tr>
<tr>
<td>Slashing</td>
<td>161.64</td>
<td>62.52</td>
<td>3.40</td>
<td>1.25</td>
<td>73.73</td>
<td>27.70</td>
</tr>
<tr>
<td>Burning</td>
<td>2.55</td>
<td>0.99</td>
<td>0.45</td>
<td>0.16</td>
<td>1.33</td>
<td>0.50</td>
</tr>
<tr>
<td>Clearing</td>
<td>7.63</td>
<td>2.95</td>
<td>11.96</td>
<td>4.40</td>
<td>9.64</td>
<td>3.62</td>
</tr>
<tr>
<td>Production operations</td>
<td>59.82</td>
<td>23.14</td>
<td>114.67</td>
<td>42.12</td>
<td>88.18</td>
<td>33.13</td>
</tr>
<tr>
<td>Planting or sowing</td>
<td>46.97</td>
<td>18.17</td>
<td>85.00</td>
<td>31.22</td>
<td>66.25</td>
<td>24.89</td>
</tr>
<tr>
<td>Weeding</td>
<td>5.64</td>
<td>2.18</td>
<td>28.35</td>
<td>10.41</td>
<td>18.74</td>
<td>7.04</td>
</tr>
<tr>
<td>Protecting rice from birds</td>
<td>7.21</td>
<td>2.79</td>
<td>1.32</td>
<td>0.49</td>
<td>3.19</td>
<td>1.20</td>
</tr>
<tr>
<td>Postproduction operations</td>
<td>25.89</td>
<td>10.40</td>
<td>141.78</td>
<td>52.07</td>
<td>93.30</td>
<td>35.05</td>
</tr>
<tr>
<td>Harvesting and transporting</td>
<td>19.96</td>
<td>7.72</td>
<td>126.70</td>
<td>46.53</td>
<td>82.01</td>
<td>30.81</td>
</tr>
<tr>
<td>Processing and marketing</td>
<td>6.93</td>
<td>2.68</td>
<td>15.08</td>
<td>5.54</td>
<td>11.29</td>
<td>4.24</td>
</tr>
<tr>
<td>All operations</td>
<td>258.53</td>
<td>100.00</td>
<td>272.26</td>
<td>100.00</td>
<td>266.18</td>
<td>100.00</td>
</tr>
</tbody>
</table>


*A working unit is defined as an adult-equivalent.

...erected less active as food producers than females, as some studies on Sub-Saharan Africa seem to suggest (Savané 1988; Snyder 1990; Saito 1991).

Intensity of Agricultural Labor Use

The amount of labor use per hectare is one of the key variables expressing the extent of labor use in the farm sector. This variable has serious implications for both the cost and the productivity of labor input. The amount of labor use per hectare of cultivated area was estimated at about 1,717.1 adult-equivalent hours during the 1982/83 crop year. The coefficient of variation of this amount of labor across households was about 64.5 percent. That is, the intensity of labor use varied from 609 to 2,825 adult-equivalent hours per hectare across households.

This amount of labor use per hectare is high compared with other parts of the developing world and is particularly disturbing in an area characterized by low population density, such as the Zairian Basin. For example, Lassiter (1982) reported 822 hours per hectare in the production of sorghum in eastern Burkina Faso, and in the Mumbwa area of Zambia, farmers spent about 568 hours per hectare in the production of maize (Dodge 1977).

The high intensity of labor use per hectare observed in the study area is explained by a number of factors. The amount of labor required for land preparation is generally high where shifting cultivation is the prevailing mode of production. This labor requirement is further exacerbated when shifting cultivation is practiced in a rain forest zone like the Zairian Basin. Since this mode of production is associated with fallowing, the length of the fallow period is likely to affect the amount of labor...
required per hectare to slash, burn, and clear the land. The intensity of labor use is also affected by the type of tools used to perform different farm operations such as land preparation, planting, weeding, harvesting, processing, and transporting.

Intensity of labor use is also a function of the type of crop mix. The most prevalent cropping method in the study area is mixed cropping, and the survey was able to distinguish two types: one based on cassava and plantain, the other on rice and maize. It is clear that, other things being the same, the labor requirement per hectare will be different for each type of crop mix. This will be particularly true for the amount of labor time allocated to crop-specific operations such as planting, weeding, scaring birds, harvesting, processing, transporting, and marketing.

Another factor that has a bearing on the intensity of labor use is the timing of different farm operations. The survey found that 32.6 percent of the 132 study households did not follow the recommended agricultural calendar. For example, a late slashing of forest or fallow will not allow the debris and tree branches to dry properly. This will result in a poor burn. A poor burn means that time has to be spent cutting over, stacking, and reburning the remaining plant debris. More branches and logs on the ground will impede planting, weeding, and harvesting. Furthermore, a poor burn does not inhibit weed growth, hence leads to extra labor for weeding. Thus a late slashing of forest or fallow resulting in a poor burn is likely to affect the productivity of labor in two ways—by reducing crop yield and by increasing the intensity of labor use per hectare.

It is also expected that the better a location is connected to markets through a good road network and transportation system, the more labor time farmers will allocate to each hectare of cultivated area in order to produce a good harvest. Therefore, the state of the infrastructure is expected to positively affect the amount of labor time allocated to farming per hectare. Furthermore, farmers tend to allocate more labor time to farming as the farmgate terms of trade between farm and nonfarm products improve. Hence the farmgate terms of trade between farming and nonfarming is also expected to positively affect the intensity of labor use per hectare. Moreover, the amount of labor use per hectare is also expected to be positively affected by the size of the labor force available in the household.

The relationship between the intensity of labor use per hectare and the above variables can be formally expressed as follows:

\[ L/A = f(W/A, K/A, T_{an}, I, T, X, F_a, e) \]  \hspace{1cm} (15)

where

\[ L/A = \text{intensity of labor use in adult-equivalent hours per hectare}; \]
\[ W/A = \text{number of working units per hectare expressing the size of the labor force}; \]
\[ K/A = \text{capital input per hectare in zaires per hectare}; \]
\[ T_{an} = \text{farmgate terms of trade between farm products and nonfarm products}; \]
\[ I = \text{state of infrastructure}; \]
\[ T = \text{dummy for timing (1 for households that observed correct timing; 0 otherwise)}; \]
\[ X = \text{dummy for crop mix (1 for mix based on rice and maize; 0 for mix based on cassava and plantain);} \]

\[ F_a = \text{dummy for the length of the fallow period (1 for falls of seven years or more; 0 otherwise); and} \]

\[ e = \text{error term.} \]

A least squares method applied to the survey data provides the results summarized in Table 8. The regression equation shows that the fit is fair and the F-statistic is highly significant at the 1 percent level. All the regression coefficients have the expected signs. The regression coefficients for the type of crop mix \((X)\), the length of the fallow period \((F_a)\), and the capital input per hectare \((K/A)\) are not significantly different from zero. The regression coefficients for timing \((T)\), terms of trade between farming and nonfarming \((T_{nm})\), infrastructure \((I)\), and the size of the labor force \((W/A)\) are statistically significant at the 1, 5, 10, and 10 percent levels, respectively.

The estimate of the elasticity of the intensity of labor use per hectare is about \(-0.51\) with respect to timing, 0.26 with respect to farmgate terms of trade between farming and nonfarming, 0.08 with respect to the state of infrastructure, and 0.04 with respect to the size of the labor force per hectare of cultivated area. This analysis shows that the timing of farm operations and the farmgate terms of trade between farming and nonfarming—and to a limited extent the state of infrastructure and the size of the household labor force available per hectare of cultivated area—are the main determinants of labor use per hectare of cultivated area in the Zairian Basin.

It is particularly important to stress the effect of timing on the intensity of labor use per hectare. As can be seen from this analysis, a 1.00 percent increase in the number of households observing the appropriate timing of farm operations will result in a 0.51 percent decline in the amount of labor use per hectare of cultivated area. It follows that efforts to encourage farmers to observe the recommended agricultural calendar will result in a significant payoff, as the amount of labor use per hectare has a bearing on both the cost and the productivity of labor input.
Table 8—Regression results for the determinants of intensity of labor use per hectare of cultivated area

<table>
<thead>
<tr>
<th>Explanatory Variables and Important Statistics</th>
<th>Dependent Variable, (L/A) (adult-equivalent hours/hectare)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1,679.52 (4.83)***</td>
</tr>
<tr>
<td>W/A</td>
<td>7.66 (1.43)*)</td>
</tr>
<tr>
<td>K/A</td>
<td>0.47 (0.85)</td>
</tr>
<tr>
<td>$T_{an}$</td>
<td>233.52 (2.16)**</td>
</tr>
<tr>
<td>I</td>
<td>331.51 (1.84)*</td>
</tr>
<tr>
<td>T</td>
<td>-1,245.20 (-6.89)***</td>
</tr>
<tr>
<td>X</td>
<td>101.33 (0.63)</td>
</tr>
<tr>
<td>$F_a$</td>
<td>182.05 (1.12)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.38</td>
</tr>
<tr>
<td>F</td>
<td>12.70</td>
</tr>
<tr>
<td>n</td>
<td>132</td>
</tr>
</tbody>
</table>


Notes: The numbers in parenthesis are t-values. W is the size of the labor force, K is capital input, A is the cultivated area, $T_{an}$ is the farmgate terms of trade between farming and nonfarming, I is the state of infrastructure, T is the timing of farm operations, X is the type of crop mix, and $F_a$ is the age of the fallow. The mean value of the intensity of labor use (L/A) is about 1,717.1 adult-equivalent hours per hectare, with a standard deviation of 1,108.2 adult-equivalent hours per hectare. The capital input per hectare of cultivated area is about 175.4 zaires per hectare, with a standard deviation of 144.8 zaires per hectare. The terms of trade between farm and nonfarm products (producer price of food crops/producer price of palm wine) is about 1.9 liters of palm wine per kilogram of cereal-equivalent with a standard deviation of 0.8 liters of palm wine per kilogram of cereal-equivalent. The average size of the labor force per hectare is about 8.7 working units per hectare with a standard deviation of 15.3 working units per hectare. The mean value for the dummy representing the infrastructure is about 0.4 with a standard deviation of 0.5. For the dummies representing the type of crop mix and the length of the fallow period, the mean values are 0.5 and 0.6 with standard deviations of 0.5 and 0.5, respectively. For the dummy representing the timing, the mean value is 0.7 with a standard deviation of about 0.5.

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.
LABOR AND CULTIVATED AREA

In a situation where land is abundant relative to labor and capital, and use of yield-increasing technologies is limited, expansion of cultivated area is the main source of food and agricultural growth. This situation depicts most parts of Sub-Saharan Africa, and the Zairian Basin in particular. In fact, the economic history of Zaire since 1960 suggests that technological change in smallholder agriculture is not going to improve in the foreseeable future unless some drastic changes in policy are initiated (Tshibaka 1986).

Even if the current political changes succeed and lead to fundamental changes in policies and in the management of the economy, expansion of cultivated area is likely to remain, in the medium term, the key determinant of production growth in smallholder agriculture. The relationships between labor use, timing, and cultivated area are examined in this chapter.

Model

Since land is abundant and freely accessible in the Zairian Basin, the size of cultivated area can be considered as a function of capital input, the amount of labor time allocated to land preparation, and the timing of this farm operation. Formally, this postulate can be written as follows:

\[ A = f(L_{mp}, L_{fp}, K_t, T, D, e), \quad (16) \]

where

- \( A \) = size of cultivated area,
- \( L_{mp} \) = male labor time allocated to land preparation,
- \( L_{fp} \) = female labor time allocated to land preparation,
- \( K_t \) = capital-tools input spent on land preparation,
- \( T \) = dummy for timing of land preparation,
- \( D \) = dummy for locational differences, and
- \( e \) = error term.

From this construction, it is expected that the size of cultivated area will be positively related to labor and capital inputs. But these explanatory variables cannot be expected to be independent of each other. The amount of female labor allocated to land preparation is expected to increase with declining male participation in land preparation and vice versa. As all the tools (hatchets and cutlasses) used for land preparation are hand-held, a high degree of correlation is expected between this input and the labor time allocated to land preparation.
Finally, the cultivated area is expected to be positively affected by the timing of land preparation. A late slashing of forest or fallow is expected to constrain the household members to reduce the size of cultivated area in order to cope with subsequent farm operations such as burning and clearing.

Definition of Variables

As stated above, the model relates the size of cultivated area (A), expressed in ares,\(^{10}\) to the following inputs: male (\(L_{\text{mp}}\)) and female (\(L_{\text{fp}}\)) labor time in adult-equivalent hours devoted to land preparation, and capital-tools (\(K_t\)) input, expressed in zaires, allocated to land preparation. In addition, a dummy variable (T) is used to express the effect of timing on the size of the cultivated area. This variable displays a value of one for all the households that observed correct timing, and zero otherwise. To account for locational differences among the six study sites that form the study area, another dummy variable is used. This dummy displays a value of one for the location of concern, and zero for any other location.

The main statistics describing the dependent and some explanatory variables are presented in Table 9. These data show that an average rural household cultivated less than 1 hectare of land during the 1982/83 crop year. This cultivated area varies between 0.25 and 1.09 hectares, with an average of 0.67. More specifically, the cultivated land area varies by a factor of 4.4 across households.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>67.15</td>
<td>41.86</td>
<td>62.34</td>
<td>Cultivated area per household (in ares)(^{a})</td>
</tr>
<tr>
<td>(L_{\text{mp}})</td>
<td>283.27</td>
<td>152.14</td>
<td>53.71</td>
<td>Male labor time allocated to land preparation (in adult-equivalent hours)</td>
</tr>
<tr>
<td>(L_{\text{fp}})</td>
<td>31.80</td>
<td>45.80</td>
<td>144.03</td>
<td>Female labor time allocated to land preparation (in adult-equivalent hours)</td>
</tr>
<tr>
<td>(K_t)</td>
<td>75.40</td>
<td>55.49</td>
<td>73.59</td>
<td>Capital-tools input used (in zaires)</td>
</tr>
</tbody>
</table>


\(^{a}\)One are = 100 square meters.

\(^{10}\)One are equals 100 square meters.
Specification of the Regression Equation

The capital input allocated to land preparation in the Zairian Basin is mostly made up of hand-held tools (hatchets and cutlasses). As a result, this variable is highly correlated with labor input. To account for this correlation, the theoretical model postulated above is transformed as follows:

\[
\frac{A}{K_i} = f\left(\frac{L_{mp}}{K_i}, \frac{L_{fp}}{K_i}, T, D_i, e\right).
\]  

(17)

A Leontief-Diewert specification, which requires that quadratic and interaction terms be included, was applied to the survey data. As documented earlier, the timing of different farm operations such as land preparation affects the amount of labor used. Therefore, the full specification to be estimated is given by

\[
\frac{A}{K_i} = a_0 + a_1\left(\frac{L_{mp}}{K_i}\right) + a_2\left(\frac{L_{mp}}{K_i}\right) + a_3\left(\frac{L_{mp}}{K_i}\right)^2 + a_4\left(\frac{L_{fp}}{K_i}\right) + a_5T + a_6\left(\frac{L_{mp}}{K_i}\right)\left(\frac{L_{fp}}{K_i}\right) + a_7\left(\frac{L_{mp}}{K_i}\right)(T) + a_8\left(\frac{L_{fp}}{K_i}\right)(T) + \sum_{i=1}^{n} b_iD_i + e,
\]  

(18)

where \(D_i\) is the dummy representing location \(i\), with \(i = 1, 2, 3, \ldots, n\), so that \(n = k-1\) where \(k\) = number of study locations. All other variables have their previous meanings.

Regression Results

The ordinary least squares method applied to the survey data provides the regression results summarized in Table 10. The regression equation has a very good fit and the F-statistic is highly significant at the 1 percent level. The regression coefficient for the male labor per capital variable \((L_{mp}/K_i)\) and for its quadratic term are positive and statistically different from zero. The coefficient for the female labor per capital variable \((L_{fp}/K_i)\) is positive and not statistically different from zero. The regression coefficient for the female labor quadratic term is positive and statistically different from zero. The regression coefficient for the male-female labor interaction term is negative and statistically significant at the 1 percent level. This indicates that male and female labor are substitutes in production.

With respect to timing \((T)\), the regression analysis shows that the coefficient for the dummy variable representing this variable is positive and highly significant at the 1 percent level. This implies that correct timing of land preparation affects positively the size of cultivated area. The coefficient for the male labor per capital-timing interaction term \((L_{mp}/K_i)(T)\) is positive and statistically insignificant.

With respect to the interaction between timing and female labor per capital input \((L_{fp}/K_i)(T)\), the regression coefficient is positive and highly significant at the 1 percent level. This finding can be interpreted to mean that correct timing of land preparation leads females to allocate more labor time to land preparation, and this
### Table 10—Determinants of cultivated area

<table>
<thead>
<tr>
<th>Explanatory Variables and Important Statistics</th>
<th>Dependent Variable: Cultivated Area/Capital Input ($AK_t$) (ares/zaire)$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>$(9.96)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(1.02)$</td>
</tr>
<tr>
<td>$L_{mp}/K_t$</td>
<td>$(12.46)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(6.34)$***</td>
</tr>
<tr>
<td>$L_{fp}/K_t$</td>
<td>$(-8.49)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(-0.98)$</td>
</tr>
<tr>
<td>$(L_{mp}/K_t)^2$</td>
<td>$(0.06)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(2.48)$**</td>
</tr>
<tr>
<td>$(L_{fp}/K_t)^2$</td>
<td>$(8.97)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(4.76)$***</td>
</tr>
<tr>
<td>$T$</td>
<td>$(30.76)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(3.19)$***</td>
</tr>
<tr>
<td>$\begin{bmatrix} L_{mp} \ K_t \ L_{fp} \ K_t \end{bmatrix}$</td>
<td>$(-2.85)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(-5.91)$***</td>
</tr>
<tr>
<td>$\begin{bmatrix} L_{mp} \ K_t \end{bmatrix}(T)$</td>
<td>$(1.80)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(0.96)$</td>
</tr>
<tr>
<td>$\begin{bmatrix} L_{fp} \ K_t \end{bmatrix}(T)$</td>
<td>$(31.99)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(3.18)$***</td>
</tr>
<tr>
<td>Dummies for location</td>
<td></td>
</tr>
<tr>
<td>$D_1$</td>
<td>$(-1.14)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(-0.10)$</td>
</tr>
<tr>
<td>$D_2$</td>
<td>$(4.05)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(0.38)$</td>
</tr>
<tr>
<td>$D_3$</td>
<td>$(26.67)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(2.65)$</td>
</tr>
<tr>
<td>$D_4$</td>
<td>$(-11.27)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(-1.24)$</td>
</tr>
<tr>
<td>$D_5$</td>
<td>$(-13.05)10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>$(-1.51)$</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.91</td>
</tr>
<tr>
<td>$F$</td>
<td>96.58</td>
</tr>
<tr>
<td>$n$</td>
<td>130</td>
</tr>
</tbody>
</table>


Note: $L_{mp}$ stands for male labor time in adult-equivalent hours allocated to land preparation, $L_{fp}$ for female labor time in adult-equivalent hours devoted to the same operation, $K_t$ for capital tools, $T$ for a dummy accounting for timing of land preparation, and $D$ for a dummy accounting for locational differences.

$^a$One are = 100 square meters.

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.
affects positively the size of cultivated area. With regard to locational differences, the analysis suggests that these differences are negligible.

The elasticity estimate of the area-capital ratio is 0.73 with respect to the male labor-capital ratio and 0.11 with respect to the female labor-capital ratio. This implies that a 1.00 percent increase in male labor will be associated with a 0.73 percent increase in cultivated area, while a 1.00 percent increase in female labor will lead to about a 0.11 percent increase in cultivated area.

With respect to timing, the elasticity estimate of the area-capital ratio with respect to this variable is about 0.49. This suggests that a 1.00 percent increase in the number of households observing correct timing of land preparation will lead to a 0.49 percent upward shift in the curve describing the cultivated area function. It is useful to note that only 67.4 percent of the 132 study households observed correct timing during the 1982/83 crop year.

From this analysis, it can be concluded that the amount and timing of male labor time allocated to land preparation are the key factors affecting the size of cultivated area in the Zairian Basin.
LABOR AND AGRICULTURAL OUTPUT

This chapter establishes the relationship between the volume of farm output, the amount of labor time, and the timing of farm operations in order to estimate the contribution of male and female labor time to agricultural production and to examine the effects of timing on farm output and labor productivity.

Production Function Analysis

Model

Since land is not a binding constraint in the Zairian Basin, the farm output in this area can be regarded primarily as a function of labor and capital input. The timing of farm operations as well as the type of crop mix used also affects the volume of farm output. The observed variations in the volume of farm output are also explained by the level of soil fertility and by locational differences among study locations.

A Cobb-Douglas transformation with constant returns to scale was chosen to estimate the structural parameters describing the agricultural production function in the study area. More clearly, the following Cobb-Douglas production function is estimated:

\[
\ln Q = \ln c + \alpha_1 \ln L_m + \alpha_2 \ln L_f + \alpha_3 \ln K + \beta_1 T + \beta_2 X + \beta_3 F_s + \sum_{i=1}^{n} \varepsilon_i D_i + \varepsilon
\]

where

- \( Q \) = farm output,
- \( c \) = intercept or constant term,
- \( L_m \) = male labor time,
- \( L_f \) = female labor time,
- \( K \) = capital input,
- \( T \) = dummy for timing,
- \( X \) = dummy for crop mix,
- \( F_s \) = dummy for length of fallow period,
- \( D_i \) = dummy for study location \((i = 1, 2, \ldots, n); \text{ so that} \ n = k - 1 \text{ where } k = \text{number of study locations}\), and
- \( \varepsilon \) = error term.

A positive relationship is expected between the volume of farm output, labor, and capital. The volume of farm output is also expected to be positively related to the length of the fallow period. An improvement in the timing of different farm operations is expected to be associated with an upward shift in the production curve. Since cassava and plantain are more productive than maize and rice in calories per unit of land, it is expected that a cropping mix based on cassava and plantain will lead to an
upward shift in the production curve, while a mix based on rice and maize will be associated with a downward shift.

Definition of Variables

The volume of agricultural output is expressed in kilograms of cereal-equivalents, labor time in adult-equivalent hours, and capital input in zaires. For the level of soil fertility, the length of the fallow period is used as a proxy. This variable is expressed as a dummy, which assumes a value of one for a fallow of seven years or more, and zero otherwise. Therefore, the regression coefficient for the dummy fallow is expected to be positive.

For the timing of farm operations, a dummy expressing this variable is given a value of one for households that observed the recommended agricultural calendar and zero for other households. The regression coefficient for timing is expected to display a positive sign. With respect to cropping mix, a dummy displaying a value of one is used for a mix based on rice and maize, and zero for a mix based on cassava and plantain. For the reason advanced above, the coefficient for the cropping mix is expected to be negative.

The main statistics for the dependent and explanatory variables used in estimating the farm production function are described in Table 11. The data show that an average household in the Zairian Basin produced about 2,539 kilograms of cereal-equivalents in 1982/83, representing 423 kilograms of cereal-equivalents per capita or 686 kilograms of cereal-equivalents per working unit. Male members of an average household contributed about 426 hours of work to farming and females provided about 564 hours. An average household had, during the study year, about 3.7 working units, of which 1.6 were male and 2.1 were female. The capital input allocated to farming was about 100.7 zaires, representing at that time about US$17.52.

Table 11—Statistical description of variables for total output, labor, and capital

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation (percent)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>2,539.31</td>
<td>2,183.95</td>
<td>86.01</td>
<td>Farm output (in kilograms of cereal-equivalents)</td>
</tr>
<tr>
<td>Lm</td>
<td>426.24</td>
<td>254.41</td>
<td>59.69</td>
<td>Male labor to farming (in adult-equivalent hours)</td>
</tr>
<tr>
<td>Lf</td>
<td>563.89</td>
<td>385.69</td>
<td>68.40</td>
<td>Female labor to farming (in adult-equivalent hours)</td>
</tr>
<tr>
<td>K</td>
<td>100.74</td>
<td>68.80</td>
<td>68.29</td>
<td>Capital (tools and seeds) input to farming (in zaires)</td>
</tr>
</tbody>
</table>

Regression Results

An ordinary least squares method applied to the survey data provides the regression results described in Table 12. The regression equation shows that the fit is good and the F-statistic is highly significant at the 1 percent level. All the regression coefficients display the expected signs and are statistically different from zero at the

<table>
<thead>
<tr>
<th>Explanatory Variables and Important Statistics</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(c)</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>(3.89)**</td>
</tr>
<tr>
<td>ln(L_m)</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>(4.41)**</td>
</tr>
<tr>
<td>ln(L_f)</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>(3.92)**</td>
</tr>
<tr>
<td>ln(K)</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(2.24)**</td>
</tr>
<tr>
<td>(X)</td>
<td>-0.42</td>
</tr>
<tr>
<td></td>
<td>(-4.27)**</td>
</tr>
<tr>
<td>(T)</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>(4.52)**</td>
</tr>
<tr>
<td>(F_a)</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
</tr>
</tbody>
</table>

Dummies for location

- \(D_1\): -0.07  
  (-0.37)
- \(D_2\): -0.63  
  (-3.26)**
- \(D_3\): -0.15  
  (-0.85)
- \(D_4\): 0.66  
  (3.86)**
- \(D_5\): 0.34  
  (2.42)**
- \(\bar{R}^2\): 0.73
- \(F\): 32.43
- \(n\): 132


Notes: Output for all crops (\(Q\)) combined—rice, maize, cassava, and plantain—is expressed in kilograms of cereal-equivalents using the following conversion factors: 1.60 for maize kernels, 0.60 for paddy rice, 0.303 for fresh cassava tubers, and 0.220 for plantain. \(L_m\) and \(L_f\) are male and female labor time allocated to agriculture, \(K\) is capital input; \(X\), \(T\), and \(F_a\) are dummies representing the type of crop mix, the timing of farm operations, and the age of the fallow period, respectively.

**Significant at the 0.05 level.
***Significant at the 0.01 level.
1 and 5 percent levels. Locational differences are not negligible. These results suggest that the above explanatory variables are the main determinants of farm output in the Zairian Basin.

The elasticity estimate of farm output (Q) is 0.44 with respect to male labor time (Lₘ), 0.34 with respect to female labor time (Lₕ), and 0.16 with respect to capital input (K). Since the sum of these elasticity estimates is statistically equal to 1.00, which implies constant returns to scale, these output elasticities are also the factor shares, representing the contribution of individual inputs to farm output.

The elasticity estimate of the farm output with respect to the type of crop mix is about -0.42, indicating that, other things being the same, a 1.00 percent increase in the number of households using a rice-potato cropping mix will be associated with a 0.42 percent downward shift in the farm production curve. The elasticity estimate of the farm output with respect to the timing of farm operations is about 0.47 percent, implying that a 1.00 percent increase in the number of households observing correct timing of farm operations will be associated with a 0.47 percent upward shift in the farm production curve.

The analysis indicates that the type of cropping mix and the timing of farm operations are important shifters affecting the farm production curve. With regard to farm inputs, male labor, followed by female labor, and then capital are the main production inputs in the Zairian Basin.

**Labor Productivity**

On the basis of the above regression equation depicting the farm production function, the average and marginal products of labor input are estimated for the entire sample and summarized in Table 13. The average and marginal products of male labor time are 34.3 and 74.1 percent higher, respectively, than those of female labor.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average product of labor (kilograms of cereal-equivalents/hour)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>6.89</td>
<td>7.35</td>
<td>106.68</td>
</tr>
<tr>
<td>Females</td>
<td>5.13</td>
<td>3.70</td>
<td>72.12</td>
</tr>
<tr>
<td>Males and females</td>
<td>2.61</td>
<td>1.79</td>
<td>68.58</td>
</tr>
<tr>
<td>Marginal product of labor (kilograms of cereal-equivalents/hour)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>3.03</td>
<td>3.23</td>
<td>106.60</td>
</tr>
<tr>
<td>Females</td>
<td>1.74</td>
<td>1.26</td>
<td>72.41</td>
</tr>
<tr>
<td>Males and females</td>
<td>2.04</td>
<td>1.40</td>
<td>68.63</td>
</tr>
</tbody>
</table>

time. In addition, the average products of labor time allocated to farming are larger than their respective marginal products. This tends to suggest that both males and females operate in the rational or second phase of production. This phase corresponds to an optimum use of labor input.

Furthermore, the productivity of labor exhibits a high degree of variability across households. The coefficient of variation for the productivity (average or marginal product or both) of male and female labor combined is about 68.6 percent. Put differently, the average product of labor time allocated to farming by males and females combined varies from 0.8 to 4.4 kilograms of cereal-equivalents per hour of work. The marginal product of the same input varies from 0.6 to 3.4 kilograms of cereal-equivalents per hour of work. This means that the productivity (average or marginal product or both) of labor allocated to farming in the Zairian Basin varies by a factor of about 6 across households.

Another interesting question to examine is how the productivity of agricultural labor in the Zairian Basin compares with that of labor in other rural areas of the Sub-Saharan region. Table 14, which is drawn from this and other studies, provides some insights.

First, the productivity of labor allocated to the production of a given crop varies greatly across and within agro-ecological zones. For example, the average product of labor in rice production in The Gambia was found to be about 1.62 kilograms of cereal-equivalents per man-hour. In Sierra Leone, the same parameter exhibits a value of about 0.96 kilograms of cereal-equivalent per man-hour. It should be stressed that the production of rice in these countries uses the same production techniques. The observed differences can be ascribed to a large extent to differences in the intensity of labor use in rice production in the two countries. Since the productivity of labor is determined by the level of crop yield and the intensity of labor use, a high intensity of labor use depresses the level of labor productivity. The intensity of labor use in the production of rice in Sierra Leone, a humid area, is about 79.8 percent greater than in the production of rice in The Gambia, a Sahelian zone. As can be seen from Table 14, the intensity of agricultural labor use in the humid zones of Sub-Saharan Africa is generally much greater than in the Sahelian and subhumid zones. The reasons for this relatively high labor intensity in the humid zones are documented in Chapter 6. Table 14 also shows that the productivity of labor varies substantially within the same agro-ecological zone. This variability can be ascribed to some extent to differences in production technology and crop mix.

Second, the estimate of the average product of labor in the Zairian Basin remains within the range observed in the Sub-Saharan region, while the estimate of the marginal product of the same input appears to be relatively high. This estimate remains, however, in the acceptable range, particularly when compared with the estimate of the average product of labor derived from the same sample. Most estimates of the marginal product of labor derived from other studies and reported in Table 14 are substantially lower than those for the average product, and in some cases they are close to zero. Since land in the Zairian Basin is abundant relative to labor, the marginal product of the agricultural labor must exhibit a value that is substantially greater than zero. The estimate of the marginal product of labor derived in this study confirms this economic principle. The areas where the other studies were conducted are relatively more populated than the Zairian Basin.
<table>
<thead>
<tr>
<th>Area/Country/Year</th>
<th>Agroecological Zone</th>
<th>Crops Studied</th>
<th>Intensity of Labor Use (hours/acre)</th>
<th>Average Product of Labor (kilograms of cereal-equivalents/hour)</th>
<th>Marginal Product of Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Burkina Faso, 1978</td>
<td>Sahel</td>
<td>Sorghum and millet</td>
<td>618.00</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>The Gambia, 1985-87</td>
<td>Sahel</td>
<td>Rice</td>
<td>1,310.70</td>
<td>1.62</td>
<td>0.39</td>
</tr>
<tr>
<td>The Gambia, 1985-87</td>
<td>Sahel</td>
<td>Maize, sorghum, and millet</td>
<td>452.64</td>
<td>1.69</td>
<td>1.25</td>
</tr>
<tr>
<td>Darwin, Zimbabwe, 1963</td>
<td>Subhumid</td>
<td>Maize</td>
<td>324.00</td>
<td>7.50</td>
<td>1.25</td>
</tr>
<tr>
<td>Cheweshe, Zimbabwe, 1963</td>
<td>Subhumid</td>
<td>Maize</td>
<td>144.00</td>
<td>3.67</td>
<td>0.53</td>
</tr>
<tr>
<td>Sierra Leone, 1979</td>
<td>Humid</td>
<td>Rice</td>
<td>2,356.00</td>
<td>0.96</td>
<td>...</td>
</tr>
<tr>
<td>Zairian Basin, Zaire, 1991</td>
<td>Humid</td>
<td>Cassava, rice, maize, and plantain</td>
<td>1,717.10</td>
<td>2.61</td>
<td>2.04</td>
</tr>
</tbody>
</table>

Sources: Data for eastern Burkina Faso and for Darwin and Cheweshe in Zimbabwe are based on J. Mellor, C. Delgado, and M. Blackie, eds., Accelerating Food Production in Sub-Saharan Africa (Baltimore, Md., U.S.A.: Johns Hopkins University Press for the International Food Policy Research Institute, 1987); for The Gambia, data are computed from I. von Braun et al., Structural Adjustment, Agriculture, and Nutrition: Policy Options in The Gambia, Working Papers on Commercialization of Agriculture and Nutrition 4 (Washington, D.C.: International Food Policy Research Institute, 1990); for Sierra Leone, data are computed from P. Maton et al., Poor Rural Households, Technical Change and Income Distribution in Developing Countries: Two Case Studies from West Africa, African Rural Economy Paper 29 (East Lansing, Mich., U.S.A.: Michigan State University, Department of Agricultural Economics, 1979); and for the Zairian Basin, data are from Table 13 of this report.

Note: Massell and Johnson (1968) found that in Zimbabwe, smallholder farmers allocate 4.5-7.0 hours to agriculture per day of work. Some other researchers report fewer hours allocated to agriculture per day of work. In the Uboma area of Nigeria, Oluwasanmi et al. (1966) report that an average male devotes 3.4 hours to farming per day of work, while his female counterpart spends about 2.4 hours. However, it is generally assumed that a smallholder farmer in Sub-Saharan Africa spends on average 6.0 hours on agriculture per day of work. Using this rough estimate, the data reported by these researchers are transformed and summarized here. It is, however, important to note that the above estimates of labor productivity come from very diverse studies. These studies did not necessarily use the most appropriate methods of data collection, the same specification of the production function, or the same definitions of the dependent and explanatory variables (for example, expressing labor in man-days instead of hours of work; a man-day of farm work has been found to vary between 2.4 and 7.0 hours of work per day). For these reasons, it appears difficult to make a firm judgment about the comparability of the estimates of average and marginal productivities of labor derived from these studies and those computed in the present study.
Effect of Timing on Farm Output and Labor Productivity

The interhousehold variation in the average and marginal products of labor observed in the study area suggests that some improvement in labor productivity can be achieved with the current resource base and technology available to rural households in the area. In fact, the above regression analysis shows that, without additional resources, the adoption of the recommended agricultural calendar by most households will have a positive and significant effect on the volume of farm output, and hence on productivity of labor and other farm inputs.

A critical observation of the different farm fields during the survey indicates that a substantial number of farmers did not follow the recommended agricultural calendar. As a result of inappropriate timing, land preparation, planting, weeding, and harvesting were not only poorly performed but also claimed more labor time than they would have with proper timing. The execution of some of these operations was extended beyond the recommended period. This inappropriate timing resulted in both increased labor use per hectare and reduced crop yield, and hence in reduced farm output and labor productivity.

The study analysis of course confirms this observation. Assuming that, other things being the same, all the sample households are led to observe the recommended agricultural calendar, what will be the effect on farm output and labor productivity? To answer the question, the sample was divided into two groups, and the amount of farm output was estimated for all the households that did observe correct timing of farm operations. The same exercise was repeated for the other group of study households. These results are shown in Table 15.

It appears from this analysis that if the households that did not observe the recommended agricultural calendar are persuaded to adopt correct timing, their farm output will increase on average by 41.5 percent, and the farm output for the entire sample will increase by about 10.6 percent. The average and marginal products of labor were computed for households that observed the recommended agricultural calendar as well as for those that did not. The data reveal that the average and marginal products of labor for households that did not observe correct timing can be increased by about 60.0 percent. For the entire sample, this increase in labor productivity is about 14.0 percent.

This potential gain in farm output and labor productivity cannot be ignored. Therefore, farmers should be encouraged to observe the recommended agricultural calendar. It follows that efforts to improve extension services are also needed.
Table 15—Effect of timing on household farm output and labor productivity, 1982/83

<table>
<thead>
<tr>
<th>Household Observation of Timing</th>
<th>Number of Households</th>
<th>Average Volume of Farm Output (kilograms of cereal-equivalents/household)</th>
<th>Potential Gain in Farm Output (percent)</th>
<th>Average Product of Labor (kilograms of cereal-equivalents/hour)</th>
<th>Potential Gain in Average Product of Labor (percent)</th>
<th>Marginal Product of Labor (kilograms of cereal-equivalents/hour)</th>
<th>Potential Gain in Marginal Product of Labor (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households that observed the recommended timing</td>
<td>67.42</td>
<td>2,807.49</td>
<td>0.00</td>
<td>2.97</td>
<td>0.00</td>
<td>2.32</td>
<td>0.00</td>
</tr>
<tr>
<td>Households that did not observe the recommended timing</td>
<td>32.58</td>
<td>1,984.24</td>
<td>41.49</td>
<td>1.86</td>
<td>59.68</td>
<td>1.45</td>
<td>60.00</td>
</tr>
<tr>
<td>All sample households</td>
<td>100.00</td>
<td>2,539.31</td>
<td>10.56</td>
<td>2.61</td>
<td>13.79</td>
<td>2.04</td>
<td>13.73</td>
</tr>
</tbody>
</table>

POLICY IMPLICATIONS AND CONCLUSIONS

Labor is the primary production input available to the small-farm sector in most of Sub-Saharan Africa. Increasing the productivity of this resource remains central to both agricultural growth and overall economic growth in the region. Consequently, an in-depth analysis of the labor resource and its related aspects should significantly contribute to agricultural policy formulation. Toward this end, the study examined the division and allocation of household labor time, identified key factors affecting the allocation of this resource among different household activities, conducted a detailed analysis of labor use in the small-farm sector, and examined the productivity of labor input and the contribution of labor to farm output in the Zairian Basin.

The natural population growth rate in the study area is low—about 1.2 percent a year from 1980 to 1983, compared with 2.8 percent for the country as a whole. However, about 42.0 percent of the study sample were under 15 years of age, which means that momentum for future growth in the labor force in the study area is already built into the population.

Division and Allocation of Household Labor Time

Income-generating activities of rural households in the Zairian Basin include farming and nonfarming activities, while non-income-generating activities are made up of domestic, sociocultural, and leisure activities. With respect to farming, slashing and burning of forest land or fallow are primarily done by men, while clearing, planting, weeding, harvesting, transporting, processing, and marketing of produce are mainly undertaken by women. The formulation of policy actions to improve the existing agricultural techniques or to introduce new production techniques and inputs has to take into account this gender division of agricultural labor and its implications for research and extension services.

In the nonfarm sector, hunting, fishing, and gathering nuts from wild palm trees are mostly undertaken by men, whereas gathering food products in the forest and extraction of palm oil are mainly carried out by women. Handicrafts and extraction of palm wine are male activities, while the processing of maize into the local alcoholic drink is done by females. Both men and women engage in petty trade. Regarding non-income-generating activities, domestic work is primarily performed by women. Gardening, building and maintaining houses, health care, schooling, meetings, church services, and other sociocultural activities are jointly performed by men and women. The study data seem to contradict some widely held beliefs that men in rural Africa tend to contribute little to household working time allocated to income-generating and domestic activities.
The allocation of household labor time to agriculture and nonagriculture was found to be mainly determined by the farmgate terms of trade between agriculture and nonagriculture, the level of household capital input available per working unit, and the state of the infrastructure. Specifically with respect to the share of household labor time allocated to agriculture, a 1.00 percent increase in the farmgate terms of trade between agriculture and nonagriculture would be associated with a 0.27 percent increase, a 1.00 percent increase in household capital input per working unit would lead to a 0.26 percent increase, while a 1.00 percent improvement in the state of infrastructure would result in a 0.23 percent increase.

This finding underlines the centrality of both private (household capital input) and public (infrastructure) capital goods in the process of labor allocation and use in the rural household economy. This implies that policy actions to improve the infrastructure and develop the rural capital and product markets need to be considered if rural households in the Zairian Basin are to divert more labor time to farming and other income-generating activities. In the medium term, there is a need to improve the practicability of the existing road network and the navigability of the rivers and to stimulate the trucking, distribution, and marketing of farm implements and products. In the long run, actions to develop rural capital and credit markets should be initiated. These actions should be associated with policy measures designed to generate and promote the diffusion of appropriate agricultural technologies and practices. This will help improve the volume and the composition of agricultural capital input available to households.

**Agricultural Labor Use**

Cassava, rice, maize, and plantain are the main crops produced in the small-farm sector of the Zairian Basin under a shifting cultivation mode of production. Land is plentiful and freely accessible to every rural household. Capital input is limited to simple hand tools and on-farm crop seeds, and labor input is provided by the household members. By any standards, labor is the main farm input available to the rural households in this area.

In 1982/83, the intensity of labor use varied from 609 to 2,825 adult-equivalent hours per hectare across households, with an average of 1,717 hours. This amount of labor time per hectare is high compared with other parts of the developing world. Efforts to reduce this use of labor will have a positive and significant effect on the cost and productivity of the labor input allocated to agriculture. The analysis indicates that the intensity of labor use per hectare would be greatly reduced if farmers followed the recommended agricultural calendar.

The assessment of the relationship between labor input, timing of land preparation, and cultivated area shows that correct timing of land preparation enables the household to slash and burn and clear a much larger area of land, using the same amount of labor time, than when the timing is inappropriate. The analysis also indicates that the amount of male labor time allocated to land preparation is the main determinant of the size of cultivated area. Furthermore, the analysis suggests that male and female labor are substitutes in production.

The analysis of farm production suggests that the volume of output could be increased by 10.6 percent if all the households observed correct timing of farm
operations. About 32.6 percent of the 132 study households were found not to follow appropriate timing. These households could increase their farm output by 41.5 percent if they followed the recommended agricultural calendar. The type of crop mix also affects the volume of output, since cassava and plantain are biologically more productive than rice and maize in terms of energy per unit of land and labor.

**Agricultural Labor Productivity**

The average and marginal products of agricultural labor in the study are estimated at 2.6 and 2.0 kilograms, respectively, of cereal-equivalents per hour of work. This level of labor productivity is not only low but also exhibits a high degree of variability across households.

It should be stressed that a low level of labor productivity does not mean that the volume of labor and capital inputs cannot be simultaneously increased in order to raise the volume of agricultural output. The study analysis suggests that increased agricultural capital input will stimulate farmers to allocate more labor to farming and consequently to increase the volume of crop output.

This change in the volume of resources and output will not necessarily lead to a change in the productivity of labor or capital input. But the adoption by most farmers of the recommended agricultural technology and practices will significantly and positively affect the productivity of labor and other inputs. For instance, the adoption of the recommended agricultural calendar by most households was found to have a positive and significant effect on labor productivity. In fact, the study indicates that agricultural labor productivity could be increased by about 14 percent if all the households observed the appropriate timing of farm operations.

**Conclusions**

To increase the volume of farm output and the productivity of labor and other inputs, this study suggests a number of policy measures. In the near future, educating farmers to observe the recommended agricultural calendar will have a significant payoff in terms of increased farm output and productivity. Therefore, efforts to improve research, extension, and weather forecasting need to be seriously considered. This will help develop a sound agricultural calendar. The data show that in 1982/83 the cultivated area per capita was about 0.11 hectare. If all the households observe the presently recommended agricultural calendar, this will result in a 13.7 percent increase in cultivated area. The cultivated area per capita will then increase from 0.11 to 0.15 hectare.

In the medium term, the improvement and expansion of basic infrastructure such as road networks and distribution and marketing channels for farm inputs and products should be pursued in order to stimulate rural households to allocate more resources, including labor, to farming and other income-generating activities. Increased agricultural labor input will ultimately be associated with increased farm output.

In the long run, actions to develop rural capital and credit markets should be initiated. These actions should be associated with policy measures designed to
generate and promote the diffusion of appropriate agricultural technologies. This will help improve the volume and composition of agricultural capital input available to rural households.

At first glance, suggesting land expansion in a forest zone runs contrary to current concerns about degradation of the environment. It is even more questionable in the case of the slash-and-burn fallow mode of production that prevails in the study area. To put this issue into context, it has to be noted that two seemingly contradictory objectives are concurrently pursued. These are the growth of the economy and the protection of the environment. Finding a trade-off between these two goals is a matter of serious debate among policymakers and scientists worldwide. In fact, the kind of land expansion contemplated in this study does not represent a serious threat to the environment in the Zairian Basin, a sparsely populated area with fewer than five people per square kilometer.

The tropical rain forest zone represents almost 40 percent of the total land area of Zaire, so the question to be addressed is what type of agriculture should be promoted in this area. From an ecological viewpoint, the tropical rain forest zone is more suitable to perennial (tree) crops than annual (food) crops. Tree-crop agriculture approximates the natural environment by replacing the natural forest with an artificial one composed of trees that produce crops such as palm oil, coffee, cocoa, and rubber. Thus its negative effect on the environment, particularly on soil and forest conservation, is relatively small compared with the shifting cultivation that characterizes the production of annual crops in the study area.

From a long-term standpoint, it is clear that efforts in the Zairian Basin have to be directed toward the promotion of tree-crop production systems and the development of food markets. However, in the short and medium terms, farm households have to produce food crops not only for home use but also for markets in order to generate cash income that could be partly invested in the development of tree-crop production systems and food markets.

It is therefore imperative to increase the farm output and productivity of individual farm households in the near or intermediate future, while relying on the available domestic resources and technology. This is not to say that efforts should not be concurrently initiated to increase both the productivity of labor and the productive capacity of land through use of an appropriate package of technologies, and consequently to preclude any need for shifting cultivation. Research conducted in the humid tropics of Africa indicates that the use of mineral and organic fertilizers coupled with appropriate land management would help achieve this goal.
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The International Food Policy Research Institute was established in 1975 to identify and analyze alternative national and international strategies and policies for meeting food needs in the world, with particular emphasis on low-income countries and on the poorer groups in those countries. While the research effort is geared to the precise objective of contributing to the reduction of hunger and malnutrition, the factors involved are many and wide-ranging, requiring analysis of underlying processes and extending beyond a narrowly defined food sector. The Institute’s research program reflects worldwide interaction with policymakers, administrators, and others concerned with increasing food production and with improving the equity of its distribution. Research results are published and distributed to officials and others concerned with national and international food and agricultural policy.

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