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SMALL FARM PRODUCTION SYSTEMS IN UPPER VOLTA
DESCRIPTIVE AND PRODUCTION FUNCTION ANALYSIS

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The senior author (Professor of Economics, Illinois State University) worke for approximately two years as Agricultural Economist and Team Leader of Farming Systems Research under Semi-Arid Food Grain Research and Developmei (SAFGRAD) in Upper Volta, West Africa. The authors gratefully acknowledge the valuable assistance that was received from colleagues, in the FSU and other SAFGRAD units, and the USAID in Upper Volta. However, for all errors and/or opinions the authors alone are responsible.

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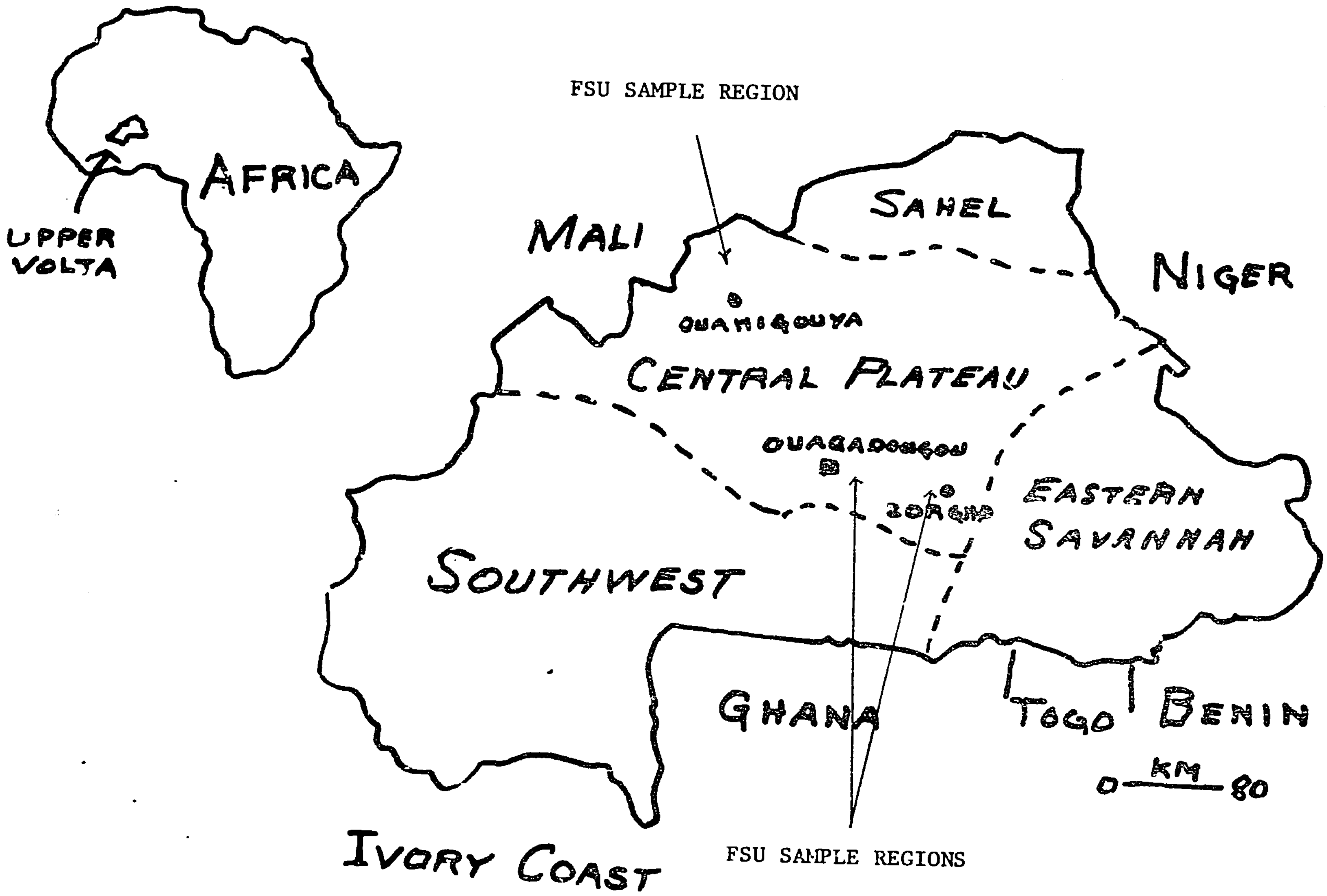

Map 1. Upper Volta Showing Sample Regions.

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SMALL FARM PRODUCTION SYSTEMS IN UPPER VOLTA: DESCRIPTIVE AND PRODUCTION FUNCTION ANALYSIS

I. Introduction

The majority of farmers in West Africa have small land holdings and under low yield conditions produce subsistence crops to satisfy family needs. Cropped land per capita ranges from as low as 0.1 hectare in Cape Verde to 3.2 hectares in Niger. Operational holdings per household in general are small with about one hectare (2.47 acres) of land per person in the household, and in some cases and in some years family farms do not produce enough to meet the household's needs. The main cereals produced and consumed by small-farm families are millet, sorghum and corn which together account for over 70 percent of the total area devoted to cereals. Agro-economic indicators for countries in West Africa and a select group of countries in semi-arid regions of Africa are presented in Tables 1 and 2. These countries have drawn considerable attention lately from the international community, donor countries and international organizations alike.

All countries in West Africa are net importers of cereals (Table 1) and most of these countries are chronically food deficit countries with frequent droughts. Extremely low farm productivity is reflected in low yields which in most cases range from 300 kilograms to 700 kilograms of grain per hectare of land (270 pounds to 625 pounds per acre). Perhaps these are the lowest yields in the world. Poor soils, unfavorable and often unpredictable climatic conditions, lack of improved technologies for rainfed cereal crops, disincentives created by government marketing and pricing policies are factors in the slow growth in farm productivity in almost all of these countries.

Rainfed crops have by and large lagged far behind irrigated crops (rice in particular) in development of technologies for more economical and higher yields. No technological breakthrough is in sight for cereal crops, particularly with regard to varietal improvements. Those new varieties of sorghum, millet and maize that have been or are being developed and/or tried by plant breeders and agronomists for the low rainfall and high risk regions of Africa have not yet been demonstrated to be superior to current local varieties.

Upper Volta is noteworthy in West Africa, not because of any noticeable or remarkable developmental achievement made currently or in the past, but because of a comparatively large international investment in agricultural research made through 8 to 10 research groups located in this country and financed by varioius foreign agencies. The major share of such financial aid comes from the USAID (United States Agency for International Development), the UNDP (United Nations Development Program), and the French development funds (FAC). Some of the research centers have been working in Upper Volta for only a few years, whereas IRAT (Tropical Agricultural Research Institute, a French institute) has been there for several decades. A considerable amount of foreign assistance has poured into this landlocked country without any significant impact on agriculture with the exception of cotton production and irrigated rice. A better understanding of the existing production systems practiced by Voltaic farmers and the constraints

TABLE 1

AGRICULTURAL ECONOMIC INDICATORS FOR SOME SELECTED SEMI ARID COUNTRIES OF AFRICA

SAFGRAD Countries (Africa)	GNP/CAPUT 1976 (US $)	Cereal Yield (ton/ha) 1975-1977	Cereal Output (million Tons) 1975-1977	Cereal Consumption/ Caput (Kg/year) 1975-1977	Fertilizer Consumption NPK kg/ha 1976	Tractor Density (no./1000 ha) 1976	Import Content in Cereal Consumption Percent 1975-1977
Ivory Coast	650	0.9	0.7	119	5	0.3	20
Zambia	450	0.9	1.2	252	13	0.8	10
Senegal	410	0.6	0.7	210	16	0.2	28
Nigeria	400	0.6	8.4	145	5	0.3	10
Botswana	390	0.6	0.1	186	2	1.4	32
Ghana	370	0.7	0.6	73	8	1.2	21
Cameroon	310	0.9	0.8	128	2	*	8
Sudan	270	0.6	2.6	145	14	1.2	2
Togo	270	0.8	0.3	131	1	0.1	6
Kenya	250	1.3	2.2	160	25	2.8	E
Mauritania	250	0.3	*	135	1	n.a.	69
Centr. Afr. Republic	240	0.5	0.1	57	**	*	10
Guinea	210	0.7	0.7	177	**	*	7
Sierra Leone	190	1.4	0.6	206	**	0.1	6
Benin	180	0.7	0.3	110	1	*	11
Gambia	180	0.8	0.1	198	10	0.3	28
Tanzania	180	0.8	1.5	113	5	1.2	13
Niger	150	0.4	1.2	271	**	*	3
Cape Verde	140	0.5	*	131	4	0.8	90
Guinea Bissau	140	1.0	0.1	223	1	*	25
Chad	120	0.5	0.6	145	1	*	3
Somalia	110	0.6	0.2	110	n.a.	1.2	34
Ethiopia	100	1.0	4.9	174	2	0.3	1
Upper Volta	100	0.5	1.1	186	1	*	2
Mali	100	0.7	1.1	203	1	0.1	6

Source: World Bank, FAO, International Agricultural Development Service and Government publications.

*Less than 0.1; **Less than 0.5; n.a.: not available; E: net exporter.

TABLE 2

AGRICULTURAL ECONOMIC INDICATORS FOR SOME SELECTED SEMI ARID COUNTRIES IN AFRICA

SAFGRAD Countries (Africa)	Arable Land as % Total Land	Cereal Area (million ha 1975-1977)	Cereal Area as % Arable Land	Maize as % Cereal Area	Sorghum as % Cereal Area	Millet as % Cereal Area	Rice as % Cereal Area	Wheat as % Cereal Area
Ivory Coast	-	0.7	-	-	-	-	-	-
Zambia	6.6 1/	1.3	11.9	-	-	-	-	-
Senegal	11.7 1/	1.1	-	5.0	-	81.2	13.8	-
Nigeria	-	13.0	50.1 1/	16.5	42.8	34.3	16.4	-
Botswana	-	0.2	-	-	-	-	-	-
Ghana	4.4	0.8	88.5 1/	56.5	19.6	14.3	9.6	-
Cameroon	14.2	0.8	12.6	49.1	-	19.1	1.8	-
Sudan	2.8	4.1	53.6	0.6	70.4	17.9	-	11.0
Togo	-	0.3	-	-	-	-	-	-
Kenya	2.7	1.7	11.3	73.5	-	16.5	1.6	6.8
Mauritania	1.0	0.2	16.7	9.1	-	90.9	-	-
Centra Afr. Republic	-	0.2	-	-	-	-	-	-
Guinea	16.9 1/	1.0	24.7 1/	27.7	-	12.2	60.1	-
Sierra Leone	-	0.4	-	-	-	-	-	-
Benin	-	0.4	-	79.1	17.8	3.1	-	-
Gambia	-	0.1	-	-	-	42.9	57.1	-
Tanzania	11.8	2.0	7.5	33.3	-	57.0	9.2	0.8
Niger	11.8 1/	2.9	18.6 1/	0.3	28.7	65.4	5.6	-
Cap Verde	-	*	-	-	-	-	-	-
Guinea Bissau	-	0.1	-	-	-	-	-	-
Chad	5.4 1/	1.1	13.0	1.2	-	91.4	6.4	1.0
Somalia	1.6	0.4	54.5	-	-	-	-	-
Ethiopia	10.6	5.1	45.5	25.1	17.6	3.9	-	16.5
Upper Volta	19.4	2.2	41.9	7.1	58.8	30.8	3.3	-
Mali	9.4 1/	1.5	12.6 1/	6.9	-	69.8	23.3	-

Source: World Bank, FAO, International Agricultural Development Service and Government publications.

1/ Includes permanent crops.

*Less than 0.1

confronting them may help us appreciate the problems of low productivity and low farm income in African countries, and aid the search for solutions.

The remainder of this paper will be devoted to presentation of the farm production system in Upper Volta with major focus on the three sample regions selected for intensive study under the Farming Systems Research Unit. The main objectives of this study were to describe the existing farming systems, identify the major constraints faced by small farmers, and to provide a linkage between farmers and agricultural scientists. Agronomic field trials were conducted under farm conditions (in farmers' fields) with a view to evaluate alternative production technologies and their applicability under existing farm conditions. Economic and other data were gathered by personal interview using structured questionnaires. Interviewers lived in the villages and visited farmers and their fields one to two times a week while collecting the data during the entire production year (1980). In all, there were 105 households in the sample of which 60 were selected for intensive inquiry regarding the socioeconomic structure of households, farm production systems, labor time usage, yields, and other factors.

II. Agriculture in Upper Volta: An Overall View

Upper Volta is landlocked by Mali on the North and West; Ivory Coast, Ghana, and Togo on the South; and Benin and Niger on the East (Map 1). The land area is 274,200 km^2 (106,500 mi^2) with an estimated population of 6.7 million (1979). Eighty percent of the country's total population is engaged in agriculture. The latest population growth rate estimate is 2.6 percent per annum.

Most of Upper Volta lies in the Sudan vegetative zone. Annual rainfall varies from 500 mm (northeast) to 1500 mm (southwest). More than 100 mm of rainfall per month occurs in 4-5 months of the year with the maximum occuring in August. Most of the soils are classified as ferruginous tropical. Sands covered by laterite crusts are extensive in the northeast, southwest, and central regions. Soils of southern and eastern Upper Volta were developed from granite, gneisses, and schists. Soils are generally lacking in fertility, and in scanty rainfall areas may be very hard to plow.

Among the semi-arid African countries, Upper Volta, Mali, Ethiopia, Somalia and Chad, rank lowest in terms of per capita income which ranges between 100 and 120 US dollars, and literacy rate which is not more than 5 to 10 percent of the total adult population. By most major economic and agricultural indicators (Tables 1 and 2) Upper Volta can be rated as one of the least developed among the low income countries.

Arable land, however, constitutes only 19.4 percent of the total available land. According to the 1975-1977 data, Upper Volta has had 2.2 million hectares of land under cereals which accounts for about 42 percent of the country's total arable land. Cropped land per capita amounts to 0.9 hectares. The major cereal crops produced in Upper Volta are sorghum, millet and maize. The area percentages devoted to major cereal and other crops per farm estimated by the Directorate of Agricultural Services (Upper Volta, 1974-1975) are as follows: sorghum, 36 percent; millet, 29 percent; maize, 5 percent; rice, 3 percent; cowpeas, 3 percent; peanut, 7 percent; and cotton, 7 percent.

Cereal yields for the country average around 500 kg per hectare. Production of cereals varies from 170 kg to 186 kg per capita per annum. Of the total cereal consumption, imports accounted for two percent of the country's total consumption during 1975-1977 (7 percent during 1973-1974). It was estimated that Upper Volta would need to import about 75,000 metric tons of food grains a year during 1981 and 1982 to feed its population at the current level of consumption.

The data presented in Tables 3 through 6 demonstrate the gap between estimated requirements and production. The question is how to augment supply to meet the growing need for food by an increasing number of people. With the current average yield level of 500 kg. per hectare under cereal crops, the task at hand is undoubtedly difficult. Assuming a 2.6 percent rate of population growth, total food production, for example, will have to increase almost 30 percent by 1990 in order to maintain the current per capita consumption level without a greater proportion of imports. Various questions arise with respect to the problem of increasing production levels. For example, can and should extensive farming be promoted if additional land

TABLE 3

PRODUCTION LEVELS AND TRENDS IN UPPER VOLTA

(Units of 1,000 m. tons)

Years	Sorghum	Millet	Maize	Paddy Rice	Cowpea (dry)	Peanut (in shell)	Pulses Beans
1961-65	514	300	100	34	71	58	--
1970	563	378	55	34	65	68	--
1971	493	277	66	37	60	66	--
1972	512	266	59	30	60	60	--
1973	481	253	58	32	50	63	--
1974	400	220	50	25	55	40	--
1975	738[a]	383[a]	84[a]	40[a]	--	90	180
1976	534	347	60	36	--	72	180
1977	634	354	73	37	--	57	165
1978	610[b]	406[b]	100[b]	28[b]	--	70[b]	180[c]
1979	610	431	100[b]	30[b]	--	75[c]	190[c]
1980	559[c]	330	100[c]	30[c]	--	77[c]	190[c]
1981	750	400	--	--	--	77[c]	--

Source: Ministry Rural Development, Government of Upper Volta and FAO yearbook of production except as footnoted.

[a]FAO - official statistic.

[b]FAO - unofficial estimate.

[c]FAO - estimate.

TABLE 4

ESTIMATED LEVELS OF CEREAL CONSUMPTION IN UPPER VOLTA
(kg/capita/year)[1/]

Crop	1970	1980	1985	1990
Millet/Sorghum	130	131	131	130
Maize	11	11	12	12
Rice	4	4.5	5	5
Wheat	4	5	5	5.5
Cowpea	20	21	21.5	22
Peanut	6	6	6	6

[1/] Estimates for 1970 are based on actual consumption and others upon FAO projections considering elasticity of demand. Taken from International Fertilizer Development Center (IFDC), Vol. IV, Upper Volta.

Note: Range of per capita supply for 1970-79 is 148 - 181 kg. The average for the period is 167 kg/person. When adjusted for milling and other losses, the average supply is 150 kg/person.

TABLE 5

ESTIMATED FOOD REQUIREMENTS IN UPPER VOLTA
(1,000 m. tons)

Crop	1970[1/] Low - High	1980 Low - High	1985 Low - High	1990 Low - High
Millet/Sorghum	699 - 786	893 - 902	1019 - 1026	1166 - 1168
Maize	58 - 65	74 - 78	85 - 91	97 - 106
Rice	22 - 25	28 - 31	32 37	37 - 44
Wheat	23 - 26	29 - 33	33 - 41	38 - 50
Cowpea	109 - 123	139 - 145	159 - 168	182 - 196
Peanut	31 - 34	40 - 41	45 - 47	52 - 55

[1/] Estimates for 1970 are based on actual consumption. "Low" is based upon per capital consumption at estimated level of 1970 and "High" based upon elasticity of demand (as per FAO projections). Taken from International Fertilizer Development Center (IFDC), Vol. IV, Upper Volta.

TABLE 6

CEREAL IMPORTS IN UPPER VOLTA

(1,000 m. tons)

Crop	1960-65	1970-71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Wheat	8	22	34	14	21	13	16	28	24	36	50	41**
Rice	3	2	2	1	3	10	12	18	10	26	29	20**
Maize	1	1	6	22	24	5	1	0	0	2	3	--
Other	2	0	1	22	30	0	0	8	29	19	13	--
Grain Relief Aid	0	--	--	50	95	--	--	--	--	--	--	--
Total[a]	14	25	41	108	170	28	29	54	63	82	95	--

[a]Excluding missing data.

** nine months

is available for cereal production or should intensive cultivation practices be encouraged, if the necessary inputs are or can be made available to farmers? There are no obvious answers to these questions.

The farmer is a principal actor in the production-consumption process. He is influenced by a number of factors over some of which, the exogeneous ones, he has no control, and which may seriously constrain his production efforts. An important concern for farming systems research is to find appropriate technological innovations that raise the productivity of agriculture, and for public policy an important concern is the diffusion of such innovations. Innovation may take various forms, for example, improved seeds that are disease resistant and high yielding; use of chemical fertilizers, insecticides and pesticides; introduction of better management practices; and substitution of capital equipment, machinery, and animal traction for labor.

There could be some attractive propositions with regard to new crop varieties. For example, ICRISAT's[1] new sorghum variety, E-35-1, has a yield potential of 3.5 to 4.0 m. tons of grain per hectare, maize (IRAT[2] 100 and BDS III) 3.0 tons per hectare, and cowpea (KN1), 1.5 to 2.0 m. tons of grain per hectare on experimental plots. Even if only 50 to 60 percent of these yield levels are realizable under farm conditions, large shifts in production levels, and consequently in farming systems could result from the adoption of such new varieties.

Unfortunately, these potentials are not easy to realize. The grain producing farmers in Upper Volta have not, as demonstrated by data in the following sections, adopted this technology. Commercial fertilizer use by small farms (10,000 tons per year) is insignificant. The production system in effect continues to follow traditional crop patterns and management practices. Questions regarding reasons for this have been raised by agronomists, economists, and policy makers. Is the current situation caused by technological relationships, economic feasibilities or lack of knowledge and resources needed to translate the various yield potentials into realities under real farm conditions and constraints.

Varietal improvements, more efficient agronomic practices, use of animal traction, and the use of modern farming practices are all needed. However, equally and perhaps most important is whether we can succeed in finding a suitable technology that is adaptable by current operators to the existing farm systems and which will increase production on a substantial number of the small farms that make up those systems.

In order to gain insight into this question we consider the farming systems and methods used by small farmers in the three sample regions of Upper Volta with major emphasis on crop production systems, factors influencing crop yields, use of modern inputs, animal traction and its impact on production and labor use, and some implications for research and development.

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[1] ICRISAT = International Crop Research Institute for Semi-Arid Tropics, Regional Office, Upper Volta.

[2] IRAT = Institute for Research in Tropical Agriculture.

III. The Sample Regions

The three areas, Ouagadougou, Ouahigouya and Zorgho (Map 1), selected for study in the first phase of the Farming Systems Research during 1979 and 1980, are in the central region of the country. In terms of agricultural potential the Ouagadougou and Zorgho regions have been categorized as "poor" while the Ouahigouya region was categorized as a "very poor" region.[1]

The three study areas have much higher population density (35 to 43 persons/sq km) than the rest of the country (average density 18 persons/sq. km). The pressure of population on agricultural land is accordingly highest in these regions.

The data presented in Table 7 provide a comparative view of the cropping systems and levels of productivity in the three study regions vis-a-vis some of the country's selected regional development organizations (called ORD's).[2] These data indicate that cereal crops occupy the highest proportion of land under cultivation in all regions, although in the lower rainfall regions, the relative area under cereals is larger than in the high rainfall areas. For example, cereals occupy 92 to 93 percent of cultivated land in Dori located in the Sahel region (400-700 mm rainfall) and Yatenga (600-700 mm rainfall) regions of the Northwest Central Plateau as compared to 70 percent in the western regions of Bobo, Diebougou and Banfora (1100-1400 mm). Similarly, in Ouagadougou, Yatenga and Koupela (Central regions) sorghum and millets are comparatively more important in cropping patterns than they are in the Western and the Eastern regions. In the Western and the Eastern regions, maize, peanut and cotton occupy a more important place than in the Central region.

Also noticeable are significant inter-regional yield differentials for the major crops such as millet and sorghum. Per hectare yield of millet is as low as 229 kg in Dori, 300 kg in Ouahigouya (Yatenga), 408 kg in Ouagadougou region as compared to 690 kg in Bobo and 618 kg in Fada. These differences are consistent with rainfall patterns. Other crops evidence similar yield differences. The average per hectare yield for cereal crops in the country is estimated to be 500 kilograms.

Differences in yield reflect, among other things, conditions of rainfall, soil fertility, management practices, and the overall resource endowments of the various regions. Equally important, they may suggest future possibilities and prospects for productivity-increasing efforts through technological changes, and developmental policies with regard to infrastructures, credit and fertilizer distribution, and farmer training and skill formation programs. This is especially true of differences in yields among farmers of the same and/or relatively homogeneous regions. There are cases

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[1] Singh, Ram D., Major Cropping Patterns in SAFGRAD Countries and Government of Upper Volta, Ministry of Planning and Rural Development Annual Reports.

[2] There are in all 11 ORD's (Regional Development Organizations) which are geographic units covering the country. These are autonomous organizations responsible for extension services, credit, marketing and rural infrastructures.

TABLE 7

LAND USE, CROPPING SYSTEMS AND YIELD LEVELS IN THE THREE STUDY REGIONS VIS-A-VIS SOME SELECTED REGIONS OF UPPER VOLTA

Area/Food/ Rainfall	Study Regions/ORDs			Other Selected ORDs				
	Ouaga	Yatenga	Koupela	Bobo	Diebougou	Banfora	Fada	Do
Total Cultivated Land Area 1977 (1000 h)	490	220	130	150	200	90	190	14
Area Under Cereals (ha) (1000 h)	390	205	100	105	140	70	155	13
Percent of Area Under Cereals	79.6	93.2	76.9	70	70	78	82	9
Cotton (1000 h)	[illegible]	-	-	20	4	-	-	-
Legumes (1000 h)	15	9	18	11	16	8	17	-
Cultivated Area per Active Person	0.96	0.80	1.0	1.02	1.10	-	1.02	0.
Per Farm Area Under								
Sorghum (ha)	3.64	1.80	2.7	2.46	1.80	-	2.95	2.
Millet (ha)	3.64	1.20	2.7	1.26	1.90	-	1.48	2.
Maize (ha)	-	0.005	0.13	0.30	0.30	-	0.42	-
Peanut (ha)	0.15	0.15	0.56	0.42	0.45	-	0.77	-
Cowpea (ha)	-	0.20	0.15	0.24	0.65	-	-	0.
Cotton (ha)	0.09	0.03	0.03	0.72	0.11	-	0.30	-
Per Hectare Yields (1977-1978)								
Sorghum (kg)	495	368	650	844	545	560	848	148
Millet (kg)	408	300	360	690	434	520	618	229
Maize (kg)	263	206	250	1045	651	850	1230	-
Peanut (kg)	315	313	500	620	402	780	718	250
Cotton (kg)	365	201	229	866	249	140	700	200
Rainfall mm	750 to 1000	600 to 700	700 to 1000	1100 to 1200	1100 to 1200	1200 to 1400	700 to 1000	400 to 700

Source: Ministry of Rural Development, Government of Upper Volta.

in other countries where traditional farm management specialists have simply carried the "best" of the local practices from one farmer to another.[1] Researchers have isolated and developed varieties and methods to make the high yields easier to achieve. Incentives and infrastructure needs were isolated in the process and considerable economic development achieved at relatively low cost.

It is worthwhile to compare the existing farm yield levels with those realized at the experiment stations, research managed trials, and model farms (Table 8). Consider the case of sorghum and maize, for which data are available. The ICRISAT's sorghum variety E-35-1 has the potential of an average yield of 3.5 m. tons to 4 m. tons per hectare with the recommended fertilizer applications and management practices. Such yield levels are of course realized under controlled conditions which are currently difficult to realize in farmers' fields.

The Farming Systems Research Unit's managed farmer field trials conducted during 1980 (Table 9) yielded 1.8 m tons of grain per hectare of E-35-1, and 1.3 m tons of SVP 35, the two sorghum varieties said to be promising for semi-arid regions in Africa. More evidence is needed to evaluate the performance of these varieties under farm conditions. Under the usual farm practices and soil fertility levels E-35-1 does not appear to yield more than local varieties (Tables 7, 9). More than a simple change of varieties may be involved if higher yields at the farm level are to be achieved.

On IRAT's experimental plots and Saria (research station) model farms (Table 8), the average per hectare yield of sorghum ranged between 2 to 2.5 metric tons. The model farm technology was highly controlled and subsidized. The recipients of this subsidized technology were the employees of the Institute that was diffusing the new technology.

Maize yields reported by maize agronomists and breeders (IITA, IRAT) vary from over 2 metric tons to over 3 metric tons per hectare. Such yield levels are related to different levels of fertilizer applications, management practices, and varietal changes under West African farming conditions. The feasibility of realizing the yield potentialities of the new varieties under farm conditions has yet to be established.

It is unlikely that the ideal or potential yield of 3.5 to 4 m tons of grain per hectare will be realized under farm conditions for either sorghum or for maize. Of course, there may be areas and farmers with relatively more favorable conditions for which higher yields than 1 to 2 m tons per hectare are fairly attainable. The national average yield statistics for cereals is only about 500 kg per hectare, a figure which hides yield potentialities in the regional and subregional contexts. For example, as shown by the data in Table 7, the average yield for sorghum ranges from as low as 148 kg per hectare in Dori region and 368 kg in Yatenga region to as high as 844 kg per hectare in Bobo region and 848 kg in Fada region. Likewise for maize, it ranges from 206 kg in Yatenga to 1230 kg in Fada and 1045 kg in

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[1] This system was used extensively by the extension services in the U.S.A. Farm records systems and farm tours have this comparative aspect as one of their functions.

TABLE 8

YIELDS OF SORGHUM AND MAIZE REALIZED AT
EXPERIMENT STATIONS AND MODEL FARMS, UPPER VOLTA

Variety	Average Yield in kg/ha	Observations
<u>Sorghum</u> E-35-1	3500 to 4000	Reported by scientists of ICRISAT in the basis of experimental results.
<u>Red Sorghum</u> SARIA MODEL FARM (IRAT) 1969-1974	2551	IRAT's model farm in SARIA (HV) with 4.4 hectares of cropland since 1969, with 6 persons (3 active), was phased to bring 1 hectare a year under improved technology. Yield figures arrived in fifth year.
IRAT P & K Experiments for sorghum 1964-1974	975	0 level
	1806	50 kg of P205/H (16.6 kg grain/ kg of P205)
	1958	100 kg P205/h (3 kg grain/kg)
	1228	0 level
	1679	50 kg K20/h (9 kg of grain/kg K20)
	1846	100 kg K20/h (3.4 /kg)
<u>Maize</u> IRAT 100	3023	Mean yield based on IITA's trials in Upper Volta, Senegal, Mali, Ivory Coast & Benin (1979)
B D S III	2970	Mean yield based on IITA's trials in Upper Volta, Senegal, Mali, Ivory Coast & Benin (1979)
Jaune de Fo	2328	
Massayomba	2286	
Cowpea	1500	3 years average based on IITA SAFGRAD trials

Source: ICRISAT, IITA/SAFGRAD and IRAT, Reports, 1979 and 1980.

TABLE 9

YIELDS OF NEW SORGHUM AND COWPEA VARIETIES
ON FSU/SAFGRAD RESEARCH MANAGED FIELDS
IN SAMPLE VILLAGES, UPPER VOLTA, 1980

Crop Variety	Yield in kg/ha	Observations
E-35-1 (Sorghum)	1800	Village fields with preplanting cultivation and 100 kg RP + 20 kg Urea per hectare 1980 research-managed trial
	1500	Village fields without preplanting cultivation: no fertilizer. 1980 research-managed trial
	750	Bush fields with preplanting cultivation and 100 kg RP + 20 kg Urea per hectare. 1980 research-managed trial
	150	Bush fields without preplanting cultivation: no fertilizer. 1980 research-managed trial
SVP 35 (Sorghum)	1300	Sandy valley soils Ouahigouya 1980 with preplanting cultivation and 100 kg rock phosphorous and 20 kg Urea per hectare research-managed trial
	600	Sandy valley soild Ouahigouya 1980 without preplanting cultivation, no fertilizer research-managed trial

Source: FSU Field Trials in Sample Villages, 1979-1980, (Paul Christensen's Report)

Bobo. For AVV[1] farms, it is estimated over 1000 kg per hectare. For other crops there is a similar pattern of yield differentials.

Such productivity differences in existing farming systems in the country may give some useful guidelines for comparing the experiment station's yields with the existing yields already realized by farmers in different regions, especially by those who are already obtaining yields around 1 m. ton or more per hectare. Based on only four paired comparisons in one village, the FSU reported the mean yield of E-35-1 (sorghum) at 1120 kg as compared to the local sorghum yield of 1690 kg per hectare with the same input usage. However, other observations of E-35-1 in the same area, but unfortunately with no local checks showed an average yield of 1720 kg per hectare. In this case, the two crop varieties were planted on relatively high quality village fields.

It is possible that some of the local varieties may yield as much as new (or improved) varieties do under similar conditions of management practices and input use. In such cases the farmers will have little incentive to try the new variety. The relative superiority of any new technology has to be clearly demonstrated. For valid comparisons and meaningful extrapolations, the macro level average yields do not represent a true picture. It is necessary to compare yields in the regional, subregional and even village context. This can identify regions with different potentialities with respect to various varieties, cropping systems and crop improvement programs. If the objective is to achieve maximum increase in cereal production in as short a period as possible for countries such as Upper Volta, scarce research and development resources need to be allocated on selective bases with relatively higher priorities for areas with greater potential for using yield-increasing technologies, and higher economic returns to investment.

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[1] This is a land resettlement organization under government control and supervision under which farmers are allocated land with package of practices to be followed for different crops (in the Volta river basin).

IV. Household Farm Production Systems: A Survey of Cross Section Population

A household in Mossi villages generally consists of the head of the household, his wife or wives, and their young children. Sometimes married sons and other relatives are present in the household. The average size of a household in the sample is about 12 persons present in the household, and 15 including the absent members. Only about 5 percent of the household heads had had any schooling and were literate. The average age of household heads is 56.5 years.

Land and labor are the two most important resources of small farm households in African agriculture. Land distribution has generally been governed by local tribal customs and traditions. Individual rights and ownership follow a well defined system but are quite different from Western systems, or those found in several other Anglophone countries in the third world.

The capital of small farm operators consists mostly of small hand tools and implements used for planting and weeding operations. Animal traction is not universal in Upper Volta. The FSU survey indicated that its use at present is limited.[1] Farm production is heavily dependent on labor because most of production activities are carried out by hand.

Land Holdings and Food Supply

The average size of farm operated by households in the sample is 5.05 hectares (12.5 acres) of cropped area which is less than a half hectare (1 acre) of land area per person in the household. Given the existing low farm productivity (420 kilograms to 572 kilograms of grain per hectare), a farm size of 5 hectares is very small and may be inadequate to provide reasonable quantities of food for the family let alone any saving for further investment in agriculture. The estimated total production per sample household during 1980 consisted of 2.35 m tons of crops (Table 10) of which millet accounted for 58.4%, sorghum, 23.4%, maize, 5.6%, cowpea, 3.4%, peanut, 6.8%, Bambarra nuts, 1%, and the miscellaneous crops, 2.4%.

Based on the above estimates the per capita availability of food grains and dry pulses is 156 kilograms per annum, while for all crops it is about 172 kilograms. However this is the available food grain supply of the households assuming no marketing. Households do sell some of the crops to meet their cash obligations. This is estimated to be between 10 percent to 15 percent of total production.[1] Thus, if one were to take out the quantities sold by households, the available food grain supply per person per annum will be reduced to 120 kilograms of food grains and dry pulses, and 146 kilograms of all crops produced by households.

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[1] World Bank and the Government of Upper Volta.

TABLE 10

HOUSEHOLD CROP PRODUCTION: SMALL FARMS SAMPLE, UPPER VOLTA, 1980
(Kilograms)

Crop	Quantities Produced Per Household	Quantity Available Per Person[1/]
Millet	1370.0	100.0
Sorghum	548.4	40.0
Cowpea	80.4	6.0
Maize	134.0	10.0
Peanut	160.0	11.6
Bambarra nuts	23.3	1.9
Okra	8.0	0.5
Misc.	22.0	1.7
All Crops	2346.1	171.7

Source: FSU Sample Survey, 1980.

[1/] Per capita available to household = Total production - 15% to account for grain loss and seeds etc. ÷ the number of persons in the household.

Crop Production Systems

Millet and sorghum are the two most important cereal crops produced and consumed by farmers in Upper Volta. As shown by the data in Table 11, millet, the principal field crop occupies 66.4 percent of the total cropped area followed by sorghum with about 20 percent. The other cereal crop grown almost universally by farmers is maize, although in terms of its relative share in the total cropped area it occupies only about 3 percent of the total farmed land. Peanuts are an important cash crop which is grown on 7.6 percent of the total cropped land in the study regions. In addition, there are a number of minor crops such as okra, Bambarra nuts, roselle, etc. that are grown either as sole crops or as associated crops. In terms of land area, such crops occupy between 1 and 2 percent of total cropped land.

Growing crops in association is an important characteristic of the existing farming system that is practiced universally by small farmers in most parts of Africa. Sometimes farmers grow four to five crops in the same field. Data in Tables 12 and 13 show the crop associations followed by farmers in the study regions. Cowpea is by far the predominant second crop grown in association with cereal crops such as millet and sorghum. In fact, cowpea is grown mostly as an associated crop. Cowpea as a sole crop is more the exception than the rule on small farms in West Africa.

There are at least two hypotheses regarding the practice of growing crops in association in preference to mono cropping. Some crops are more susceptible to insects when grown in pure stands. Secondly, cowpea, the most important associated crop is a legume with some nitrogen fixation effects. However, this effect may be small with the low proportion of cowpeas in the usual crop mix.

In most cases farmers in the sample followed a continuous crop rotation pattern, i.e., millet (and associated crops) after millet, and sorghum after sorghum with minor adjustment with changes in peanut planting. Farmers have followed this practice for decades without any application of fertilizers. Despite the cultivation of cowpea as a legume crop in association, soil fertility has definitely been depleted over time. Farmers have tried to avoid this problem to some extent in some areas of the Mossi Plateau by leaving land fallow. However, the practice of fallowing has been limited considerably by the increasing pressure of population on land.

Cowpea as stated earlier is grown universally as an associated crop with millet and sorghum. In the sample of 50 farmers selected for intensive observation, there was only one who grew cowpea as a single crop and that also in only one of his fields which constituted 0.4 percent of the number of fields operated by the farmer.

Since cowpea production as a single crop is not common, it could be difficult to promote the idea of a single cowpea crop at this stage. In most of the crop research and field trials it has been assumed that farmers will grow cowpea, or other crops such as sorghum or millet, as a single crop not in association with other crops. Farmers in general do not follow such a practice, nor do they generally accept such a system.

TABLE 11

CROP AREA DISTRIBUTION IN SAMPLE OF SMALL FARMS, UPPER VOLTA, 1980

Principal Crops[1/]	Area in Sample Under Crops		Average Cropped Area Per Household
	(ha.)[2/]	(Percent)	(ha.)[2/]
Millet	203.58	66.4	3.40
Sorghum	60.89	19.8	1.00
Maize	8.63	2.8	0.14
Peanut	23.34	7.6	0.34
Bambarra Nuts	3.96	1.3	0.07
Okra	0.73	0.2	0.01
Misc. Crops	5.64	1.9	0.09
Total	306.77	100.0	5.05

Source: Farming Systems Unit's Sample Survey, 1980.

[1/] 96 to 98 percent of the field areas under millet and sorghum and associated crops with cowpea as the most dominant second crop in association. Millet and sorghum are also grown as associated crops.

[2/] 1 hectare = 2.47 acres.

TABLE 12

CROPPING PATTERNS: RELATIVE DISTRIBUTIONS OF FIELDS BY CROPS, SAMPLE OF SMALL FARMS IN THREE REGIONS, UPPER VOLTA 1980

(Percent)

	Nedogo		Aorema		Digre	
	Main Fields	All Fields	Main Fields	All Fields	Main Fields	All Fields
Millet mono	13.3	5.0	9.2	2.7	1.0	0.4
Millet cereal	6.6	2.5	---	---	5.4	1.8
Millet cowpea	63.9	24.0	69.3	20.0	91.4	29.5
Millet others	16.2	6.0	21.5	6.2	2.2	0.7
	100.0	37.5	100.0	28.9	100.0	32.4
Red sorghum mono	27.3	2.5	---	---	4.3	1.0
Red sorghum cereal	15.2	1.7	---	---	2.9	0.7
Red sorghum cowpea	33.3	2.8	---	---	84.1	20.3
Red sorghum others	24.2	2.2	---	---	8.7	2.0
	100.0	9.2			100.0	24.0
White sorghum mono	10.0	0.6	---	---	50.0	0.7
White sorghum cereal	5.0	0.3	---	---	---	---
White sorghum cowpea	85.0	4.7	100.0	13.0	25.0	0.4
White sorghum others	---	---	---	---	25.0	0.4
	100.0	5.6	100.0	13.0	100.0	1.5
Maize mono	9.3	1.0	22.2	1.8	7.7	0.4
Maize cereal	37.2	4.4	50.0	4.0	84.6	4.6
Maize cowpea	---	---	---	---	7.7	0.4
Maize others	53.5	6.3	27.8	2.2	---	---
	100.0	11.7	100.0	8.0	100.0	5.4
Peanut mono	46.0	8.0	48.3	12.4	50.0	9.5
Peanut cereal	---	---	---	---	---	---
Peanut cowpea	---	---	---	---	5.6	1.0
Peanut others	54.0	9.4	51.7	13.3	44.4	8.4
	100.0	17.4	100.0	25.7	100.0	18.9
Okra	95.0	10.2	40.7	2.2	85.7	4.2
Okra others	5.0	0.5	59.3	3.2	14.3	0.6
	100.0	10.7	100.0	5.4	100.0	4.8
Bambarra nuts	28.0	2.0	57.1	10.7	45.5	3.5
Bambarra nuts & others	72.0	5.0	42.9	8.0	54.5	4.2
	100.0	7.0	100.0	18.7	100.0	7.7
Roselle and others	---	---	---	---	---	0.7
Rice (paddy)	---	0.8	---	---	---	1.4
Cowpea	---	---	---	---	---	0.4
Cowpea and others	---	---	---	---	---	---
Other crops	---	0.3	---	---	---	2.8
Red pepper	---	---	---	---	---	---
		100.1		99.7		100.0

Source: FSU Sample Survey, 1980.

TABLE 13

RELATIVE DISTRIBUTION OF FIELDS BY CROP COMBINATION,
SAMPLE OF SMALL FARMS IN THREE REGIONS,
UPPER VOLTA, 1980

Crop Combination	Percent distribution of all fields operated by households		
	Nedogo	Aorema	Digre
Millet mono	5.0	2.7	0.4
Millet and cowpea	3.0	8.4	2.2
Millet and roselle	5.0	6.2	0.4
Millet and red sorghum	1.0	-	0.7
Millet and earthpea	0.3	-	-
Millet and cowpea and roselle	20.5	-	15.0
Millet and bitto and cotton	0.6	-	-
Millet and red sorghum and cowpea	0.6	-	14.0
Millet and white sorghum and roselle	0.6	-	0.4
Millet and cowpea and rice	0.3	-	-
Millet and other	0.8	11.7	0.7
Red sorghum mono	2.5	-	1.0
Red sorghum and maize	0.8	-	-
Red sorghum and white sorghum	0.6	-	-
Red sorghum and white sorghum and roselle	0.3	-	0.7
Red sorghum and cowpea	1.0	-	4.0
Red sorghum and cowpea and roselle	2.5	-	14.0
Red sorghum and cowpea and sesame	0.3	-	-
Red sorghum and roselle	1.0	-	1.0
Red sorghum and others	-	-	1.0
White sorghum mono	0.6	-	3.3
White sorghum and cowpea	0.8	-	-
White sorghum and copwea and millet and roselle	0.3	4.0	-
Maize mono	1.0	2.0	0.4
Maize and red sorghum	0.8	-	0.7
Maize and white sorghum	1.3	-	-
Maize and roselle	1.3	2.2	0.4
Maize and other	7.0	4.0	4.0
Peanut mono	8.0	12.4	10.0
Peanut and roselle	9.0	2.7	5.2
Peanut and other	0.3	10.7	4.8
Okra mono	10.0	-	4.4
Okra and other	0.6	5.4	0.7
Rice mono	0.8	-	-
Bambarra nuts mono	2.0	10.4	3.6
Bambarra nuts and roselle	5.0	4.8	1.8
Bambarra nuts and other	-	3.0	2.5
Other crops	0.3	-	2.5
Total	100.0	100.0	100.0

Source: FSU Sample Survey, 1980.

Maize is grown by every household with an average of one to two fields per household. However, only a small proportion of cropped land is devoted to this crop. Maize is usually grown on land closest to the compound (champs de case). Fields close to the compound are generally of better quality in terms of soil fertility. Farmers have, over time, augmented the fertility of the soil in these fields with household and other forms of organic waste materials.

Peanuts are produced by almost all households because of the cash value to the household. This crop occupies 7 to 8 percent of total farm land and is of greater economic importance than the rest of the minor crops in the household's farm production system. As explained later, women play an important role in the production of this crop.

Labor Supply on Small Farms

Estimates of the available labor supply are presented by village in Table 14. On an average, a farm household in the sample has 4 to 6 labor units available for work. Next in importance to land, the amount of available labor determines household farm production because of the dominance of human labor in production activities. Agriculture in Africa is a highly labor intensive industry which caters to the subsistence needs of rural farm households. Under the existing production technology which is basically a land and labor using technology with minimal or no use of modern capital, the available labor supply plays a crucial role in determining the quantity of land that households can farm, and the timeliness of the various operations necessary to realize crop production. Labor shortage in a rather land abundant and capital scarce system of production can seriously constrain production.

A fairly substantial part of the household labor supply is comprised of women and children in the household. Women and children provide 50 to 66 percent of the total labor available to households. Amounts of labor used in farm activities will be considered in later sections.

Role of Women in Household and Production Systems

Wives play an important role in the Mossi family's socioeconomic structure. Normally, the head of a household has more than one wife, and as he rises in the socioeconomic status, he tends to marry more. Women provide a very important source of labor, first by their own work, and second by producing children who later augment the household labor supply. As shown in Table 15, of the total labor available per household, female labor accounts for 43 to 51 percent, and children, 8 to 16 percent in the three areas studied.

In addition to social status, wives and children provide important sources of economic power to tradition-bound farm households. Data on number of fields farmed by households, number wives per household head, and number of children in the households (Table 16) reveal a positive association between the number of wives and the children on the one hand and the number of fields operated by households on the other.

TABLE 14

ESTIMATE OF AVAILABLE LAVOR FORCE[1/], SAMPLE OF SMALL FARM HOUSEHOLDS IN THREE REGIONS, UPPER VOLTA, 1980

Category by Age/Sex	Nedogo		Digre		Tanghin		Aorema		Sodin	
	No.	%	No.	%	No.	%	No.	%	No.	%
Male adult (per household)	1.8	33	1.7	41	1.5	42	1.8	41	3.2	52
Female adult (per household)	2.8	51	2.0	48	1.6	44	2.2	51	2.2	35
Male child (per household)	0.4	7	0.20	5	0.40	11	0.30	7	0.35	6
Female child (per household)	0.5	9	0.25	6	0.10	3	0.05	1	0.45	7
Total male and female child (per household)	0.9	16	0.45	11	0.50	14	0.35	8	0.80	13
All labor force (per household)	5.5	100	4.2	100	3.6	100	4.4	100	6.2	100
Average size of household	11.3		11.0		11.0		13.4		15.2	

Source: FSU Sample Survey, 1980.

[1/] This estimate is based on the following conversion ratios:

1 man labor = 1 labor unit

1 female labor = 0.75 labor unit

1 child labor (10-14 years) = 0.50 labor unit

Absentee members of households are excluded.

TABLE 15

RELATIVE DISTRIBUTION OF HOUSEHOLDS, NUMBER OF CHILDREN AND NUMBER OF FIELDS BY NUMBER OF WIVES AND REGIONS, SAMPLE FROM UPPER VOLTA, 1980

Number of Wives Per Head of Household	Percentage of Households			Number of Fields Per Household			Number of Children in the Household			Number of Other Married Women in Household		
	Ned	Dig	Tang	Ned	Dig	Tang	Ned	Dig	Tang	Ned	Dig	Tang
1	30	20	33	9	16	11	5	4	5	1	3	0.2
2	27	73	27	10	20	12	8	9	9	1	1	0.7
3	27	7	7	14	35	19	17	22	17	2	5	4.0
4	13	--	27	20	--	17	15	--	20	1	-	2.5
5	--	--	6	--	--	18	--	--	21	-	-	1.0
6	3	--	--	25	--	--	22	--	--	5	--	--

Source: FSU Sample Survey, 1980.

Ned = Nedogo (Ouagadougou region).

Dig = Digre (Zorgho region).

Tang = Tanghin (Zorgho region).

TABLE 16

DISTRIBUTION OF FIELDS UNDER SELECTED CROPS BY HOUSEHOLD MEMBER CLASSIFICATION, SAMPLE FROM THREE REGIONS OF UPPER VOLTA, 1980

Crops	Percent of Fields								
	Head of household			Head's wives and other female members			Head's sons and other male members		
	Nedogo	Aorema	Digre	Nedogo	Aorema	Digre	Nedogo	Aorema	Digre
Millet	49	62	71	36	23	24	15	15	5
Red Sorghum	79	--	40	12	--	40	9	--	20
White Sorghum	75	60	81	20	30	11	5	10	8
Maize	98	89	80	--	--	7	2	11	13
Peanut	24	19	39	68	76	48	8	5	13
Okra	3	8	--	97	84	100	--	8	--
Bambarra Nuts	--	--	36	100	100	59	--	--	5
Roselle	--	--	--	100	--	100	--	--	--
Rice (paddy)	100	--	25	--	--	--	--	--	75
Cotton	--	--	--	--	--	--	--	--	--
Cowpea, Bambarra Nuts	--	--	100	--	--	--	--	--	--
Other crop	--	--	--	--	--	--	--	--	--
Red Pepper	--	--	100	--	--	--	--	--	--

Source: FSU Sample Survey, 1980.

Another characteristic of the crop production system on small farms is the role of women in managing crop fields.[1] For crops such as peanuts, Bambarra nuts (pois de terre), okra and roselle (bitto), women, mainly the household head's wife or wives play an important role in managing production and sales of the household (Tables 16 and 17). In all but one of the sample villages, all the Bambarra nut fields were farmed by women. Eighty-four to 100 percent of the fields and 43 percent of the land area in okra, 100 percent of roselle fields, and 48 to 76 percent of the fields and 25 percent of the land area in peanut were under the management of women in the households. The women also produced cereal crops. The number of millet fields farmed by women accounted for 23 to 36 percent of all millet fields and 6 percent of the land area under millet. Twelve to 40 percent of all sorghum fields and 4 percent of the area under sorghum were in charge of women.

Although women play an important role in production and marketing operations, they have been bypassed by development and extension agencies. With respect to health, education and information systems, women are the most neglected segment of rural society. Women in the sample (i.e., wives of household heads and other married women in the household) are 100 percent illiterate. They have little or no access to rural institutions because they are male dominated. Traditionally the husbands who are heads of households (menages) have kept their women away from such contacts.

Deficiencies in nutritional intake, environmental conditions and lack of basic health and clinical services, are reflected in high infant mortality. By the survey estimate, 33 percent of the children born per wife die while young (before they reach 5 years of age). This is indeed a very high death rate. The women (and children) in the household bear a major share of the burden of economic hardships caused by poverty.

Crop Yields, Input Use and Animal Traction

Crop Yields. Table 18 presents per hectare yields of major crops estimated on the basis of total production divided by total area in the crop. These data include the kilograms harvested per hectare of the main crop, the associated crops and all crops combined.

As shown by the data in Table 18, on the average, farmers in the sample harvested 415 kilograms of crops per hectare from their millet fields, of which 376 kilograms was millet and the rest other cereals such as sorghum (20 kg), cowpea (15 kg), and miscellaneous crops (5 kg).

Per hectare yield from sorghum fields was estimated to be 572 kilograms -- about 36 percent higher than the millet field yield. Of the per hectare production on sorghum fields, sorghum production accounted for 460 kilograms, cereals other than sorghum, 73 kg, cowpea, 30 kg, and miscellaneous crops in association, 9 kg. Sorghum is generally grown on better quality

[1] For more details regarding the role of women see Margaret O. Saunders, "The Mossi Farming System of Upper Volta". FSU Working Paper No. 3. OUA/CSTR - Joint Project 31 between USAID and Purdue University, April 1980.

TABLE 17

CROP AREAS[1/] OPERATED BY HOUSEHOLD MEMBERS, SAMPLE FROM THREE REGIONS OF UPPER VOLTA, 1980

(Hectares with Percentages in Parentheses)

Household Member Classification	Millet	Sorghum	Maize	Peanut	Earth-peas	Okra	Misc.
Head of Household	171.9 (84.4)	53.2 (87.4)	7.3 (84.9)	10.6 (45.4)	0.5 (12.5)	0.05	2.3 (40.4)
Head's Sons	9.6 (4.7)	2.0 (3.3)	0.03 -	2.3 (9.8)	0.5 (12.5)	0.2 (28.6)	0.8 (14.0)
Head's Wives	10.5 (5.2)	1.7 (2.8)	0.01 -	3.8 (16.2)	1.7 (42.5)	0.3 (42.8)	1.3 (22.8)
Other women	2.0 (1.0)	0.8 (1.3)	0.00 -	1.6 (6.8)	0.3 (7.5)	0.05 -	0.2 (3.5)
Others (Male Members)	9.6 (4.7)	3.2 (5.2)	1.3 (15.1)	5.1 (21.8)	1.0 (25.0)	0.02 (28.6)	1.1 (19.3)
Total	203.6	60.9	8.6	23.4	4.0	0.7	5.7
Percent	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Source: FSU Sample Survey, 1980.

[1/] Total areas in the sample, not per household.

TABLE 18

YIELDS OF MAJOR CROPS, SMALL FARMS SAMPLE FROM UPPER VOLTA, 1980

(Kilograms per Hectare)

Crops and Their Associations	Average Yield for All Fields
Millet in Associations	
Millet (main)	375.9
Cereals (association)	20.0
Cowpea (association)	14.8
Others (association)	4.7
Total Yields	415.4
Sorghum in Association	
Sorghum (main)	459.6
Cereals (association)	72.6
Cowpea (association)	29.7
Other (association)	9.3
Total Yields	572.2
Maize in Association	
Maize (main)	960.5
Cereals (association)	146.0
Cowpea (association)	1.0
Other (association)	54.9
Total Yields	1162.4
Peanuts in Association	
Peanuts (main)	470.5
Cereals (association)	10.2
Cowpea (association)	0.0
Other (association)	38.4
Total Yields	519.1
Bambarra Nuts in Association	
Bambarra Nuts (main)	331.4
Cereals (association)	0.0
Cowpea (association)	0.0
Other (association)	0.0
Total Yields	331.4

Source: FSU Sample Survey, 1980.

soils than is millet. Hence, soil differences may be important in explaining yield differences between these crops.

The fields with maize as the main crop yielded 1162 kg per hectare, the highest per hectare yield of all crop fields. Of the total, maize accounted for 960.5 kg, other cereals (sorghum mainly) 146 kg, cowpea 1 kg, and other crops 55 kg. Maize is always grown on fields around the house, and generally receives the most manure and care. The fertility of soils around the compound is higher than in other fields. It is therefore reasonable to expect higher per hectare yields of maize. However, in terms of total crop area and production, maize occupies a very small place in household farm production activities.

Peanut yields averaged 470.5 kg per hectare. In addition, peanut fields yielded about 52 kg of other crops grown in association.

Overall, the per hectare yields estimated for the major crops demonstrate very low productivity conditions on small farms. This is a major factor in the domestic supply of food crops.

Use of Modern Inputs. Cereal crops are grown under traditional farming practices which in general do not include the use of modern inputs such as high yielding seed varieties, chemical fertilizers, and modern means to control insects, pests and diseases. The use of such modern inputs on the sample farms appears minimal in Table 19. Low levels of application were used and only on parts of the fields. A difference in yield was usually observed between the fertilized and unfertilized portions. In all, 7.5 percent of the sample farms applied some phosphate with a total expenditure of about $12 per farm that used this fertilizer. In the case of sorghum, 2.5 percent of the sample farmers used phosphate with an average expenditure of $16 per farm. It is important to note that in all cases, farmers received this fertilizer at government subsidized prices from the Farming Systems Research Unit conducting trials in farmers fields. Otherwise, farmers would not have used any fertilizers for these crops.

Per farm expenditure on chemical insecticides and fungicides was $0.50 to $1.50 based on the four farmers in the entire sample of 50 that used such chemicals. Fifteen percent of the millet producing farmers and 5 percent of the sorghum farmers reported to having used some chemicals. For all the purchased inputs, the per hectare expenditure is estimated at $0.50 for millet and sorghum and about $6 for maize.

Except for a few farmers who tried new crop varieties (mainly sorghum and cowpea) under the supervision of experiment station scientists, the farmers in the sample grew local varieties. Some of the local varieties are fairly drought-resistant. It may be possible to achieve higher yields from some of these varieties with the use of fertilizer and moisture conserving management practices.

Use of Animal Traction. Most production activities on the majority of farms are carried out manually with small farm tools and equipment that have been in use for several hundred years. In the entire sample, only 33 percent of the households have animal traction, and 90 percent of these use a donkey to pull the hoe or cultivator. Of the sample villages, Nedogo in the

TABLE 19

FERTILIZERS AND PESTICIDES USED BY SAMPLE FARMERS[1/], UPPER VOLTA, 1980

Fertilizer and Pesticide Category	Percentage of Farms		Average Value (US $) Per Farm Using Inputs	
	Millet	Sorghum	Millet	Sorghum
Phosphate	7.5	2.5	$12.00	$16.00
Cotton Fertilizer	2.5	-	$ 5.00	-
Organic Manure	30.0	10	Not Estimated (Home Produced)	
Pesticides/ Insecticides Fungicides	15.0	5	$ 1.5	$ 0.50

Source: FSU Sample Survey, 1980.

[1/] These estimates are based on selected farmers in the three sample villages (Nedogo, Digre and Tanghin).

Ouagadougou region which is close to the capital city has the largest frac tion (60 percent) of sample households with animal traction. In the othe sample villages, this ranges from 10 percent to 40 percent of total far households. Where animal traction was used, the data in Table 20 show tha for major crops, cropped area on which animal traction was used varies fro about 31 percent (peanut and maize) to 40 percent (millet) of the tota cropped area under the respective crops.

The data in Table 21 also show that not all of the farmers owning ani mal traction have used it uniformly for comparable farming operations. Ani mal traction was not used by the sample farmers for either land preparatio or for planting activities of major crops such as millet and sorghum i Nedogo, the village with the largest percentage of sample farmers with ani mal traction. In the other villages the percentages of fields for whicl animal traction was used by the sample farmers for land preparation an planting were rather small. However, for crops such as maize and peanuts farmers used animal traction for land preparation in 38 to 39 percent o fields in Nedogo and 17 to 50 percent of fields in Aorema (Table 21).

Animal traction was used for weeding in most of the villages unde study, but not on all fields. However, it was used in weeding almost all major millet and sorghum fields.

Yield and Production Levels on Animal Traction Farms

First, the per hectare overall yield (Table 22) is higher for fields where animal (donkey) traction was used than for the fields where no animal traction was used. This is true for the three major cereal crops (millet, sorghum and maize). However, except for maize, the yield differential is not substantial. A farmer with animal traction harvested an average of 426 kilograms of crops per hectare from millet fields, whereas a farmer with no animal traction harvested 408 kilograms from such fields--a difference of almost 4 percent. Similarly, a total of 578 kilograms of crops was realized from a hectare of sorghum fields where animal traction was used as compared to 568 kilograms with no animal traction, a difference of about 2 percent. In the case of maize, the per hectare yield on animal traction fields was 33 percent higher than that on the no-animal traction fields, a rather substantial difference.

Also, households with animal traction operate two to two and a half times larger farms than the no-animal traction households. Households with animal traction farm an average of 5 hectares (12.3 acres) of millet fields and 2 hectares (about 5 acres) of sorghum fields whereas households without animal traction farm 2 hectares (5 acres) of millet field and 1 hectare (2.47 acres) of sorghum fields. This relationship between farm size and animal traction is important from the standpoint of total production per farm households that own animal traction may be trying to maximize. The first advantage of animal traction that a farmer points out[1] is that it helps him farm a larger land area. He may not obtain greater yield per unit

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[1] Based on informal interviews with approximately 25 farmers that own draft animals in the study regions.

TABLE 20

USE OF ANIMAL TRACTION ON SMALL FARMS, SAMPLE FROM UPPER VOLTA, 1980

Principal Crops1/	Total Cropped Area2/	Cropped Area on Which Animal Traction Was Used
	(Hectares3/)	(Percent)
Millet	203.6	40.3
Sorghum	60.9	33.4
Maize	8.6	30.9
Peanut	23.3	31.4
Bambarra Nuts	4.0	20.7
Okra	0.7	6.8
Misc. Crops	5.6	16.3
Total	306.7	100.0

Source: Farming Systems Unit Sample Survey, 1980.

1/ 96 to 98 percent of the total cropped area under millet and sorghum had associated crops (secondary crops also grown in the field). Cowpea was the crop most used in such associations. Millet and sorghum were grown as associated crops as well as principal crops.

2/ Total area in the sample under various crops.

3/ One hectare equals 2.47 acres.

TABLE 21

USE OF ANIMAL TRACTION FOR FARMING OPERATIONS ON MAJOR CROPS OF SAMPLE FARMERS OWNING ANIMAL TRACTION, THREE REGIONS, UPPER VOLTA, 1980

Crop/ Operations	Percent of Farmers Using Animal Traction and Percent of Fields on Which Animal Traction Was Used					
	Nedogo (Ouagadougou)		Aorema (Ouahigouya)		Digre (Zorgho)	
	Farmers	Fields	Farmers	Fields	Farmers	Fields
Millet						
Land preparation	-	-	70	25	-	-
Planting	-	-	10	2	-	-
Weeding	63	24	20	5	10	10
Sorghum						
Land preparation	-	-	40	27	10	3
Planting	-	-	-	-	-	-
Weeding	53	46	-	-	10	3
Maize						
Land preparation	32	38	44	39	-	-
Planting	-	-	-	-	-	-
Weeding	-	-	-	-	-	-
Peanut						
Land Preparation	33	17	60	50	-	-
Planting	6	2	-	-	-	-
Weeding	16	5	-	-	-	-
% of Farmers Owning Animal Traction	60	-	40	-	10	-

Source: FSU Sample Survey, 1980.

TABLE 22

MAJOR CROP YIELDS ON ANIMAL TRACTION AND NO ANIMAL TRACTION FIELDS, SMALL FARMS SAMPLE, UPPER VOLTA, 1980

(Kilograms per Hectare)

Crops and Their Associations	Animal Traction Fields	No Animal Traction Fields
Millet		
Millet (main)	412.0	351.5
Cereals (association)	6.5	29.2
Cowpea (association)	5.1	21.4
Others (association)	2.8	6.0
Total Yields	426.4	408.1
Sorghum		
Sorghum (main)	532.6	422.8
Cereals (association)	16.1	101.1
Cowpea (association)	15.9	36.7
Others (association)	13.7	7.1
Total Yields	578.3	567.7
Maize		
Maize (main)	1323.7	772.3
Cereals (association)	6.0	208.3
Cowpea (association)	0.0	1.3
Others (association)	11.3	74.3
Total Yields	1401.0	1056.2
Peanuts		
Peanuts (main)	440.7	484.2
Cereals (association)	3.1	0.5
Cowpea (association)	0.0	0.0
Other (association)	39.4	37.9
Total Yields	483.2	522.6

Total Area Farmed (Millet)

Animal Traction Farms--------5.0 hectares
No Animal Traction Farms-----2.3 hectares

Total Area Farmed (Sorghum)

Animal Traction Farms--------2.1 hectares
No Animal Traction Farms-----0.9 hectares

Source: FSU Sample Survey, 1980.

of land area, but he can farm more land and produce more grain per farm and per person in his household than without animal traction.

Animal Traction and Saving in Labor Use

Animal traction affects labor usage on the farm. The data on per hectare labor time usage on the sample farms (Table 21) show that invariably planting of all major crops was done by hand, with human labor the key factor in this operation. On the other hand, animal traction was used to some extent for operations such as land preparation (clearing and plowing), and weeding.

Land preparation of maize fields with the help of animal traction required 178 man hours per hectare, whereas by hand alone, it required 218 man hours (Table 23)--a saving of 18 percent in labor attributable to animal traction. The saving was greater for peanuts. The high saving in labor in maize production occurs because maize fields are ploughed before planting, whereas other crops fields are seldom ploughed before planting.

Weeding is another labor time intensive operation very critical to crop production under the current farming system. Farmers used animal traction for weeding. However, most weeding by animal traction occurred on millet and sorghum fields which are relatively large fields. On millet fields, farmers with animal traction spent 176 labor hours per hectare as compared to 237 labor hours for such fields weeded by hand. On sorghum fields it took 200 hours per hectare for animal traction contrasted with 285 hours without (Table 23). Thus, weeding the two major crops by animal traction resulted in a labor savings in the range of 26 percent (millet) to 42 percent (sorghum).

The amount of labor available in a household serves as a constraint on the amount of land farmed. Animal traction appears to facilitate farming more land by the household. However labor usage increases also. The land-labor ratio is approximately the same for farmers with and without animal traction.[1] Rather than substituting capital (animals and equipment) for labor, the farmers are using the new technology as a means of increasing scale or size of the farming unit.

Increasing Demand for Animal Traction

The currently increasing demand for animal traction by Voltaic farmers is partly an attempt to increase farm size. Although farms are small in terms of land and use of modern inputs by Western standards, the relatively large sized farms have greater need and also more resources for animal traction than the small sized farms. Owning draft animals such as donkeys, oxen, and horses, and equipment, is a symbol of social prestige. Households owning such capital enjoy higher socio-economic status in the community. Hence, there is incentive to have such items even when not used to the fullest extent possible.

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[1] For greater detail on animal traction see SAFGRAD/FSU "1982 Annual Report" IE&R and IPIA, Purdue University, May 1983.

TABLE 23

LABOR USAGE FOR SELECTED FARMING OPERATIONS,[1/] SAMPLE OF SMALL FARMS IN THREE REGIONS, UPPER VOLTA, 1980

Operations	Hours of Labor Per Hectare: Millet	Sorghum	Maize	Peanut
Land Preparation by Hand	25	29	218	136
Land Preparation by Animal Traction	-	-	178	58
Planting by Hand	61	76	91	85
First Weeding by Hand	237	285	254	302
First Weeding by Animal Traction	176	200	-	-

Source: FSU Sample Survey, 1980.

[1/] Second weeding, animal care and several other operations are not included.

Credit Constraint for Animal Traction

When questioned regarding the credit constraint and credit use the majority of farmers surveyed said that it most severely limited the purchase of trained and reliable draft animals, and "houe manga", a local name for a donkey drawn hoe first used in Manga, U.V. More than 80 percent of the farmers surveyed wanted credit from formal credit institutions, the ORD's, the banks and cooperatives for the purchase of animal traction (both animals and draft equipment). Credit is unavailable to these farmers and trained animals relatively unavailable in the market. The absence of a well-integrated credit program that combines credit supply with supervision and production related information may be severely limiting the spread of technological innovations.

V. Production Functions for Major Crops: Results of Regression Analyses

Production relationships using log linear functions were estimated for the four major crops: millet, sorghum, maize and peanut. The dependent variable in the equations was per hectare yield of the principal crops with the parcelle (field) as the unit of observation. This allowed for more degrees of freedom, although household characteristics other than land, labor and input use could not be incorporated into the model. However, the estimated relationships enable us to measure the contribution of production factors such as field size, labor, associated crops, input use, and animal traction on farm yields. The variables of the production model are specified in Tables 24 through 29.

Impact of Field Size

The impact of the land variable, the size of the parcelle (field) on per hectare yield is consistently negative for all the four crops and in all the estimating equations of the production model. The regression coefficient for this variable is negative and statistically highly significant in all cases (Tables 24 through 29). This means that as the size of the parcelle or field increases the per hectare yield tends to decline. The relationship is plausible under the present farming system. In most cases the largest fields operated by households are located farthest from the compounds and village fields, and these fields are inferior in terms of soil fertility. Such fields are given the lowest priority in regard to timely performance of operations such as planting and weeding. The households first try to plant and/or seed the better quality fields located closer to the compounds and the village and then move to the big fields that are located farther away. It may also be more difficult to manage labor and other inputs on the more distant large fields.

The size-yield relationship as estimated in this study on the basis of per hectare yields and size of field or parcelle does not imply anything about farm size as related to efficiency. The question being addressed is how farm production per hectare is influenced through the use of yield augmenting inputs and other factors. In some cases animal traction may lead to somewhat larger farms. However, in regions of high population density e.g., the Mossi plateau, high quality land may not be available for more extensive farming.

Impact of the Yields of Associated Crops

Increased associated crop yields tended to have negative effects on the yields of the major crops with the exception of cowpeas in association with maize. This is indicated by preponderance of significant negative coefficients for associated crop yields (Tables 24, 25, 26, 27).

These negative coefficients for the associated crop yields imply a competitive relationship between the main crop and the associated crop in question. In the case of cowpeas with maize, the significant positive coefficients indicate a complementary relationship.

TABLE 24

ESTIMATED REGRESSION COEFFICIENTS FOR MILLET:
LOG LINEAR FUNCTION

Independent Variables of the Production Model	Equation 1 1/ 3/	Equation 2 2/ 3/	Equation 3 1/ 4/
Size of Parcelle (Hectare)	-.4905**** 5/ (.0520) 6/	-.4978**** (.0521)	-.4507**** (.0507)
Relative Yield of Cereal Crop (Association)	-.0940*** (.0449)	-.0918*** (.0449)	- -
Relative Yield of Cowpea (Association)	-.0840*** (.0332)	-.0834*** (.0331)	- -
Relative Yield of Other Crops (Association)	-.0844**** (.0260)	-.0848*** (.0260)	- -
Land Preparation Labor (Hours)	.0159 (.0311)	.0165 (.0334)	.0290 (.0311)
Planting Labor (Hours)	.1085 (.0552)	.1080 (.0556)	.1071 (.0551)
1st Weeding Labor (Hours)	.0707* (.0583)	.0778* (.0588)	.0663* (.0584)
2nd Weeding Labor (Hours)	.0354* (.0264)	.0385* (.0279)	.0902*** (.0261)
Use of Animal Traction	.3771*** (.1320)	.3794**** (.1316)	.2672**** (.1289)
Input Expenses	.0042 (.0264)	.0032 (.0263)	-.0181 (.0265)
Constant 'a'	4.1843		4.4746
R^2	.2607	.2643	.2258
$\bar{R}^2$	.2370	.2407	.2086
F	11.00	11.2	13.13
n	323	323	323

1/ All labor hours weighted equally regardless of source, i.e., male, female and children.

2/ Labor hours weighted: 1 male labor hour = 1 labor hour; 1 female labor hour = .75 labor hour; 1 child labor hour = .50 labor hour.

3/ Dependent variable = per hectare of yield (kilograms) of millet.

4/ Dependent variable = per hectare of yield (kilograms) of all crops (millet and associated crops).

5/ **** = significant at 1% level, *** = significant at 5% level, * = significant at the 20% level.

6/ Figures in parentheses are standard errors.

TABLE 25

ESTIMATED REGRESSION COEFFICIENT FOR SORGHUM:
LOG LINEAR FUNCTION

Independent Variables of the Production Model	Equation 1 1/3/	Equation 2 2/3/	Equation 3 1/4/
Size of Parcelle (Hectare)	-.4791**** 5/ (.0809) 6/	-.4921**** (.0811)	-.4966**** (.0821)
Relative Yield of Cereals (Association)	-.3558**** (.0812)	-.3536*** (.0808)	-
Relative Yield of Cowpea (Association)	-.3244 (.0631)	-.3179 (.2200)	-
Relative Yield of Other Crops (Association)	-.0724 (.0665)	-.0748* (.0663)	
Land Preparation Labor (Hours)	.0472 (.0556)	.0582 (.0596)	.0266 (.0564)
Planting Labor (Hours)	.0571 (.1036)	.0703 (.1039)	.1051 (.1055)
1st Weeding Labor (Hours)	.0092 (.0932)	.0010 (.0942)	.1163* (.0958)
2nd Weeding Labor (Hours)	.0507 (.0458)	.0526 (.0483)	.1041*** (.0461)
Animal Traction Dummy, 0-1	.0585 (.2204)	.0590 (.2200)	-.1886 (.2265)
Input Expenses CFA	-.0769 (.0551)	-.0792 (.0551)	-.0922* (.0567)
Constant 'a'	4.3338	4.2854	4.3863
R^2	.4471	.4212	.2645
$\bar{R}^2$	.4064	.4109	.2275
F	11.0	11.18	7.14
n	147	147	147

1/ All labor hours weighted equally regardless of source.

2/ Labor hours weighted: 1 male labor hour = 1 labor hour; 1 female labor hour = .75 labor hour; 1 child labor hour = .50 labor hour.

3/ Dependent variable = logarithm of per hectare yield (kilograms) of millet.

4/ Dependent variable = logarithm of per hectare yield (kilograms) of all crops (millet and associated crops.

5/ **** = significant at 1% level, *** = significant at 5% level, ** = significant at the 10% level, * significant at the 20% level.

6/ Figures in parenthese are standard errors.

TABLE 26

ESTIMATED REGRESSION COEFFICIENTS FOR MAIZE: LOG LINEAR FUNCTION

Independent Variables	Equation 1[1/][3/]	Equation 2[2/][3/]	Equation 3[1/][3/]
Size of Parcelle (Hectare)	-.5862***[4/] (.1090)[5/]	-.6012*** (.1088)	-.7832*** (.1556)
Relative Yield of Cereal (Association)	-.0750 (.1483)	-.0636 (.1486)	- -
Relative Yield of Cowpea (Association)	1.6656**** (.2771)	1.6360**** (.2756)	- -
Relative Yield of Others (Association)	-.1389* (.1037)	-.1544* (.1030)	- -
Land Preparation Labor (Hours)	-.1135 (.1505)	-.0940 (.1490)	.0545 (.1786)
Planting Labor	-.3002* (.1695)	-.3387** (.1682)	-.2860* (.2046)
1st Weeding Labor	.4687*** (.1569)	.4729** (.1609)	.4610** (.1869)
2nd Weeding Labor	.2229*** (.0859)	.2402** (.0908)	.2169** (.1038)
Animal Traction	.4028* (.2724)	.4191* (.2701)	.2327 (.3269)
Input Expenses CFA	-.0250 (.0803)	-.0342 (.0796)	-.0231 (.0972)
Constant 'a'	4.4504	4.4188	3.7075
R^2	.6338	.6366	.4019
$\bar{R}^2$	.5774	.5807	.3404
F	11.25	11.38	6.53
n	76	76	76

1/ All labor hours weighted equally regardless of source.

2/ Labor hours weighted: 1 make labor hour = 1 labor hour; 1 female labor hour = .75 labor hour; 1 child labor hour = .50 labor hour.

3/ Dependent variable = logarithm of per hectare yield (kilograms) of maize.

4/ **** = significant at 1% level, *** = significant at 5% level, ** = significant at 10% level, * = significant at 20% level.

5/ Figures in parentheses are standard errors.

TABLE 27

ESTIMATED REGRESSION COEFFICIENTS FOR PEANUT:
LOG LINEAR FUNCTION

Independent Variables	Equation 1[1]	Equation 2[2/3]	Equation 3[1/4]
Size of Parcelle (Hectare)	-.4211****[5/] (.0623)[6/]	-.4404**** (.0679)	-.4890**** (.0715)
Relative Yield of Other Crops	-1.0389* (.7033)	-1.0572** (.6902)	-
Land Preparation Labor (Hours)	.1574*** (.0585)	.1921*** (.0605)	.1338*** (.0613)
Planting Labor (Hours)	-.0127 (.0849)	-.0326 (.0839)	.0303 (.0891)
1st Weeding Labor (Hours)	.1736*** (.0659)	.1954*** (.0665)	.1785*** (.0674)
2nd Weeding Labor (Hours)	-.0898 (.1213)	-.1059 (.1359)	-.0417 (.1273)
Animal Traction	.1425 (.1456)	.1695* (.1431)	.1351 (.1528)
Input Expenses CFA	.1070 (.2071)	.1125 (.2123)	.1338 (.2173)
Constant 'a'	4.0049	3.0376	3.8718
R^2	.2119	.2342	.2198
$\bar{R}^2$	.1784	.2016	.1909
F	6.3190	7.1881	7.606
n	197	197	197

1/ All labor hours weighted equally regardless of source.

2/ Labor hours weighted: 1 male hour = 1 labor hour; 1 female labor hour = .75 labor hour; 1 child labor hour = .50 labor hour.

3/ Dependent variable = logarithm of per hectare yield (kilograms) of peanut.

4/ Dependent variable = logarithm of per hectare yield (kilograms) of all crops (peanut and associated crops).

5/ **** = significant at 1% level, *** = significant at 5% level, ** = significant at the 10% level, * = significant at the 20% level.

6/ All labor treated equal. Figures in parentheses are standard errors.

TABLE 28

ESTIMATED REGRESSION COEFFICIENTS FOR MILLET: QUADRATIC FUNCTION

Independent Variables of the Production Model	Coefficient[1/]
Size of Parcelle (Hectare)	320.3249****[2/] (16.7698)[3/]
Cereal Crops Relative Yield	-110.3155* (67.2628)
Cereal Crops Relative Yield Squared	36.3340* (25.7473)
Cowpea Relative Yield	-96.95.36* (57.6148)
Cowpea Relative Yield Squared	12.0186* (9.2607)
Other Crops Relative Yield	-102.0852 (209.5350)
Other Crops Relative Yield Squared	76.8300 (147.73201)
Land Preparation Labor (Hours)	.5680*** (.2722)
Planting Labor (Hours)	.9298*** (.2642)
1st Weeding Labor (Hours)	-.0598 (.0826)
2nd Weeding Labor (Hours)	.0052 (.0692)
Animal Traction	45.0259* (30.6806)
Purchased Inputs	.0069 (.0276)
Constant 'a'	-3.5711
R^2	.8197
$\bar{R}^2$	.8123
F	108.072
n	323

1/ Dependent Variable = Logarithm of total production (kilograms) of millet/parcelis.

2/ **** = signficant at 1% level, *** = significant at 5% level, ** = significant at 10% level, * = significant at 20% level.

3/ Figures in parentheses are standard error.

TABLE 29

ESTIMATED REGRESSION COEFFICIENTS FOR SORGHUM: QUADRATIC FUNCTION

Independent Variable of the Production Model	Coefficient[1/]
Size of Parcelle (Hectare)	-458.6395****[2/] (43.0311)[3/]
Relative Yield of Cereals (Association)	-43.1831* (27.5320)
Relative Yield of Cereals Squared (Association)	1.6631 (2.1016)
Relative Cowpea Yield (Association)	4.4499 (88.4837)
Relative Yield of Cowpea Squared (Association)	-20.7892 (24.5289)
Relative Yield of Other Crops (Association)	41.8141 (136.3184)
Relative Yield of Other Crops Squared (Association)	-5.4259 (25.3404)
Land Preparation Labor (Hours)	-.5298 (.7693)
Planting Labor (Hours)	-.3816 (.5126)
1st Weeding Labor (Hours)	-.1994 (.1834)
2nd Weeding Labor (Hours)	.2528* (.2072)
Animal Traction Dummy 0-1	89.5023* (54.3913)
Input Expenses CFA	-.1222** (.0678)
Constant 'a'	43.4027
R^2	.6286
$\bar{R}^2$	.5923
F	17.32
n	147

1/ Dependent variable = Logarithm of total production (kilograms) sorghum/parcelle.

2/ **** = significant at 1% level, *** = significant at 5% level, ** = significant at 10% level, * = significant at 20% level.

3/ Figures in parentheses are standard error .

To test further for complementarity between the crops for a range on the production possibility curve, quadratic production functions for sorghum and millet were estimated. The results (Tables 28 and 29) do not show any strong complementarity among the crops grown in association with these major crops.

The situation investigated involves only existing systems of production for both sole cropping and associated cropping of the parcelles. The relative yield situation might change with varieties and production technology.

Yield-Labor Relationships

For millet, the relationship between yield and labor used for land preparation, planting and weeding operations is positive (Table 24). Although the coefficient of labor input is relatively small, it is statistically significant at the 5 percent level for planting labor, at the 10 percent level for weeding labor, but not significant for land preparation labor. This indicates that the use of more labor would increase yields for this major crop. However, the marginal productivity of labor is very low.

The marginal productivity of labor in sorghum production is positive but low (Table 25). Also, it is not significant statistically.

For maize, both the land preparation and planting labor had negative but non-significant coefficients (Table 26). However yield was strongly positive and significantly related with weeding labor time. The coefficient of maize weeding labor is much greater in magnitude and higher in the level of statistical significance than for all of the other crops.

For peanut, land preparation and weeding labor had a positive influence on yields. The regression coefficient of labor in both cases is statistically significant at the 5 percent level (Table 28).

Animal Traction. This variable was treated as a "dummy" with 0-1 values (zero for no animal traction). Hence, the coefficient of this variable indicates change in the level of yields for any given input combination, i.e., change in the Y-intercept in the logarithmic form of the model without changing the other coefficients of the production function.

The results show a positive and in most cases statistically significant impact of animal traction on yield levels. In all the production models the coefficient of the animal traction dummy appears positive (Y intercept = constant 'a' $\pm$ the positive dummy coeffient). This means that other things constant, animal traction farms will harvest higher levels of yield than the farmers without animal traction. Animal traction shows a greater positive effect on yield levels of millet and maize than it does on the other two crops.

The results of the regression analyses are supporting evidence that two important effects of animal traction on the household farming system are (1) a positive effect on crop yields, and (2) enables households to farm more land. It appears that the principal constraint to area expansion was timely first weeding. Animal traction apparently overcomes this constraint and enables land area expansion.

Purchased Inputs

Of the variables considered, the purchased input variable had the least effect on crop yields. In the case of millet and peanut, the estimated coefficient for this variable was positive, although statistically non-significant. In the case of sorghum and maize, the coefficient was negative but not statistically significant. These results are not surprising since modern input use is negligible in the existing production systems. The effects of the modern inputs are not statistically detectable probably because the levels of input use are so low.

Overall Performance of the Production Models

On the basis of the multiple coefficient of determination, R^2, the production function models leave a large part of the variation in yields unexplained. In the case of millet, none of the three estimating equations explains more than 23 to 26 percent of total variation in yield. For sorghum and maize, the performance is a little better with R^2 in the range of .41 to .63. For peanut, the value of the R^2 ranges between .18 and .20. In all cases however, R^2's were significantly different from zero.

On the other hand, with production in semi-arid Africa so heavily dependent upon weather conditions, it may not be possible to formulate a production function that can better explain variation in yield without a weather variable. Also, the production functions used in the present analysis were not intended for predictive purposes. The above analysis was made to give evidence that crop yields in the sampled region were responding to certain important controllable input variables and to show the direction and relative size of these responses.

The Estimated Marginal Value Products (MVP) of Factors of Production

The marginal value products (MVP) estimated from production functions for the four major crops are presented in Table 30.

TABLE 30

ESTIMATED MARGINAL VALUE PRODUCTS (MVP) OF FIELD SIZE AND LABOR FOR MAJOR CROPS: SMALL FARMS, UPPER VOLTA

Input	Millet[1/] (CFA)	Sorghum[1/] (CFA)	Maize[1/] (CFA)	Peanut[1/] (CFA)
Field Size (Hectares)	13422.0	14400.0	25480.0	22000.0
Planting Labor (Hours)	27.2	9.0	--	6.0
1st Weeding Labor (Hours)	5.3	--	8.3	8.2
2nd Weeding Labor (Hours)	4.0	8.3	--	--
Purchased Inputs (CFA)	0.85	--	--	--

1/ 1 US dollar = 225-250 CFA

The Marginal Value Product of Land

Maize land yielded the highest marginal value product of 25480 CFA (US $115) per hectare of area, followed by peanut with a marginal value product of 22000 CFA (US $98) per hectare. Millet land gave the lowest marginal value product of 13422 CFA (US $60). Looking at the MVP figures, it would appear that farmers in the study region would be better off transferring land from millet and sorghum crops to maize and peanut production. However, this depends principally on three factors: (1) the availability of land suitable to maize production under the present conditions, (2) farmers' tastes and preferences, and (3) the input supplies including information systems required for growing maize and/or peanut. In the latter group of factors, the availability of labor input can be a serious constraint in view of the relatively much higher priority currently assigned by farmers to millet and sorghum--the two most dominant crops in the existing farming systems which compete with maize and peanuts for labor and other inputs.

The Marginal Value Product of Labor

The marginal value product of planting labor is generally higher than that of weeding labor. However, overall the MVP of labor under the existing production system is extremely low. Except for planting labor of millet for which the MVP of labor per hour is 27 CFA (US $0.12), the MVP of labor estimated for the major production operations does not exceed 9 CFA per hour. Such low marginal value products indicate the low value of additional labor in the current farming system. Wages of hired labor are usually no higher than its marginal value product otherwise no labor is hired. The fact that little if any labor is hired on a wage rate basis in present day agriculture of Upper Volta is consistent with this finding. (The navetane system is used instead.)

The Marginal Value Product of Purchased Inputs in Millet Production

The marginal value product of purchased inputs with current production practices was estimated for millet. However, there was an insufficient number of users to give a reliable estimate.

VI. Low Farm Yields, New Technology, Adoption Problems and Prospects

The farm level yield data collected in the present study indicate extremely low crop yield conditions in the agriculture of the region. There are several questions and issues involved in a search for the variables causing low yields and for the ways to effectively promote yield-increasing technology. One is: Do we, more specifically those in charge of planning and development efforts, have adequate information and understanding to create conditions for improving farming practices enough to increase yields per hectare from the present low level of around 500 kilograms to, say, 1000 kilograms?

Despite the fact that some of the improved varieties of crops such as sorghum and maize have been found to give much higher yields, 3 to 4 m. tons of grain per hectare on experimental plots at research stations under highly controlled conditions, and despite the successful performance of these new crop varieties, and other "improved" practices in some farmers' fields they are not fully accepted. If the farmers were informed and convinced that the new maize varieties perform profitably under their conditions and constraints, adoption of such technology could be expected.

Apparently the farmers are not convinced that the new varieties maximize returns to their scarce resources. An irregular supply of modern inputs at affordable prices may affect the situation. Additionally, the new varieties may differ from the traditional varieties with respect to timing of labor requirements. This may create labor constraints that affect timeliness in planting and in performance of other field operations that are sensitive to rainfall patterns.

On the other hand, sorghum, millet, and maize prices have risen about twice as much since 1968 as the amount of inflation and the prices of alternative crops.[1] This should favor higher yielding varieties unless the prices are offset by an unfavorable input cost situation.

Grain marketing conditions probably do not favor technological improvement and growth in the farm productivity of Upper volta. From 1978 to 1980, the official government prices ranged between 40 and 45 CFA per kilogram of millet and 32 to 37 CFA per kilogram of sorghum. These prices were lower than open market prices. For example, in the latter half of 1980, farmers were selling millet and sorghum in open markets for 60 to 75 CFA per kilogram. At that time the government was considering setting the minimum prices of 40 to 45 CFA per kilogram. Even though this price policy provides some disaster insurance, it may not alter greatly the farmers' view of the risk associated with investments required to increase the production of the various crops. The farmers do what they consider most advantageous under the local marketing conditions, but there may be little incentive to take any risks with modern inputs that may or may not pay off immediately under the variable rainfed production conditions coupled with a relatively uncertain product price situation.

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[1] See Table 1-8, World Bank, "Upper Volta Agricultural Issues Study," Report No. 3296-UV, October 29, 1982.

In low resource areas of high risk farming new technology has to be low in cost if the individual farmers are to adopt it without special incentives and outside assistance. Farmers in the plateau area of Upper Volta run high risks of crop losses from lack of rainfall and its erratic distribution. They have no control over this variable and risk of crop losses can not be completely eliminated with rain-fed farming in semi-arid zones of Africa. A great challenge to agricultural scientists is to evolve technologies that permit crop production to better withstand these weather conditions, technologies that fit well into the known farming systems, and insure higher return to farmers than the traditional technologies that have evolved by trial and error.

Other conditions faced by farmers in the sample areas are equally unfavorable. In general the farm extension services do not reach most of the farmers. These services are poorly organized, lack trained personnel and have limited financial resources. In one of the five sample villages, farmers said they had not seen any ORD extension agent for the last ten years! In a country where 95 to 98 percent of the farm population is illiterate, a weak and often inefficient system for extension of technical information can seriously limit technological change and improvement in agriculture. An innovation does not spread unless there are effective communication linkages.

Availability of input supplies such as chemical fertilizers, insecticides and pesticides, farm equipment, draft animals to pull such equipment, and the lack of credit to buy these modern inputs pose serious problems to farmers. Poor transportation coupled with inefficient input markets can cause farmers to view modern imput use as uneconomical. This may further discourage farmers from investing in new production technology.

It is extremely difficult to increase agricultural production under present conditions. There are strong forces favoring the status quo in the production system. It may very well be an efficient agriculture under the existing conditions and constraints. However, it is not a progressive agriculture from the viewpoint of the needs of the country in a changing world.

This situation does not imply that farmers in Africa are primitive, backward, inefficient and irrational because they follow old production practices. Their action merely indicates rational resource allocation decisions and choice of production practices under the set of conditions and constraints with which they are faced. The view that these farmers are irrationally following outdated practices indicates (1) a failure to appreciate the social and economic realities of farming in these regions and (2) a failure to understand the constraints of the existing farming systems.

Conditions for Adoption of Improved Production Technology

Innovation is generally considered an important part of progress in a productive agricultural sector. A number of factors may affect the search for productive innovations and their acceptance by farmers. This section focuses on conditions for adoption of a different technology assuming that it is available for consideration.

1. The first and a necessary condition is that a new production technology has to be less costly in the use of the farmer's resources or achieve greater returns from the same resources when compared with the traditional technology given the resource availability and constraints at farm level. Yield maximization *per se* is generally not one of the farmer's goals. His production decisions and choices involve trade-offs among goals. Under rainfed farming conditions he tries to reduce risks to an acceptable level. Those methods and technologies that increase achievement of one objective with little decrease in others given the farmer's economically most scarce resource (labor in many cases) are the best candidates for adoption.

2. A second condition is that the farmer have the knowledge and wisdom to evaluate the benefits and costs of the new technology and the skill or means of acquiring the skill to implement it. Involved here are farmers' training, schooling, the extension services, and other information systems. In the long run this means education of children and women which is a long-term investment. For payoff in the short term, adult education through extension services or other means is a likely necessity.

3. Improved infrastructure to serve rural areas, such as better roads and marketing facilities, is another condition that promotes movement of goods and services, information and people. The flow of technical information and information which facilitates exchange and efficient marketing as well as lower transport costs increases output-input price ratios which in turn furnishes incentive for economic changes.

4. Adequate input supplies, credit and distributional systems are needed to support yield increasing technologies. The current situation is inadequate with respect to both availability and stability of supplies and credit.

5. Farmers use expectations of market price to make decisions regarding levels of production, methods of production and product mix. This is especially true as economic development proceeds. Subsistence farmers may at first only sell surplus crops but eventually as economic development proceeds, they seek more of the benefits of exchange. The pricing system should give the producers adequate signals of the society's needs. For this to happen, governmental policy and actions must be consistent with those same needs and the government must be strong enough and stable enough to create a suitable political and economic environment.

Under the above conditions the farmer would be motivated to adopt improved farming practices and modify farming systems to achieve his goals and those of society. When appropriate and transferrable technology is available under the above conditions, the farmer would have the incentive to use it. However, the farmer is generally expected to be shrewd enough not to accept any new idea until its benefit to him has been amply demonstrated.

Micro Level Crop Substitution: Problems and Prospects[1]

Sorghum and maize are two crops for which improved varieties are being promoted for farmers in Upper Volta and in other parts of West Africa. In most cases these crops compete with each other for fertile soils. However farmers generally allocate a relatively greater proportion of cultivated land to sorghum than to maize. Maize is relatively more sensitive to weather conditions than is sorghum and farmers run greater risks of losing this crop when there is drought. As a rainfed crop sorghum has relatively greater probability of survival under drought conditions than the maize, other things equal.

The relative cost-benefit perspective of sorghum and maize can be altered by technological changes, such as introduction of a drought resistant high yielding seed variety, or modification of the existing management practices. If this makes maize relatively more profitable, the chances for allocating more land to this crop will increase. Effective profitability may be realized through lessening risk of low yields, reducing per unit cost of production, or increasing per hectare yield with the same input cost. Since maize occupies a relatively much smaller fraction of total cultivated land under the existing farming system, one might expect the area devoted to it to be potentially expandable.

However, maize production cannot be expanded over all of the country. The agro-climatic requirements of this crop give certain areas such as the Southwest and the Fada regions higher potential for production increase than the Central and Northern regions. These regions have a comparative advantage in terms of soils, rainfall and other favorable resource endowments (Table 7). In the region of study, the maize area continues to be very small despite the fact that the marginal value product for land sufficiently fertile to support maize is much higher than the less fertile land needed for sorghum. Farmers have some constraints preventing them from expanding area under maize. The amount of fertile land available for maize including the cost of fertilizer and possibly the higher risks that maize may be subjected to as a result of inadequate and fluctuating rainfall are some of the constraints. In addition, a currently limited market for maize for roasting ears may be another constraint on expansion of maize area and production. The price for the dry grain is apparently not high enough to encourage expansion of this crop.

In terms of kilograms of grain per hectare, cowpeas could compete with peanuts for land and other inputs if farmers were to plant it as a single crop. The improved cowpea variety, KN-1 performs much better when grown as a single crop since that permits certain necessary operations, particularly spraying, which are key elements influencing yield.

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[1] For a more complete land use discussion see Mahlon Lang, Ronald Cantrell, and John Sanders, "Identifying Farm Level Constraints and Evaluating New Technology in the Purdue Farming Systems Project in Upper Volta". Paper presented at Farming Systems Symposium, Kansas State University, Manhattan, Kansas, October 31, 1983.

The yield potential for the cowpea variety KN-1 is at least 1500 kg per hectare given three to four sprayings of insecticides. Even if one assumes that in farmers' fields, the per hectare yield only reaches 1000 kg, this would be much higher than the present yield levels of 200 to 250 kg per hectare.

A rough and quick cost benefit calculation suggests the following. For a hectare of land under the new cowpea variety, the farmer will need to incur a total cost of 31800 CFA (labor cost = 11600 CFA, seed cost = 3200 CFA, fertilizer 3000 CFA, and spraying including variable costs and depreciation on the sprayer 14000 CFA). He will receive a total revenue of 45000 CFA (based on 45 CFA/kg and a yield of 1000 kg/hectare under the new variety). The net revenue realized by the farmer will be 13200 CFA per hectare. However, to realize this net revenue, he will need to make an initial investment of 24000 CFA (of this the sprayer at the subsidized rate will cost 15000 CFA). Before a farmer makes any decision, he faces two important questions. First, how and where to get 24000 CFA to undertake the initial investment. Second, even if he were successful in getting the money, is it more advantageous for him to invest this money in the sprayer than elsewhere, e.g., to buy a houe manga or a donkey.

There are other questions as well. Will cowpea yield higher revenue per hectare of land than its competitor, other things being equal? We do not know if this is so. Marketing and pricing of cowpea, if production in the region changed, are other issues that would need consideration. Then there is the question of an infrastructure that would promote cowpea production. Farmers' knowledge and capabilities are essential elements in the whole process of spreading the new cowpea technology on small farms, knowledge about the use of sprayers to make them economical, money to buy the equipment, repair facilities, etc.

Various questions pertinent to new cowpea technology that need to be investigated include the following: 1) Relative profitability or returns from cowpea vis-a-vis its competitors; 2) Extent of competition for land and other resources among crops, e.g., cowpea and peanut; 3) Economic returns to sprayings--estimates of yield in relation to the timing and number of sprayings, and alternate uses of sprayers that make investment remunerative; and 4) Relative economics of cowpea production as a single versus an associated crop.

VII. Some Comments on National and International Research and Development Efforts

There are several international institutions in Upper Volta with competent and devoted agricultural scientists: plant breeders, agronomists, soil and water management specialists, entomologists, plant pathologists, and farming systems experts. Effective coordination is made rather difficult by the lack of a strong national research system that can furnish an appropriate linkage to avoid duplication, to promote areas of research best suited to the country's felt needs and priorities, and to monitor the flow of foreign aid in the area of agricultural research. This situation is not uncommon in developing countries.

It seems reasonable that a fairly substantial part of foreign assistance, no matter whether from individual countries or from international organizations, should be devoted to building strong national research capabilities with indigeneous trained scientists. The initiative for this effort will have to come from the host country. A cadre of scientists and other experts subject to the vagary of foreign interests and funds cannot substitute for national scientists whose future depends on the host country. However, building and strengthening national research capabilities will require investment of resources in local research and educational institutions and facilities, training of local personnel, and making appropriate modification in the existing systems of education, and research. International educational and research organizations and their scientists also can be an important means initiating such changes. These organizations can aid in the development of centers of higher learning and research (universities, colleges, research institutes) in the host country. There is certainly effort made to do this but even more is required. In most cases, this will require additional funds for faculty and graduate students at the local institutions as well as for foreign experts. Such a process may be slow, but should be effective for developing indigeneous capabilities in the long run.

Good working relationships and interaction among the various groups of international scientists are important. If they can use their limited resources to work harmoniously together to coordinate their research and avoid duplication they will be of better service to the host country or countries. Some of their resources allocated to areas of high pay off even when not the most popular projects can benefit the host country greatly. Having international scientists in the country may contribute to the host country's prestige internationally and make it difficult not to accept offers of all kinds of research. The donor countries must accept considerable responsibility for direction and coordination in this situation.

Formal schooling has been neglected in Upper Volta and several other less developed African countries. Educating rural people and farmers, men and women, and children may well be an investment with a very high payoff. Not more than 10 to 15 percent of rural children in Upper Volta attend any kind of school. Illiteracy among farm women is almost one hundred percent. So far most of foreign aid received by the country has gone to the construction of physical capital rather than human capital. Foreign aid could play an important role in the creation of human capital in the farm population, the most neglected segment of Upper Volta's population. The farm population has been given least priority in the allocation of both national and international resources. Foreign aid for higher level training is also important, but training a few students at the graduate level is not enough. A broad-based foundation of human capital at the farm and community level is essential to farm modernization. However, this requires some change in priorities of both the donor country and the receiving country with respect to foreign assistance.

It may be time that those of us concerned with agricultural development and welfare of the farm people in the developing countries pay heed to what Dr. T.W. Schultz said at Stockholm (Sweden) when delivering his Nobel lecture (1979) entitled "The Economics of Being Poor". To quote:

> "We have learned that agriculture in many countries has the potential economic capacity to produce enough food for the still growing population and in so doing can improve significantly the income and welfare of the poor people. The decisive factors of production in improving the welfare of poor people are not space, energy and crop land. The decisive factor is the improvement in population quality.[1]

The above comments are not meant to minimize the importance of previously stated observations on the need for efficient markets with appropriate price signals, construction of infrastructure necessary to sustain price signals, construction of infrastructure necessary to sustain a productive agricultural technology, and the establishment of effective backward and forward linkages between research and extension agencies, and priorities for allocating resources for agricultural development and research. These are important considerations with policy implications that must not be neglected if the development of the agricultural sector and economy as a whole is desired.

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[1] Theodore W. Schultz, "The Economics of Being Poor," Nobel Lecture, December 10, 1979, Stockholm, Sweden (Nobel Foundation).

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APPENDIX TABLE 1

LABOR USAGE ON MAJOR CROPS: SMALL FARMS IN UPPER VOLTA, 1980

Crop/Type of Farm	Number of Parcelles	Land Prep.	Planting	First Weeding	Second Weeding	Exchange Labor From Outside of Family1/
		- - - - - hours/hectare - - - - -				
I. Millet						
1. All parcelles	340	25	61	212	136	18
2. Animal Traction Fields	58	26	50	176	98	18
3. No-animal Traction Fields	282	24	68	237	162	18
II. Sorghum						
1. All parcelles	147	29	76	256	166	14
2. Animal Traction Fields	24	34	50	200	124	11
3. No-animal Traction Fields	123	27	89	285	187	15
III. Maize						
1. All parcelles	97	203	91	254	169	0
2. Animal Traction Fields	22	178	98	244	234	0
3. No-animal Traction Fields	75	218	88	259	140	0
IV. Peanut						
1. All parcelles	220	112	85	302	14	5
2. Animal Traction Fields	49	58	88	293	38	2
3. No-animal Traction Fields	171	136	83	307	4	7

Source: FSU Sample Survey 1980.

1/ This is for all operations during the agricultural season.

APPENDIX TABLE 2

CROPPING PATTERN - SMALL FARMS, UPPER VOLTA, 1980
(All areas measured in hectares[1/])

Principal Crops[2/]	Total Area in Sample	Total Area Under All Crops	Area Where Animal Traction Was Used	Total Area Under The Crop	Area Without Animal Traction[2/]	Cropped Area Per Household
	(ha.)	(%)	(ha.)	(%)	(ha.)	(ha.)
Millet	203.58	66.4	82.19	40.3	121.34	3.40
Sorghum	60.89	19.8	20.34	33.4	40.51	1.00
Maize	8.63	2.8	2.66	30.9	5.97	0.14
Peanut	23.34	7.6	7.34	31.4	16.00	0.34
Earthpea	3.96	1.3	.82	20.7	3.14	0.07
Okra	.73	.2	.05	6.8	.68	0.01
Misc. Crops	5.64	1.8	.92	16.3	4.72	0.09
Total	306.77		134.32		172.45	5.05

Source: Farming Systems Unit's Sample Survey, 1980.

[1/] 1 hectare = 2.47 acres.

[2/] 96 to 98 percent of the field areas under millet and sorghum had associated crops with cowpea as the dominant crop in association. Millet and sorghum are also grown as associated crops.

APPENDIX TABLE 3

Estimated Regression Coefficients for Millet: Log Linear Function

(Dependent Variable: Per Hectare Yield in kilograms)

Independent Variables of the Production Model	Coefficient
Size of Parcelle (Hectare)	-.4913****1/ (.0517)2/
Relative Yield of Cereals Crops (Association)	-.0933**** (.0454)
Relative Yield of Cowpea (Association)	-.0882**** (.0339)
Relative Yield of Other Crops (Association)	-.0762**** (.0261)
Land Preparation (Male Labor)	-.0272 (.0498)
Land Preparation (Female Labor)	.0151 (.0475)
Land Preparation (Child Labor)	.0617 (.0604)
Planting Labor (Male)	.0090 (.0606)
Planting Labor (Female)	.0965** (.0538)
Planting Labor (Children)	-.0133 (.0557)
1st Weeding Labor (Male)	.0541* (.0441)
1st Weeding Labor (Female)	-.0646* (.0450)
1st Weeding Labor (Child)	.0568* (.0424)
2nd Weeding Labor (Male)	.0810** (.0462)
2nd Weeding Labor (Female)	-.0103 (.0380)
2nd Weeding Labor (Child)	.0041 (.0383)
Animal Traction	.3651*** (.1337)
Input Expenses (CFA)	.00003 (.02720)
Constant 'a'	4.5618
R^2	.2882
$\bar{R}^2$	.2461
F	6.84
n	323

1/ **** = significant at the 1% level, *** = significant at the 5% level, ** = significant at the 10% level, * = significant at the 20% level.

2/ Figures in parentheses are standard errors.

Summary

Upper Volta in West Africa has a relatively unproductive, rainfed, small-farm agriculture. This country has been the recipient of a considerable amount of foreign assistance for agriculture but agricultural development has been slow. Two and two-tenths million hectares (42% of the arable land) are used to produce cereals. Cereal yields average around 500 kg. per hectare. Unless agricultural productivity increases more of the countrys' resources will be needed for food imports to satisfy a growing population. There is some hope that new or improved agricultural technologies including new crop varieties can successfully resolve this difficulty.

Household farming systems are described in this bulletin based on a sample survey at three locations in Upper Volta in 1980. Land and labor are the farmers' most important resource. Capital is limited mostly to hand tools, a few farmers have draft animals and simple traction implements. The average farm size operated by a household is about five hectares or less than half a hectare of land per person.

Millet and sorghum are the two most important cereal crops. These crops are generally grown in association with other crops of which cowpea predominates. Small fields of maize are usually close to the compound where the most fertile soil is maintained by the use of organic wastes. Peanuts are the principal cash crop.

Women and children provide over 50 percent of the household's farming labor. There is a definite pattern in the role of women in the farming system.

Farming practices do not involve more than minimal use of fertilizers and other modern inputs. Mostly local cereal crop varieties are grown. The crops are grown on many small fields. Only 33 percent of the households had donkey (animal) traction. Households with animal traction tended to have higher yields and farm more land than households without draft animals. Use of animal traction for weeding apparently relieved a labor bottleneck.

Production relations were estimated with regression analysis. The smaller fields of all four major crops (millet, sorghums, maize and peanuts) tend to yield relatively more per hectare than larger fields. This probably is a result of the most fertile fields closest to the compound being smaller than the less fertile fields farther away.

Associated crops tended to compete with the main crop rather than be complementary to the main crop. That is, the higher the yield per hectare of the associated crop, the lower the per hectare yield of the main crop, other things equal.

Results of the labor input analysis were somewhat mixed. Timeliness rather than amount of labor usage probably affects the situation. As previously indicated animal traction had a positive effect on yields per hectare and allowed a household to farm more land, other things equal.

In general yields were low. Farmers used traditional methods and varieties apparently not finding it in their interests to use much fertilizer or grow varieties of crops currently tried at the experiment stations. The high variability caused by the weather of their semi-arid agriculture as well as uncertain markets were a part of this situation.

Some general views of economic development that may be considered reinforced by the researchers' experience with the farming systems survey and analysis follow. Innovation is generally considered as an important part of progress in a productive agricultural sector. A new technology to be successful has to achieve more with the same resources than the current methods or cost less to get the same results. Further, if it isn't possible to implement the new innovations with the range of skills and knowledge of the potential users is will not be rapidly accepted. Education and information resources may also be needed.

Infrastructure such as transportation, farm supply markets, product markets and technical assistance play an important role in speeding technological change. Also, suitable sources of credit and a favorable political climate may be considered in this context.

It is possible to change varietal characteristics through breeding and experimentation. Although cost-benefit analyses indicate great potential gains, the problems of fitting the experimental varieties to the actual farming environment is complex.

Assistance programs that contribute to training local personnel as well as modifying the existing systems of education and research seem desirable for lasting impact. Perhaps the most underated technical assistance investment is simply formal schooling of rural people. Illiteracy rates are exceptionally high among the men, women and children involved in the small-farm peasant agriculture of Upper Volta.