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TITLE OF THESIS.INTERREGIONAL..COMPETITION..IN
..ETHIOPIAN...AGRICULTURE.....
....

UNIVERSITY..UNIVERSITY..OF..ALBERTA..........

DEGREE FOR WHICH THESIS WAS PRESENTED..PH..D..............

YEAR THIS DEGREE GRANTED........1973....................

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NL-91 (10-68)

THE UNIVERSITY OF ALBERTA

INTERREGIONAL COMPETITION IN ETHIOPIAN AGRICULTURE

by

© TELAHUN MAKONNEN

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

EDMONTON, ALBERTA
FALL, 1973

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Interregional Competition in Ethiopiah Agriculture," submitted by Telahun Makonnen in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

The main objective of the study was to examine the regional pattern of production and the interregional flow of cereals in Ethiopia in 1966 and 1980. A linear programming technique was used to determine the optimum distribution of production and transportation of wheat, barley, teff, corn and sorghum. The objective function was the minimization of production and transportation costs.

For the study the country was partitioned into twenty-eight producing districts and nineteen consuming (demand) regions, for which appropriate cost coefficients and constraints were defined. The analytical procedure involved the determination of the most efficient regional allocation of resources to satisfy the 1966 and 1980 consumption requirements, given 1966 and 1980 data. Under both conditions cultivated land was assumed to remain constant.

Ex post analysis for 1966 indicated that regional specialization according to the regional comparative advantage would be beneficial to the country. The least cost solution to Model I suggested that it would be possible to save up to approximately one million hectares of land for purposes other than the production of the crops in question by allowing regional specialization alone. If fertilizer were applied, it would be possible to save up to 2.4 to 2.7 million hectares of land, depending on the amount of foreign exchange allocated for fertilizer importation.

The 1980 projected demand for the various commodities under investigation could not be met without increases in the cultivated land or addition of sufficient amounts of fertilizer which necessitated the use of about $227 million worth of foreign exchange.

Changes in institutions, infrastructure, economic conditions, and social organizations were suggested to facilitate the implementation of regional specialization. Since implementation of these programs would require heavy capital investment, the importance of developing priorities was emphasized. To acquire firsthand knowledge of the responses of farmers to the economic incentives suggested above, pilot programs in selected districts of the country should be conducted.

ACKNOWLEDGEMENTS

Many individuals and organizations have contributed to the successful completion of this manuscript. The author gratefully acknowledges their contributions.

I am particularly grateful to my major supervisor, Dr. Travis W. Manning, whose assistance was beyond the call of duty. I feel privileged to have had the opportunity to work with him. The criticism and suggestions provided by Drs. William E. Phillips, Sten E. Drugge, and Wolfgang M. Schultz were extremely useful in the preparation of the thesis.

Dr. H.C. Love was of great assistance in the initial stage of the study. Messrs. Getachew Tecle-Medhin and Yilma Teclemariam provided valuable comments and suggestions during the preparation of this manuscript.

I would also like to acknowledge my debt to: Miss Evelyn Shapka, who carefully edited and improved the literary quality of the manuscript; Mr. Clare Shier, without whose assistance I could not have overcome the programming problem; Mr. Ronn Bence for his assistance in preparing the maps; and Mrs. Lasha Savage who did an excellent job of typing the manuscript.

Major financial assistance for my study in Canada was obtained from the Canadian International Development Agency. The University of Alberta and the Haile Selassie I University have also contributed towards my financial support.

Most of the data on Ethiopian agriculture were obtained from the files and publications of the Stanford Research Institute. I thank the

Institute for allowing me the use of all available materials on Ethiopia. I am particularly grateful to Dr. Clarence J. Miller and Mr. James Mackin of the Stanford Research Institute and Mr. James Sartor, formerly of the Institute, for their personal assistance.

Finally, I wish to thank my wife, Sinkinesh, who had to go through the hardship and loneliness of living in a strange land. Without her loving care and understanding, this study would not have been accomplished.

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CHAPTER I

INTRODUCTION

Purpose and Scope of the Study

Ethiopia's present and future economic conditions depend very heavily on its agriculture. Without improvement in agriculture, its drive towards growth and development would likely be hampered. At present the agriculture of the country is dominated by peasant cultivators who depend on traditional techniques of production and distribution. Although the country is primarily agricultural, it has not been able to provide nutritionally adequate food for its rapidly growing population. Unless the techniques of production and distribution are improved, it might even be difficult to maintain the existing level of consumption in the very near future. In the past, general shortages of agricultural products and even sporadic famines were not uncommon in many parts of the country.

Most of Ethiopia's agriculture is concentrated in the plateau portions of the country, mainly in the highlands of Harargie, Arussi, Shoa, Wollo, Gojam, Begemdir, Tigre, and Wollega. The agriculture of these regions is characterized by mixed farming. Cereals, pulses, oil seeds and livestock are raised. Since exen are needed for draft purposes, the raising of livestock is necessary. Generally these regions are densely populated, and range from 20 to 160 persons per square kilometer. The highland areas are so densely populated that lands too steep for farming are being cultivated, thus exposing them to severe erosion.

The main reasons for the concentration of settlements in the Central Plateau of Ethiopia are: sufficiency of precipitation for dryland farming, accessibility to market areas and other parts of the country, and favorable weather conditions from the standpoint of health. The highlands of the south and southwestern provinces have generally good soil and ample rainfall for agricultural purposes, but these regions are presently under-occupied, primarily due to severe problems of accessibility. The lowlands of Ethiopia, too, are presently underutilized due to lack of water and health problems associated with these regions.

Expansion of agriculture into the south and southwestern provinces and into the lowland regions would require heavy investment in infrastructure such as dams and irrigation facilities, roads, health facilities, and the like, entailing expenditure levels that are out of reach, especially in the very near future. Thus, the possibility of expanding Ethiopia's agricultural output by bringing new land into cultivation is limited. With the exception of a few regions, the amount of land being cultivated together with the amount that is needed for grazing has about exhausted the effectively available area where a great part of the population live. There is very little in the way of an extensive margin of cultivation in the areas presently settled under the traditional system of cultivation.

Assuming that there is very little opportunity for increasing agricultural output by bringing new land into cultivation because of (1) the lack of unused, cultivatable land in the presently settled high density areas and (2) the heavy capital commitment necessary to settle people in the under-occupied areas, how can the country increase its agricultural output? This is the problem with which this study is concerned. Regional specialization is one way of increasing total output and this is the subject to be investigated.

The goal was to determine the extent of improvement in efficiency that could be achieved by reorganization of production according to regional comparative advantage. Specifically, the question was: Would it be possible to satisfy 1966 and 1980 demands for the commodities in question with less resource inputs (including land) by a production allocation that recognizes regional comparative advantage? Interregional commodity flows were assumed in contrast to the existing practice of locally raising most of the products needed by the family. The hypothesis selected to be tested was that spatial distribution of production according to the principle of comparative advantage would reduce the total national cost of supplying a fixed quantity of goods.

The study also attempted to investigate the possibility of releasing more land in the highlands from use by the five crops (wheat, barley, teff,[1] corn and sorghum) considered in this study. The land released could be used for other crops such as pulses and oil crops, or be converted to pasture.

Objectives of the Study

The study examined quantitatively the comparative advantages of the various agricultural producing areas in Ethiopia. Emphasis was on the determination of geographical location of crop production (namely wheat, barley, teff, corn, and grain sorghum) and interregional commodity

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[1] Teff (*Eragrostis abyssinian*) is a cereal grain of very small seeds measuring about 1 to 1.5 millimeters in diameter (2.5 to 3 million seeds per kilogram).

flows in a manner consistent with regional comparative advantage and with both domestic demand and export demand requirements.

No two geographical areas are exactly alike in their agricultural characteristics (soil, rainfall, cropping, type of farm, etc.). Some regions are more suited than others for the production of particular agricultural products. An implicit assumption of this study was that, since regions are variously endowed with factors of production and natural conditions, regional specialization of production, as dictated by the principle of comparative advantage, will increase total production with a given amount of total cost. Said in another way, the fixed level of demands for the various agricultural products could be satisfied with less cost. The study also provided a measure of the excess capacity of each region (that is, slack land area could be used to measure excess capacity). The excess land resulting from the program could be withdrawn from the production of wheat, barley, teff, corn, and grain sorghum and directed to other uses such as grazing or the production of export crops not included in the study if production were allocated according to regional comparative advantage.

The specific objectives of the study were:

1. To determine the most efficient production patterns among producing regions for the commodities in question.

2. To determine the interregional flow of output, and transportation routes and magnitudes.

3. To predict changes in the patterns of production and product distribution resulting from changes in technology (introduction of fertilizer use).

4. To study alternative means of producing for 1980 projected

demands.

5. To estimate the regional and national equilibrium product prices under each program alternative.

6. To determine regional rental values (differential rent) of cropland.

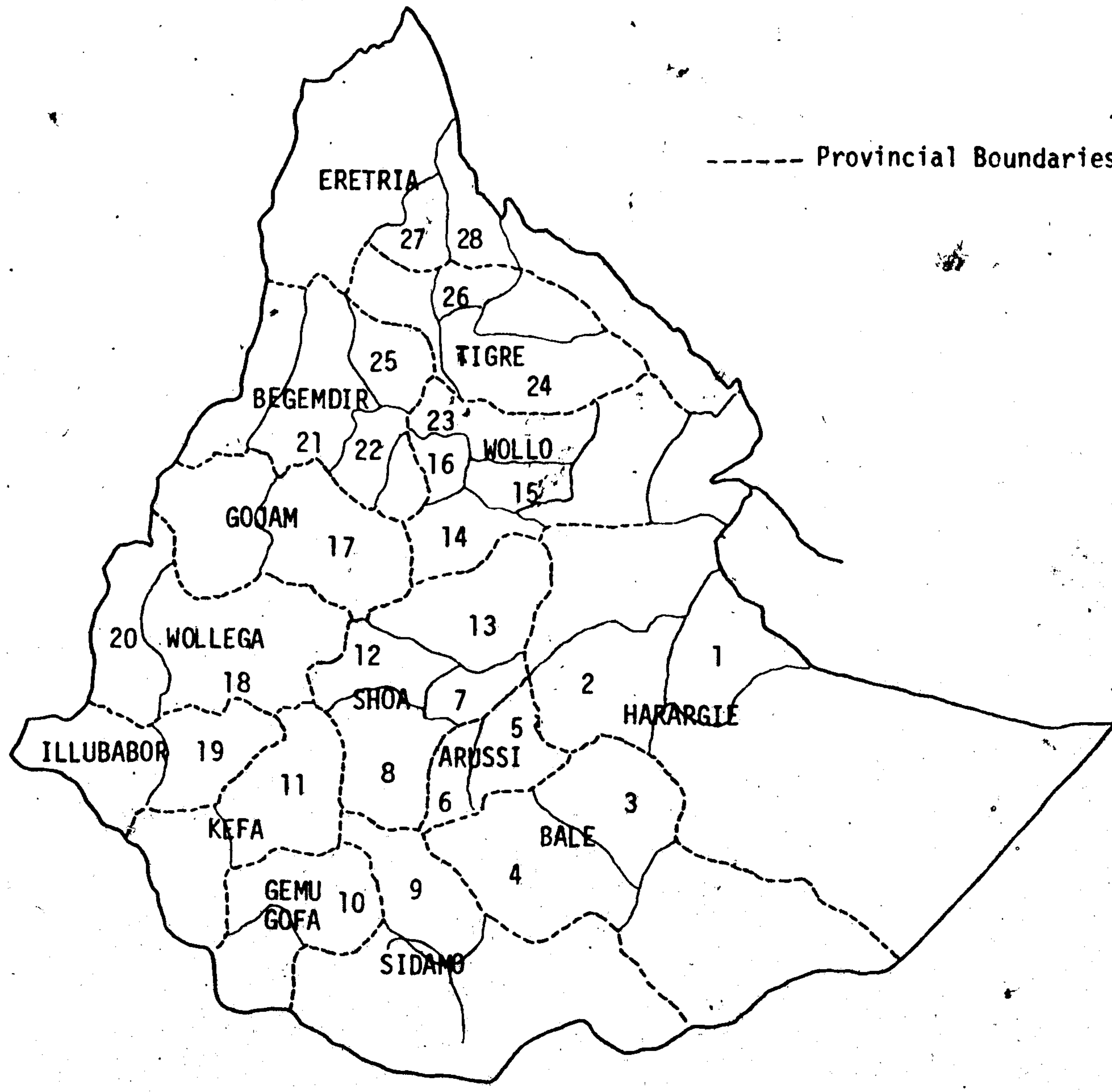
Analytical Method

The mathematical models developed required division of the country into internally homogeneous producing districts and consuming regions. The country was divided into twenty-eight production districts (Figure 1.1) and nineteen consumption regions (Figure 1.2). Most of the regional boundaries coincide with provincial boundaries. Where feasible and necessary, regions represent Awrajas (sub provinces) or groups of Awrajas. Regions 1, 7, and 18 produce only small amounts of crops and local production is subtracted from the estimated demand of these regions. One or more districts were assigned to each of the other sixteen regions in such a way that each district is completely included in a region. Activities and constraints were defined for each region and district.

Transportation activities permit the movement of commodities from regions with excess supply to those with excess demand. A central place in each region was selected from which transportation costs were calculated. These centers represent more or less the central market area for location with respect to population, this location not necessarily being the geographic center.

FIGURE 1.1

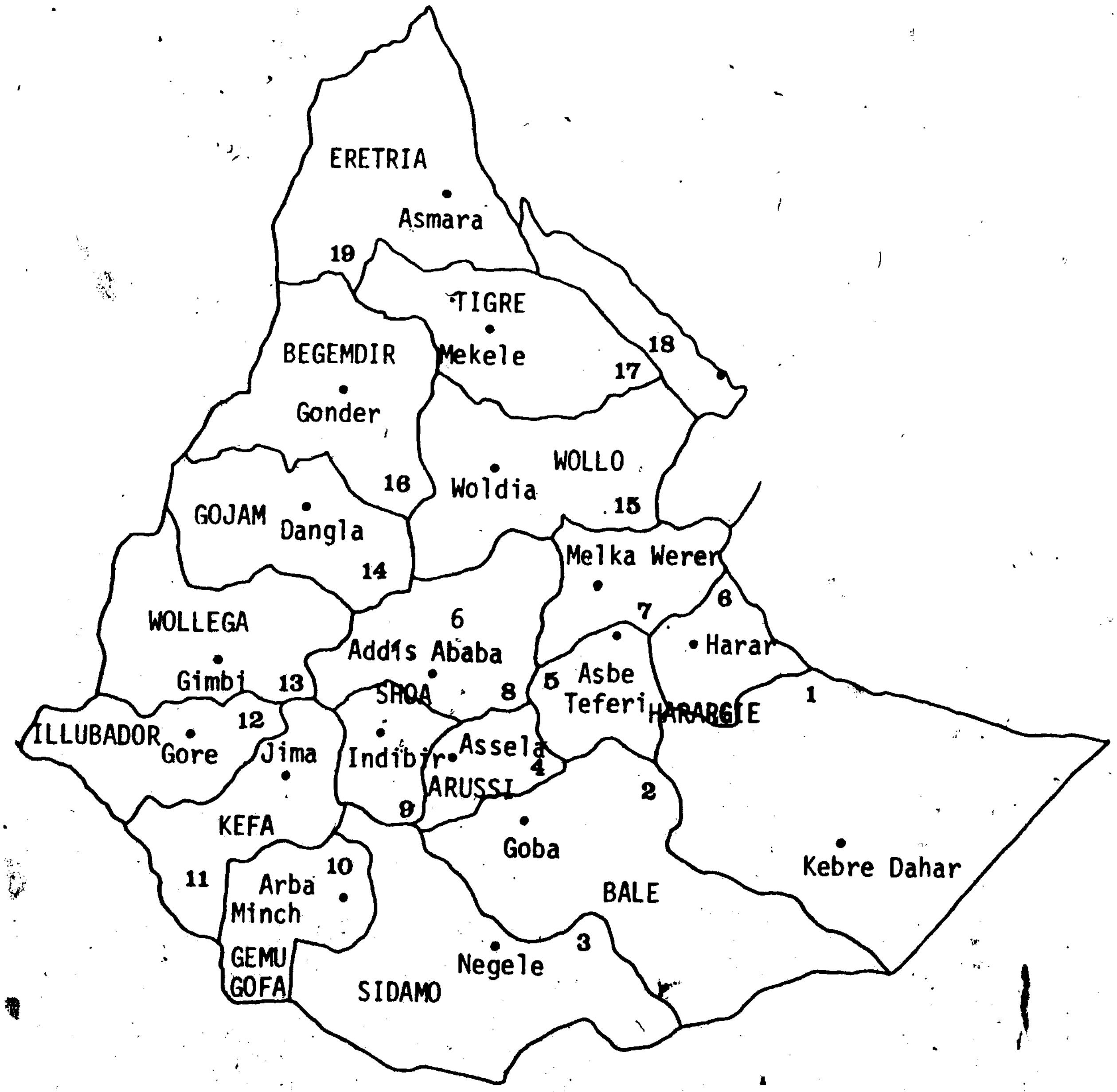
PRODUCING DISTRICTS, ETHIOPIA, 1966 AND 1980



Note: Each of the 28 producing districts is designated by number.

FIGURE 1.2

CONSUMING REGIONS, ETHIOPIA, 1966 AND 1980



Note: Each of the 19 consuming regions is designated by number. Upper case words, in the map indicate provinces and lower case words provincial capitals.

Mathematical Model

The mathematical model used in this study was a linear programming model. Linear programming is a special case of the general optimization model where the objective function and all the constraints are linear. Typical of this mathematical tool are inequalities representing functional constraints of resources, and non-negativity constraints on the variables representing the one-way nature of the production process.[1]

The standard minimization problem of linear programming in matrix notation is as follows:

$$\text{Min } f(x) = CX \qquad (1.1)$$

Subject to:

$$AX \leq B$$

$$X \geq 0 \qquad (1.2)$$

where: X is a vector representing activities,

C is a row vector of order n,

B is a column vector of order m, and

A is a m x n matrix coefficients.

In the standard program, the number of constraints, m, may bear any relation to the number of variables, n, but typically m is greater than n.

Cereal Crops Included in the Study

Wheat, barley, teff, corn, and sorghum were the crops considered in the study. These crops are important from both the standpoint of

---

[1] Earl O. Heady and Wilfred Candler, Linear Programming Methods (Ames, Iowa: Iowa State University Press, 1969), Chapter 1.

consumption and area of land cultivated. In 1966 these crops accounted for about 67 percent of the total area under corps in Ethiopia (Table 1.1). These crops are also important components of the Ethiopian diet.

Fallowing and a crop rotation program which includes pulses and oil crops in the rotation is practiced by peasant farmers. According to the Blue Nile Basin Study, fallowed land in the sample areas studied comprised between 15 and 39 percent of the cultivated land.[1] Land use data for 1966 also indicated that about 15 percent of the cultivated land in Ethiopia was used for pulses and oil crops.[2] In addition, a sizeable area of land (usually the marginal land) was used for livestock grazing. In this program the above practices were allowed to continue unhampered; that is, the land area used for pulses, oil crops and livestock was not included in the resource constraints of the various models of this study.

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[1] U.S. Bureau of Reclamation, "Appendix VI: Agriculture and Economics," Land and Water Resources of the Blue Nile Basin of Ethiopia (Washington, D.C.: U.S. Bureau of Reclamation, n.d.), pp. 21-24.

[2] Imperial Ethiopian Government, Central Statistics Office, Ethiopia: Statistical Abstract of 1967 and 1968 (Addis Ababa: CSO, 1968), p. 45.

TABLE 1.1

LAND AREA UNDER CROP PRODUCTION IN ETHIOPIA IN 1966

Crop	(Thousand hectares)	Percent of Cropland
Teff	2,132.7	20.46
Wheat	1,008.4	9.67
Barley	1,472.6	14.13
Sorghum	1,153.3	11.06
Corn	1,129.5	10.83
All Pulses	940.6	9.02
Cotton	320.5	3.07
Ensete	187.1	1.79
Industrial Plants	248.5	2.38
Oil Crops	712.1	6.83
Fruits and Stimulants	708.1	6.79
Vegetables	408.1	3.91
TOTAL	10,421.5	

Source: IEG Central Statistics Office, Ethiopia: Statistical Abstract of 1967 and 1968 (Addis Ababa, 1968), p. 45; and C.J. Miller, et.al., Production of Grains and Pulses in Ethiopia, Report No. 10, (Menlo Park, California: Stanford Research Institute, January, 1969), p. 127.

CHAPTER II

AGRICULTURE IN ETHIOPIA

Introduction

Agriculture has had a key role in the development process of most countries. Almost invariably, the initial stages of development were set by agriculture, but as development proceeds, the relative importance of agriculture usually declines. Since most of the resources of Ethiopia, particularly land and labor, are employed in agriculture, the mobilization and efficient allocation of these resources is a condition for economic progress. The fact that agriculture commands the major resources of the nation also dictates that it be the source of finance for industrial development, at least to the extent of the proportion of resources it commands. Industrial development must come about rapidly if the nation is to maintain a steady rate of progress.

Economic progress is set into motion by two important forces: (1) agriculture becoming more efficient, and (2) industries, particularly agricultural processing and servicing industries, growing and increasing in importance. As a nation develops, the share of the nonagricultural sector of the total productivity of the nation increases relative to agriculture. As rural people migrate to urban areas, the number of people engaged in agriculture declines. At the same time, agricultural productivity increases to more than offset the decrease in the agricultural labor force. This change of relationships between agriculture and industry and rural versus urban population is desirable because markets need to be created for the expanding agricultural output while the agricultural sector provides an expanded market for processed goods. The dynamics of growth thus set in motion will continue with agriculture, although important, continuing to contribute less and less of the gross national product of the country, and employment in agriculture declining to a low level.

According to John W. Mellor the rate of transformation from primarily an agricultural economy to a mixed economy depends on: (1) the proportion of the labor force initially in the agricultural sector, (2) the rate of growth of the total labor force, and (3) the rate of growth of nonfarm job opportunities.[1] The key to success in the transformation lies in the rate of capital accumulation in the nonagricultural sector as well as in the agricultural sector. The rate of growth of the non-agricultural sector can be expressed as a function of the rate of capital formation in the nonfarm sector and the development of complementary institutions. The absorption of the labor force dislocated from agriculture becomes extremely critical at this stage of development. The larger the rate of increase of population in the rural sector, the faster the rate of growth must be in the nonfarm sector to provide jobs and income for the growing industrial labor force.

Importance of Agriculture to the Ethiopian Economy

Contribution to Gross Domestic Product

Agriculture occupies a dominant place in the Ethiopian economy. The overall dominance of agriculture is reflected in its contribution to

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[1] J.W. Mellor, The Economics of Agricultural Development (Ithaca, New York: Cornell University Press, 1966), p. 22.

the Gross Domestic Product (GDP) of the country. Agriculture's contribution to Ethipia's GDP in 1967 was 55.6 percent (Table 2.1). Even though there was a decline in its importance from 64.8 percent in 1961 to 55.6 percent in 1967, it still occupies a dominant position in the economy. During the same interval (1961-1967) the share of manufacturing industries increased from 12.3 to 16.9 percent. However, the manufacturing sector is dominated by the processing of agricultural products such as textiles, food and beverages, with mining and electricity gaining some ground.

Contribution to Employment

A statistical breakdown of the employment situation of the Ethiopian labor force is not readily available. However, from the estimated distribution of population between urban and rural areas, one can get a pretty good idea of industrial versus agricultural employment. Estimated population for the provinces of Ethiopia in 1967 shows that urban population averaged only 8.1 percent of the total population of Ethiopia (Table 2.2). The statistics available also show that some 146,000 people are employed by manufacturing and service industries, the Central Government, autonomous authorities, and the armed forces (Table 2.3). This figure represent 1.20 percent of the 15 to 59 years age group, male and female population, or 2.49 percent of the male population in the same age group.

The statistics do not include local artisans such as blacksmiths, potters, weavers, etc. who earn all or part of their livelihood from such activities. Some peasant communities are self-sufficient in almost every way. However, even if these people were properly accounted for, the proportion of the labor force employed in agriculture proper (that

TABLE 2.1

GROSS DOMESTIC PRODUCT BY SECTOR OF ORIGIN
IN ETHIOPIA, 1961-1967

Sector	1961	1962	1963	1964	1965	1966	1967
	At Constant Factor Cost of 1961 (E $ Million)						
Agriculture[a]	1504.5	1530.6	1564.9	1598.1	1619.9	1650.8	1706.2
Industries[b]	286.6	312.7	372.5	364.9	400.7	448.8	518.8
Wholesale and Retail Trade	139.7	153.5	164.5	185.8	204.5	226.6	227.7
Transport and Communication	70.7	78.0	84.4	97.3	110.2	121.4	130.1
Others[c]	321.8	352.5	367.8	385.0	437.3	461.4	488.9
Percentage Distribution							
Agriculture	64.8	63.1	62.3	60.7	56.6	56.7	55.6
Industries	12.3	12.9	13.1	13.9	14.5	15.4	16.9
Wholesale and Retail Trade	6.0	6.3	6.6	7.1	7.4	7.8	7.4
Transport and Communication	3.0	3.2	3.4	3.7	4.0	4.2	4.2
Other Sources	13.9	14.5	14.6	14.6	15.5	15.9	15.9

[a] Includes forestry, hunting and fishing.

[b] Includes mining and quarrying, manufacturing, handicraft and small scale industries, building and construction, and electricity and water.

[c] Includes banking, insurance and real estate, public administration and defence, ownership of dwellings, educational services, medical and health services, domestic services and others.

Source: Imperial Ethiopian government, Central Statistics Office (IEG, CSO), Ethiopia: Statistical Abstract 1967 and 1968 (Addis Ababa: Central Statistics Office, 1968), p. 132.

TABLE 2.2

ESTIMATED URBAN AND RURAL POPULATION BY PROVINCES OF ETHIOPIA, 1967

Province	Total Population	Rural Population	Urban Population[a]	Percent of Urban Population
		(Thousands of People)		
Arussi	1,110.8	1,069.4	41.4	3.7
Bale	159.8	139.8	20.0	12.5
Beghemder	1,348.4	1,277.9	70.5	5.2
Eritrea	1,589.4	1,324.1	265.3	16.7
Gemu Gofa	840.5	818.5	22.0	2.6
Gojam	1,576.1	1,506.3	69.8	4.4
Harargie	3,341.7	3,189.2	152.5	4.6
Illubabor	663.2	637.9	25.3	3.8
Kefa	688.4	635.1	53.3	7.7
Shoa	3,970.3	3,115.4	854.9	21.5
Sidamo	1,521.9	1,430.9	91.0	6.0
Tigre	2,307.3	2,200.4	106.9	4.6
Wollega	1,429.9	1,376.0	53.9	3.8
Wollo	3,119.2	3,021.1	98.6	3.2
Total	23,667.4	21,742.0	1,925.4	8.1

[a] There is no clear definition of what constitutes an urban centre. However, for the purpose of population surveys, CSO considers all towns with town chiefs appointed within the framework of administrative authority as urban centres.

Source: IEG, CSO, _Ethiopia: Statistical Abstract of 1967 and 1968_ (Addis Ababa: Central Statistics Office, 1968), p. 26.

TABLE 2.3

EMPLOYMENT AND GROSS VALUE OF PRODUCTION
IN MANUFACTURING INDUSTRIES IN ETHIOPIA, 1965-1966

Industrial Groups	No. of Establishments	Employees No.	Employees %	Gross Value of Production Value Eth.$	Gross Value of Production %
Food	73	22,112	40.3	80,912,000	30.0
Beverages	39	2,473	4.5	41,954,000	15.6
Tobacco	2	1,093	2.0	7,347,000	2.7
Textiles	25	17,040	31.1	79,082,000	29.4
Leather & Shoes	20	2,298	4.2	13,074,000	4.9
Lumber	31	2,147	3.9	6,405,000	2.4
Building and Nonmetallic Material	24	3,684	6.7	12,668,000	4.7
Printing and Publishing	23	1,403	2.6	6,405,800	2.4
Chemicals	22	1,618	3.0	9,308,000	3.4
Steel, Metal and Electrical	13	930	1.7	12,200,000	4.5
TOTAL	272	54,798	100.0	269,355,000	100.0

Source: IEG, CSO, Ethiopia: Statistical Abstract of 1967 and 1968 (Addis Ababa: Central Statistics Office, 1968), pp. 57-58.

is, cultivate the land and raise livestock) would continue to be large.

Agriculture's Share of Foreign Trade

Ethiopia's exports are almost exclusively agricultural products. Coffee has dominated Ethiopia's foreign trade for many years. Coffee, oil seeds and cakes, pulses, hides and skins, meat and live animals, and fruits and vegetables comprise Ethiopia's major export commodities, together accounting for over 90 percent of the total export earnings (Table 2.4). Coffee is by far the major export item, constituting over half of the total value of exports (56.2 percent in 1966). Oil seeds and cakes, pulses, and hides and skins account for a further 25 to 35 percent of the export earnings (28.3 percent in 1966).

Immediately after World War II, Ethiopia exported a large quantity of wheat to Europe, but recently it has been a net importer of wheat. The other cereal crops under investigation have never been important as far as export markets are concerned. However, the outlook, particularly for maize export to the Far East (especially Japan),is very promising.

Livestock and livestock products account for a significant portion of Ethiopian exports. The growth in exports of hides and skins has been quite substantial in the 1955 to 1966 period (90 percent). Hides and skins accounted for some 10 percent of Ethiopia's export trade in 1966. Canned and frozen meat accounted for about 3 percent of Ethiopia's total export earnings. The increase in export of canned and frozen meat between 1955 and 1966 was about 133 percent.

TABLE 2.4

VALUE OF ETHIOPIAN EXPORTS BY COMMODITY, 1955-66

Commodity	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1966 Percent of Total
	(Thousands of Ethiopian Dollars)												
Coffee	90,202	80,022	123,029	97,401	97,397	104,899	93,874	107,198	110,935	158,932	188,347	156,044	56.22
Cattle Hides	4,086	3,614	2,785	3,460	8,782	7,653	8,312	7,168	6,753	4,090	4,351	9,444	3.40
Sheep Skins	4,416	4,952	4,907	4,157	6,564	6,668	11,001	11,105	9,968	11,515	11,107	13,382	4.82
Goat Skins	7,394	7,183	7,258	7,421	8,870	4,096	4,866	5,408	5,216	5,926	7,334	12,446	4.48
Other Skins	101	143	276	404	603	921	955	1,083	1,517	414	736	375	0.13
Leather and Leather Manufacture	41	66	28	9	12	14	50	--	21	3	--	1	
Cereals and Pulses	9,654	8,094	10,528	6,917	15,559	22,483	18,027	16,849	16,389	13,982	15,117	21,264	7.66
Flour	29	--	177	7	--	230	758	258	421	375	135	222	0.07
Oilseed Cakes	1,014	848	762	1,053	1,783	1,583	2,323	4,107	3,521	3,517	3,401	4,833	1.74
Oilseeds	18,213	17,754	17,921	11,637	10,417	16,477	15,051	19,581	28,280	26,613	24,930	21,778	7.84
Vegetable Oils	10	13	15	29	23	90	62	52	37	7	17	11	
Chat	6,557	6,995	4,446	5,082	7,619	7,063	10,844	10,414	12,541	5,052	1,839	2,170	0.78
Beeswax	723	1,074	1,335	1,015	1,170	1,543	1,208	1,104	1,296	1,088	1,415	1,337	0.48
Civet	426	553	467	507	552	529	603	475	536	743	766	848	0.30
Honey	5	5	3	2	2	9	6	3	9	13	47	18	
Sugar	--	--	--	--	--	--	--	--	3,889	4,497	87	4	
Animals and Chickens (live)	3,818	2,215	430	126	179	303	456	408	1,119	2,349	3,139	2,255	0.81
Clarified Butter	280	552	512	485	827	429	442	100	466	393	444	440	0.15
Raw Cotton	1,278	1,058	1,128	399	43	86	17	--	--	--	--	2	
Eggs, Fresh, Liquid or Dry	833	853	803	913	858	684	645	493	841	743	645	1,078	0.38
Spices, Chillies, Peppers	31	56	271	204	273	885	1,600	354	1,187	2,057	817	845	0.30
Fruits and Vegetables	1,588	2,057	2,693	2,842	3,616	3,188	4,070	4,413	6,424	6,479	5,392	7,674	2.76
Cement	118	133	491	364	130	--	--	--	--	3	33	1	
Metal Scrap	396	259	319	326	294	73	96	--	649	234	260	293	0.10
Button Blanks, Pearl Button and Sea Shells	1,169	642	694	245	100	204	62	163	305	399	90	87	0.03
Fish and Fish Meal	821	1,045	1,016	927	1,212	554	897	549	671	819	990	1,048	0.37
Meat, Canned and Frozen	3,393	2,924	2,187	2,219	3,399	4,740	3,213	1,489	2,503	5,846	7,405	7,329	2.64
Beer	103	61	88	51	69	55	16	41	7	--	--	--	
Salt	--	80	429	426	606	310	614	1,195	1,301	747	670	1,211	0.43
Other Products	2,384	3,226	3,054	4,149	4,807	3,655	3,430	2,157	2,652	2,317	3,531	2,663	0.95
Re-exports	3,142	4,070	3,927	3,979	3,421	3,326	5,125	3,353	3,961	3,377	6,788	8,418	3.03
Total	162,225	150,624	191,979	156,756	179,187	192,750	188,623	199,550	223,410	262,530	289,833	277,521	

[a]For the years prior to 1962, the figures refer to 12-month periods ending December 9. From 1962 onward, the figures refer to 12-month periods ending January 10 of the following year.

[b]Amended to reflect revised returns

Source: William L.K. Schwarz, Ethiopia's Export Trade in Major Agricultural Commodities, Report No. 6 (Menlo Park, California: Stanford Research Institute, January, 1969), Appendix A, p. 115.

Soil and Climate of Ethiopia

The State of Soil Information

Information on Ethiopian soils is limited. Most descriptions of Ethiopian soils are impressionistic views. The only chemical anlysis attempted on a nationwide scale was done by the Late Dr. H.F. Murphy in the late fifties and early sixties. During the course of his stay in Ethiopia, Murphy collected and analysed about 6,000 soil samples from the major agricultural areas of Ethiopia. The information presented here is a condensation of his work.[1]

Classification of Ethiopian Soils

No general classification of Ethiopian soils has been made. Distinction is often made only by the color of the soil. Shantz and Marbut[2] gave the following brief and general account of the Ethiopian soils:

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[1] H.F. Murphy, A Report on the Fertility Status of Some Soils of Ethiopia, Ext. Stn. Bull. No. 1 (Imperial Ethiopian College of Agriculture and Mechanical Arts, November, 1959); _______, The Soils of Ethiopia: Analytical Data and Notes, 1956-58, Experiment Station Bull. No. 1, Vol. 1 (Imperial Ethiopian College of Agriculture and Mechanical Arts, n.d.); _______, The Soils of Ethiopia: Analyitical Data and Notes, 1956-58, Exp. Station Bull. No. 1, Vol. II (Imperial Ethiopian College of Agriculture and Mechnaical Arts, n.d.); _______, Fertility and Other Data on Some Ethiopian Soils, Exp. Stn. Bull. No. 4 (Imperial Ethiopian College of Agriculture and Mechanical Arts, February, 1963); _______, A Report on the Fertility Status and Other Data on Some Soils of Ethiopia, Exp. Stn. Bull. No. 44 (Dire Dawa: College of Agriculture, Haile Selassie I University, 1968).

[2] H.L. Shantz and C.F. Marbut, The Vegetation of Soils of Africa (New York: American Geographical Society, 1923).

	Soil Class	Area
1.	Red loam	Central highlands soils.
2.	Chernozem	Lowest reaches of the western slopes toward the Sudan, most extensively in the Sobat River drainage basin and in the northwest (south of Metema), and on the humid parts of the Somali Plateau.
3.	Brown desert	Rift Valley and Danakil Plain.
4.	Chestnut brown	Eastern part of the Somali Plateau.
5.	Red sand	Southwest Ethiopia.

Soil Nutrients and Availability

While the number of soil samples analysed does not justify general statements about Ethiopian soils, the work done by Murphy provides a great deal of new information. The general areas from which soil samples were collected follow the major highways radiating out of Addis Ababa. Since most of the agriculture of Ethiopia lies in the areas close to the highways, it is felt that the samples analysed adequately cover the major agricultural areas of Ethiopia. In this study, only brief summaries were provided and interested readers may refer to Murphy's work cited above.

Lowland Soils

Soil development is a function of all of the soil forming processes--climate and living organisms acting on the parent material on a particular topography over a period of time. Climate in particular is one of the major factors in soil formation. The lowlands of Ethiopia are generally dry and hot, allowing for very little vegetative growth, chemical weathering, and too little leaching. Because of these factors, the soils in these regions are young and have an undeveloped soil profile.

Organic matter is low due to lack of plant growth. The nitrogen level is low also because it is a product of the organic matter and activities of soil forming organisms. Soil leaching is nil and as a result soluble basic products produced in the limited weathering processes accumulate in the young soil. Thus, the soils in the lowlands are neutral to generally basic in reaction.[1] Available phosphorus was found to be generally high in the drier regions of the country.

The Highland Soils

Crop production in Ethiopia is largely concentrated in the highland portion of the country which gets sufficient rainfall and where the climatic conditions are suitable for habitation. Generally speaking, the results of the soil analyses indicated that the southwestern provinces had some of the better soils of the country. The rich coffee soils of Kefa province are among the best soils in the country.

In terms of soil reaction, the soils of the western provinces of Wellega, Ilubabor, Western Shoa, Kefa, Begemdir, and Gojam showed high acidity. On the other hand, the provinces of Harargie, Arussi, Wollo, Sidamo, Bale,Tigre, Eritrea and Eastern Shoa were less acidic. The western provinces receive high rainfall which subjects them to a high degree of leaching of the basic soil minerals and results in a greater concentration of nonbasic minerals.

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[1] H.F. Murphy, A Report on the Fertility Status and Other Data on Some Soils of Ethiopia, pp. 6-8; The degree of acidity or alkalinity of soils is defined as follows:

Strongly acid	pH	<5.6
Moderately acid	pH	5.6 - 6.0
Slightly acid	pH	6.1 - 6.5
Neutral	pH	6.6 - 7.3
Mildly alkaline	pH	7.4 - 7.8
Strongly alkaline	pH	>7.8

In general, all the highland soils contain an abundant supply of organic matter except in the provinces of Eritrea and Tigre where 65.2 percent and 52.1 percent of the samples, respectively, rated below 2 percent.[1] The results for all samples showed 23.5 percent containing less than 2 percent organic matter, 19.2 percent containing a medium amount (2-3 percent), and the rest having a high to very high supply of organic matter.

The distribution of nitrogen is similar to that of organic matter.[2] In Eritrea and Tigre provinces, 61.2 percent and 45.1 percent of the soils respectively, contain less than 0.10 percent nitrogen. The lowlands, which are generally drier, exhibit deficiencies in nitrogen levels as well as in organic matter. For example, 95.5 percent of the samples from the lowlands of Wollo province showed less than 0.10 percent nitrogen. Of the samples from Harargie province (which includes samples from the drier portions of the country), 39.7 percent contained less than 0.10 percent nitrogen.

Phosphorous appears to be a problem in most Ethiopian soils. On the average, 47 percent of all the samples analysed range from very low to low in available phosphorus. In those highland regions where the

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[1] Nutrient and organic matter contents were classified as follows: Soils containing less than 2 percent organic matter were classified as low; 2.0 - 3.0 percent, medium; and over 3.0 percent, high. Soils containing less than 0.10 percent nitrogen were classified as low; 0.10 to 0.15 percent, medium; and over 0.15 percent, high. Soils containing less than 250 ppm of phosphorus were classified as low; 250-750 ppm, medium; and over 750 ppm, high.

[2] Murphy, <u>A Report on the Fertility Status and Other Data on Some Soils of Ethiopia</u>, p. 11, Figure 3.

acidity of the soil was high, the availability of phosphorous was usually low. On the other hand, the province of Eritrea, and the lowlands of Wollo, Harargie and Shoa showed high availability of phosphorous.[1] In acid soils the phosphorus is tied up in a form that is unavailable to the plants (phosphate fixation). Murphy explained that this was due to the fact that phosphate ions react with the hydrous iron and aluminum oxides present in the kaolinitic clay. The encouraging feature of these soils, however, is that they are generally high in organic matter, affording the seasonal liberation of some available phosphorous during the stages of organic matter decay.

Potassium, calcium and magnesium were quite high in all the soil samples analysed. No attempt was made by Murphy to conduct analyses for the rest of the minor elements.

Some of the highland black clay loam to clay soils are montmorillonitic in character and are very sticky and plastic with great swelling and shrinking capacity when wet, and hard when dry. These kinds of soils occur in many parts of the country and are quite difficult to manage. In general, the reddish brown to dark reddish brown soils varying in texture from a loam, clay loam, or sandy loam to clay are easier to manage.

In some of the highland soils, the wet conditions prevailing during the growing season limit the activities of microorganisms which liberate nitorgen in the soil. This condition is particularly troublesome in the highland soils of Shoa and, to a certain extent, in other provinces also. The extremely wet conditions, lack of aeration, and cool temperature conditions limit the production of available nitrogen (nitrate).

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[1] _Ibid._, p. 87.

Soil erosion is a problem of major consequence. Evidence of sheet erosion and gully erosion may be observed in every locality. Such factors as tillage and planting practices subject the soil to severe erosion. Overgrazing, with its constant packing of the soil by the animals, presents not only conditions favouring erosion but also problems in water conservation and its attendant effects on the kind of vegetation which can be established. The northern provinces are virtually denuded of their top soil. According to the information provided by Mr. Wolde Mariam,[1] more than 52 percent of the area of the country loses an estimated amount of more than 2,000 tons of soil per square kilometer every year.

Rainfall in Ethiopia

The distinction of Ethiopian climatic Zones is traditionally based on elevation:

Zone	Climate	Altitude	Average Annual Temperature
Dega	Temperate	Over 2400 meters	16°C
Weina Dega	Subtropical	1800 - 2400 meters	22°C
Kola	Tropical	Less than 1800 meters	26°C

Altitude is an important determining factor of the temperature that prevails in the country. Temperature and elevation are inversely related while elevation and rainfall are directly related. At elevations greater than about 1,000 meters the temperature declines by 0.84°C per 100 meters rise in elevation.[2] At lower elevations (below 1,000 meters)

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[1] Mesfin Wolde Mariam, An Atlas of Ethiopia (Asmara, Ethiopia: II Poligrafico Printing Ltd. Co., 1970), p. 16.

[2] Miller, et al., Systems Analysis Methods for Ethiopian Agriculture, pp. 54-56.

the decline is about .34°C for every 100 meters rise in elevation. Observation of precipitation data in the middle Awash Valley also shows about 60-70 mm increase in rainfall for every 100 meters rise in elevation.

Rainfall Regions

The traditional concept of classification based on elevation provides a rough indication of the rainfall conditions. However, this concept is not very useful in explaining the variation in rainfall between areas at the same elevation in different parts of the country. A combined [illegible]titude, latitude and longitude seems to explain the situa[illegible] H.P. Huffnagel and Kebede Tatu,[1] particularly the latter[illegible] to partition the country into rainfall regions by employi[illegible]bined effects of altitude, latitude, and longitude. Accordin[illegible]e analysis presented by the two authors, the further north the[illegible]ion, the less the annual rainfall amount, with annual peaks occ[illegible]g late and distribution of rainfall being less. The further eas[illegible]station lies, the less penetration of the moist air stream, resulting [illegible] less rainfall. The lower the elevation of the station, irrespective of its geographical position, the less amount of rainfall. Roughly the country is divided into the following climatic zones.[2]

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[1] H.P. Huffnagel, Agriculture in Ethiopia (Rome: FAO, 1961), p. 60; Kebede Tatu, "Rainfall in Ethiopia", Ethiopian Geographic Journal, Vol. II, No. 2 (December, 1964), p. 31.

[2] T[illegible]l rainfall figures and distribution for each region are given in Ap[illegible]x B, Tables B-1 to B-9.

1. The Highlands of Shoa, Wollo, Begemdir, Gojam, and Northeastern Wollega.

2. The Western Highlands of Illubabor, Wollega and Kefa.

3 (a) The Western, and
(b) The Northwestern Lowlands and Plains.

4. The Rift Valley (North of the Lake districts).

5. (a) The Southern Lowlands of Sidamo, Gemu Gofa, Kefa, and
(b) The Ogaden Lowlands.

6. The Red Sea Coastal Plains.

7. The Highlands of Arussi, Bale and Harargie.

8. The Northern Denkel Plain.

9. The Highlands of Tigre, Eritrea, Northern Wollo and Begemder.

The western stations generally show above-normal rainfall (as high as 2000 mm. and more). In these regions, wet conditions are guaranteed during most of the year because of their position on the windward side of the southwesterlies and because of the abruptly rising inland highlands which force the air to lifting condensation and precipitation (orographic precipitation).[1]

The mean annual rainfall chart for Ethiopia shows that the isohyet of 2000 mm. is located over the western provinces. The isohyet value decreases northward through the Rift Valley, with a ridge of high rainfall extending along the eastern and southeastern highlands of Arussi and Harargie. A minor center of 1200 mm. is located over the northeastern part of Arussi. A low cell of less than 1000 mm. is located in the western part of Shoa. A significant feature of Ethiopian climatic condition is

[1] E.R. Reinelt, "On the Role of Orography in the Precipitation Regime of Alberta," The Albertan Geographer, Vol. 6 (1970), p. 45.

the seasonal variation both in its distribution and magnitude. Except for the western provinces, rainfall is extremely variable for any of the dry months and cannot be relied upon.

The Current State of Agriculture

The low standard of living of the people of Ethiopia can be attributed mainly to the backwardness of their agriculture. In the last ten years there has been some improvement in the techniques of agricultural production. However, the predominant technique of agricultural production is still largely primitive, depending solely on human and animal power. Agriculture in Ethiopia is characterized by subsistence farming; a feudal type of land tenure relationship; continuous subdivision and fragmentation of small holdings; widespread rural under-employment and unemployment; inadequate transportation and marketing facilities; heavily eroded soil; overly grazed, unproductive pasture; heavy dependence on natural forces such as seasonal rains and other weather components; illiterate rural population; and primitive farming techniques with heavy dependence on human and animal power.

Investment in Agriculture

Savings per capita are low because of the low income of the people and perhaps because of lack of incentives. According to the Third Five Year Development Plan (TFYP) of Ethiopia, the estimated per capita saving by the nonmonetary sector (peasant economy) is about 2 percent of their disposable income.[1] The FAO estimated agricultural

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[1] Imperial Ethiopian Government, Third Five Year Development Plan 1968-1973 (Addis Ababa: Berhanena Salam H.S.I. Printing Press, 1967), p. 53.

investment in Ethiopia was about 0.5 percent of the GDP during the 1961-1965 period. The same study shows a decline in the rate of growth of agricultural output in Ethiopia between 1950 and 1960--from 4.0 percent to 3.3 percent per annum. This decline is attributed mainly to the low level of investment.[1]

Typically, a nation that depends so heavily on agriculture should put emphasis on agricultural investment, but the Ministry of Agriculture's budget is one of the lowest. According to J.H. Robinson, agriculture received only $5.8 million (2.0 percent) in 1965-66, and $6.2 million (1.9 percent) in 1966-67, excluding the external assistance received and considering only the allocation of locally generated funds.[2] In comparison with developing countries in Africa, North America, South America, and Asia, Ethiopia ranks among the lowest in terms of total agricultural expenditures as a percent of total budgeted expenditure.[3]

Gross capital investment in agriculture and allied activities is projected at Eth. $361 million--which amounts to about 11.58 percent of the total gross investment for the TFYP period.[4] This figure as an investment allocation to agriculture is not high, nor is it extemely low,

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[1] E.F. Szezepanik, "The Size and Efficiency of Agricultural Investment in Selected Countries," Monthly Bulletin of Agricultural Economics and Statistics, Vol. 18 (December, 1969), p. 2.

[2] J.H. Robinson and Ato Mammo Bahta, An Agricultural Credit Program for Ethiopia, Report No. 9, (Menlo Park, California: Stanford Research Institute, January, 1969), p. 41.

[3] Ibid., p. 43.

[4] IEG, Third Five Year Development Plan, 1968-1973, p. 59.

particularly for a country with an urgent program of industrialization. Certainly the share of investment used in building the industrial base of the economy was much higher in proportion to its relative importance at present, but no country aiming at structural transformation of the economy can be expected to allocate investment in proportion to national income. Besides, in Ethiopia, agricultural investment in fixed capital may not always be the most important determinant to any significant productivity rise; producing fertilizers, pesticides, improved seeds, etc., may be the solution. In Ethiopia there is considerable scope for mobilizing the vast masses of unemployed and seasonally under-employed rural labor on labor intensive investment projects like minor irrigation, flood control, soil conservation, reforestation programs, and leveling and road building projects.

Investment in farm tools and equipment is also meager on Ethiopia's peasant farms. A limited survey by the Stanford Research Institute (SRI) in the major agricultural areas (Figure 2.1) indicated that investment in farm tools and equipments ranged from ninteen dollars to fifty-four dollars for peasant farms (Table 2.5).[1]

In the Chercher Highland area (Alemaya vicintiy), a limited investigation indicated that investment in farm tools and equipment ranges from $15.00 to $30.00 per farm,[2] while a similar study in Ada district, an important agricultural area, showed investment in farm tools and

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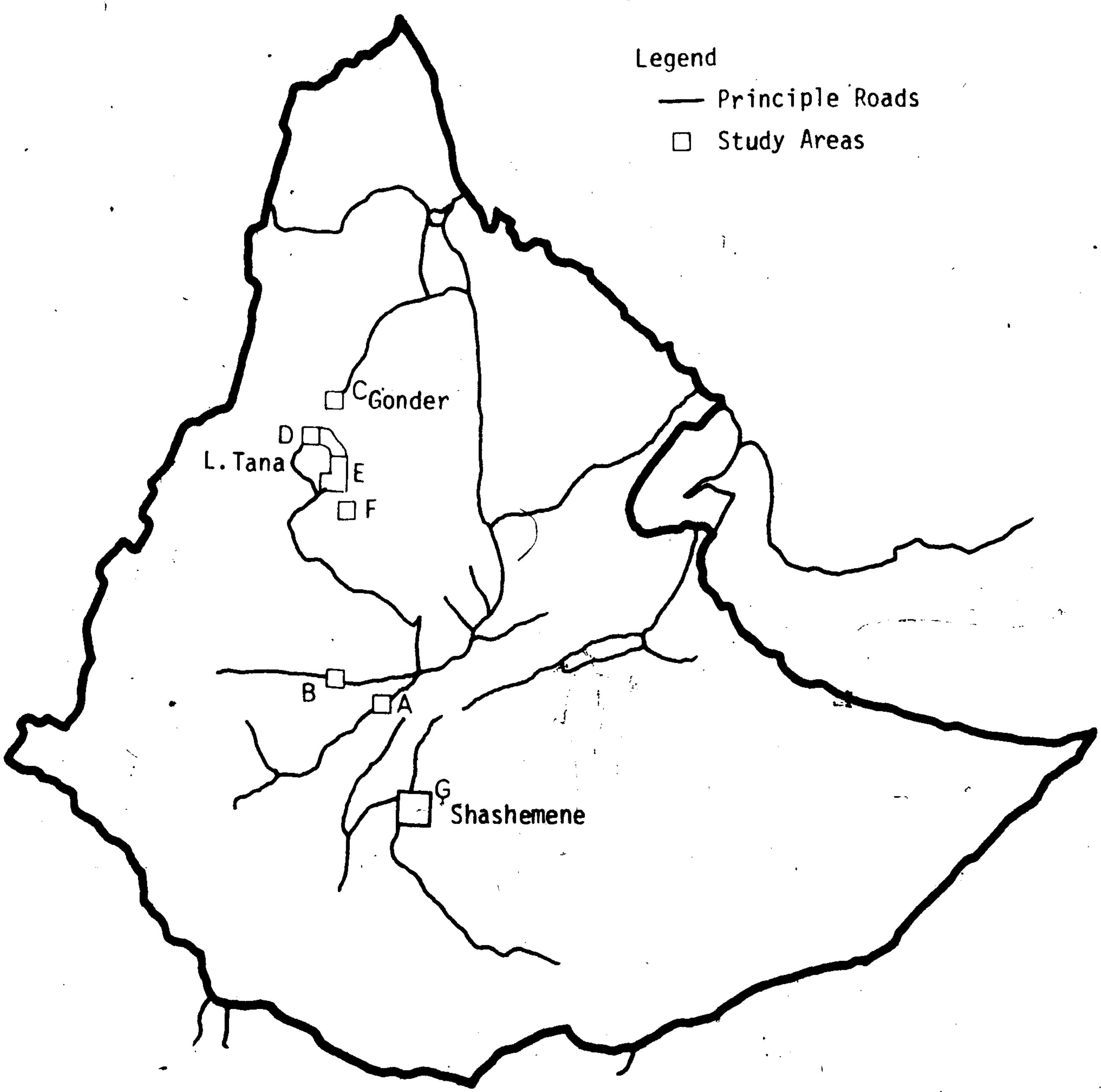
[1] Miller, et al., Production of Grains and Pulses in Ethiopia, p. 34.

[2] L.F. Miller and Telahun Makonnen, Organization and Operation of Three Ethiopian Case Farms, Exp. St. Bull. No. 35 (Imperial Ethiopian College of Agriculture and Mechanical Arts, March, 1965), p. 28.

FIGURE 2.1

LOCATION OF FARM MANAGEMENT STUDY AREA, ETHIOPIA, 1968



Source: C.J. Miller, et al., Production of Grains and Pulses in Ethiopia, Report No. 10 (Menlo Park, California: Stanford Research Institute, January, 1969), p. 34.

TABLE 2.5

FARM MANAGEMENT FACTORS ON CROP FARMS IN ETHIOPIA, 1968

Farm Management Factors	Survey Areas						
	A	B	C	D	E	F	G
Farm interviewed--number	30	30	16	31	28	10	65
Size of farms--hectares	13.5	12.7	6.1	9.4	2.0	5.6	77.0
Workers[a] per farm--number	4	3	5	4	3	3	12
Area in crops per farm--ha	10.3	6.3	3.9	6.8	1.7	1.4	29.8
Oxen per farm--number	4.5	3.2	5.5	4.6	2.4	1.3	5.9
Draft horses & mules/farm--no.	0	0	0.8	0	0	0	4.5
Capital invested in hand tool & equipment-Eth.$/farm	49	30	54	48	19	20	228[b]

[a] Includes family and non-family employees who earn their living on the farm.

[b] In addition to normal hand tools and farm equipment there were 7 tractors (value Eth. $65,931); 5 disc plows (value Eth. $3,000); 1 combine (Eth. $8,700); 1 coffee pulper (Eth. $4,000); 2 tractors discs (Eth. $1,000) and 1 tractor harrow (Eth. $500).

Source: C.J. Miller, et al., Production of Grains and Pulses in Ethiopia, Report No. 10 (Menlo Park, California: Stanford Research Institute, January, 1966), p. 36.

equipment ranging from $24 to $91, averaging $45.70 per farm.[1] The Blue Nile Basin Study showed average values of farm tools and equipment as ranging from $7.50 to $15.80 per farm.[2] Most of the farm tools and equipment used by peasant farmers are very crude and inexpensive (Appendix C, Table C-3).

The major source of power in all parts of the country, except in exceptional cases, is oxen for plowing and other farm power needs and donkeys, mules and horses for on and off-farm transportation. In general, each household has two or more oxen and a few other animals. The Ada District study found that the number of oxen owned varied from two to five, averaging about three oxen per farm for the year.[3] In the Stanford Research Institute Study, the number averaged from 1.3 to 5.5 oxen per farm (Table 2.5).

Total farm investment has been studied in only a few areas of the country. The figures for total farm investment for both crop and livestock enterprises averaged about $1,286 for the Ada area and about $1,073 for the Alemaya vicinity. Farm buildings and homes are generally simple and constructed of local materials. Farm fences, domestic water systems, pumps, wheeled carts and trucks are practically nonexistent on peasant farms.

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[1] Fekadu Ebba, A Case Study of Six Peasant Farms in Ada District, Shoa Province (Addis Ababa: Ministry of Agriculture, Dept. of Agricultural Economics and Statistics, March, 1970), pp. 51-55.

[2] USDI, Bureau of Reclamation, "Appendix VI: Agriculture and Economics," p. 20.

[3] Ebba, Op. Cit., pp. 45-46.

Types of Farms

Mixed enterprise peasant farming generally prevails in Ethiopia. The farmers produce almost all their consumption needs on the farm. Each producing district in this study produces some wheat, barley, teff, corn, grain sorghum, oil seeds, and pulses. Most farmers keep some livestock in addition to crop farming.

In recent years there has been some tendency for regional specialization due to the emergence of commercial farms, but mixed farming still prevails in the highland or plateau sections of the country. The peripheral lowlands and the Rift Valley regions north of the Lake areas are generally characterized by nomadic herding and some irrigated plantation farms. The southern, southeastern, and western peripheries of the country, with precipitation generally too low to support sedentary agriculture, specialize in nomadic herding. People in these regions depend heavily on livestock products for their diet. The overall characteristics of farming have remained unchanged for several generations. Practically no improvement has been made in the traditional techniques and equipment used.

Modern farming techniques have been introduced recently and commercial farms have emerged rapidly, but the peasantry still remains poor and tradition-bound as far as farming is concerned. Three kinds of farming can be distinguished in Ethiopia today: (1) traditional peasant farms, (2) private commercial farms, and (3) plantation farms. The latter two are mechanized to a large extent and employ modern farming methods. During the 1965-67 period alone, about Eth. $25.5 million worth of farm machinery and implements were imported into Ethiopia mainly for use by commercial farms and plantations.[1] These farms still remain relatively unimportant in terms of contribution to the total agricultural output and employment.

Most of the peasant farms are found in the highland regions (1,800-2,500 meters). Dryland farming predominates with few irrigated farms in the valleys and on riversides. The exception is the Awash Valley area where irrigated plantation farms and commercialized private farms predominate.

Two types of cropping culture are recognized in the highland farms: (1) the oxen-plow culture and (2) the hoe culture. The hoe culture is limited mostly to the ensete growing regions and some isolated areas where it is not possible to keep oxen where farm sizes are too small to keep livestock. Generally the oxen-powered culture or a combination of both cultures prevails in the highland areas where most of Ethiopia's agriculture is located.

Size of Farms

The farms in the highland areas are generally quite small. A limited study conducted by the College of Agriculture, Haile Selassie I University, in the Chercher Highland area showed that farm sizes varied from 0.04 hectares to 5.6 hectares, with about 33 percent of them farming less than one hectare.[2] A national sample survey by the Central Statistics Office indicated average cultivated area holdings ranging from 0.50

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[1] IEG, Central Statistics Office, Ethiopia: Statistical Abstract of 1967 and 1968, p. 101.

[2] K.C. Davis and Ahmed Mohamed, Farm Organization of Terre and Galmo Villages, Exp. Stn. Bull. No. 42 (Harar Province, Ethiopia: IECAMA, October, 1965), p. 20.

to 1.94 hectares per farm for eleven of the fourteen provinces of Ethiopia (Table 2.6). The report also indicated that in Sidamo and Gemu Gofa provinces more than 90 percent of the holdings were less than one hectare, while in Wollo and Begemdir 80 and 70 percent, respectively, operated less than one hectare.

Another sample study in the major agricultural areas by the Stanford Research Institute showed that the sample averages of area of land in crops ranged from 1.4 to 10.3 hectares for the peasant farmers interviewed (Table 2.5 and Figure 2.1). The same study showed that the average number of workers per farm was 3.67. The land operated per worker ranged between 0.5 and 3.0 hectares.[1]

A substantial proportion of the cultivated area is being operated in holdings that are uneconomically small, even by Ethiopian standards. Small farmers face disadvantages in getting enough supplies, credit, and technical assistance. The Agricultural Development Bank of Ethiopia does not make small loans, which the bank officials say is too costly to collect and perhaps to supervise. Although there has been some recent improvements in cooperative servicing, marketing, and provisions of agricultural supplies, their effect is still very minimal.

Apart from being too small, the holdings also consist of widely scattered fields. The average number of parcels per operational holding consisted of two to three parcels (Table 2.7).[2] Such fragmentations are

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[1] Miller, et al., Production of Grains and Pulses in Ethiopia, p. 36.

[2] IEG, Ministry of Planning, Regional Aspects of National Planning in Ethiopia, Parts I and II (Addis Ababa: IEG, August, 1967), p. 37.

TABLE 2.6

DISTRIBUTION OF HOLDINGS BY SIZE IN ETHIOPIA, 1968[a]

Province	Size Groups (In Hectares)						Average Cultivated Area Per Holding
	0-0.5	0.5-1	1-1.5	1.5-2	2-3	3+	
	(Percent)						(Hectares)
Arussi	8	23	15	14	20	20	1.94
Gojam	27	27	18	12	10	6	1.15
Shoa	23	22	16	11	13	15	1.67
Tigre	45	23	16	5	6	5	1.27
Wollo	55	25	11	3	4	2	0.97
Wollega	29	36	14	10	7	4	1.27
Gemu Gofa	73	19	4	2	2	-	0.54
Begemdir	40	30	13	9	5	3	1.40
Sidamo	73	18	5	2	1	1	0.50
Kefa	41	32	12	7	4	1	0.82
Illubabor	32	37	14	7	3	7	0.62

[a] The Statistics do not include all of the subprovinces in each province, but reflect a sample survey.

Source: H.J. Robinson and Mammo Bahta, An Agricultural Credit Program for Ethiopia, Report No. 9 (Menlo Park, California: Stanford Research Institute, January, 1969), p. 26.

TABLE 2.7

DISTRIBUTION OF LANDHOLDINGS BY PARCELS IN ELEVEN PROVINCES IN ETHIOPIA, 1968[a]

Province	Number of Parcels[b]					
	1	2	3	4	5	6
	(Percent)					
Arussi	26	20	23	15	8	8
Begemdir	19	25	27	16	8	5
Gemu Gofa	47	32	14	5	2	0
Gojam	26	27	24	12	6	5
Illubabor	28	24	20	16	7	5
Kefa	38	23	20	12	5	2
Shoa	32	23	17	12	6	10
Sidamo	65	23	8	3	1	0
Tigre	16	25	20	16	7	16
Wollo	19	24	23	14	9	11
Wollega	26	21	20	13	10	10

[a]The statistics do not include all of the sub-provinces in each province, but reflect a sample survey.

[b]All land entirely surrounded by land of other holdings or by land not forming part of any holding.

Source: H.J. Robinson and Mammo Bahta, An Agricultural Credit Program for Ethiopia, Report No. ((Menlo Park, California: Stanford Research Institute, January, 1969), p. 29.

much more characteristic of the northern part of the country. A study of some Chercher Highland farms revealed that the average number of parcels was about three to four per holding.[1] A consolidation program of holdings, which would remove a lot of division strips, could assist in soil conservation measures and irrigation projects and economize use of animal and human labor.

Structure of Farm Inputs

The structure of farm inputs and the organization of farms are quite similar for peasant farmers in all parts of Ethiopia. The nature and composition of farm inputs vary very little from region to region. The studies conducted by the Stanford Research Institute (Table 2.8) showed that average cash expenses incurred by peasant farms in the areas invetigated range from $12 to $84. The simple average for all regions investigated was about $44. The major part of these expenses consisted of taxes, hired labor, and purchased seed.

A study by the United States Bureau of Reclamation in the Blue Nile Basin showed that combined farm and home expenses ranged from $171.12 to $298.55 per family with the majority of the farm families interviewed spending less than $200.00 per year (Table 2.9).

A study in the Chercher Highland region showed average annual cash farm expenditures of about $73.55 for all farmers interviewed. Non-cash farm expenses account for a big portion of the cost of production in a peasant agriculture. Such costs as own and family labor, unpaid

[1] Miller and Makonnen, Organization and Operation of Three Ethiopia Case Farms; Davis and Mohamed, Farm Organization of Terre and Galmo Villages, p. 15.

TABLE 2.8

[illegible] PURCHASED INPUTS, ETHIOPIA, 1968[a]

Items of Pr[illegible]io[illegible] Harvesting, [illegible]ing Inputs	Survey Areas						
	A	B	C	D	E	F	G
	(Percentage of Total Cash Spent)						
Production Inpu[illegible]							
Seeds	11.3	2.2	8.5	17.0	25.4	33.4	19.3
Fertilizer	--	--	--	--	--	--	1.0
Hired Labor	17.2	8.5	21.0	19.7	17.8	--	31.9
Hired Oxen	--	14.3	11.6	--	--	15.2	2.0
Hired Machines	--	--	--	0.6	--	--	1.5
Other Field Expense[illegible]	--	--	0.7	--	--	--	6.0
Irrigation Costs	--	--	34.7	--	--	--	5.8
Cash Rent	0.7	31.3	0.9	25.2	1.0	--	9.8
Taxes[b]	58.3	28.4	8.2	17.3	41.9	46.2	8.6
Interest on Loans	--	0.3	--	--	1.6	--	5.2
Chemical Sprays or [illegible]	--	--	--	--	--	--	0.4
Harvesting Inputs							
Hired Labor	6.0	7.7	1.5	13.6	3.8	--	4.0
Field and Marketing Containers	3.4	3.5	5.2	4.5	3.1	--	1.8
Transport on Farm	1.7	1.5	--	0.5	1.1	0.4	7.8
Other Harvesting or Trashing	1.3	0.3	7.0	0.9	4.3	3.7	0.7
Marketing Inputs							
Storage (Includes Losses)	0.1	--	--	6.7	--	1.1	0.0
Other Marketing (Includes Transport Off Farm)	--	2.0	0.7	--	--	--	0.2
Total Cash Costs	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Average Costs/Farm (Eth.$)	$52	$43	$84	$61	$12	$14	$2,175
Area in Crops	10.3	6.[illegible]	3.9	6.8	1.7	1.4	29.8

[a] For all farms reporting.

[b] For land owned.

Source: C.J. Miller, *et al.*, *Production of Pulses and Grains in Ethiopia*, Report No. 10 (Menlo Park, California: Stanford Research Institute, January, 1969).

TABLE 2.9

FARM AND HOME EXPENSES PER FAMILY, ETHIOPIA, 1960

Farm and Home Expenses/Family	Ambo-Guder	Sululta-Chancho	Lekempt-Sire	Bure-Jiga
(Eth. $)	(Number of Families)			
0-50	6	4	4	32
50.01-100.00	32	6	3	60
100.01-200.00	29	20	2	85
200.01-300.00	21	14	-	45
300.01-400.00	5	8	-	13
400.01-500.00	4	4	1	7
500.01-600.00	2	5	-	5
600.01-700.00	1	3	-	1
700.01-800.00	2	0	2	-
>800	-	5	-	3
Total	102	69	11	251
Average/Family (Eth. $)	185.78	298.55	231.82	171.12
Percentage Distribution of Farm and Home Expenses				
0-100.00	37.3	14.5	54.5	31.1
100.01-200.00	28.4	29.0	18.2	57.8
200.01-300.00	20.6	20.3	-	6.7
300.01-400.00	4.9	11.6	-	2.2
>400.00	8.8	24.6	27.3	2.2

Source: United States, Bureau of Reclamation, Land and Water Resource of the Blue Nile Basin of Ethiopia, p. 26.

help by neighbors, depreciation on farm assets, and interest on investment were important components of cost found in this study.

The consumption of fertilizers, pesticides, herbicides, and fungicides is very low. Peasant farmers have not been acquainted with these technologies until recently. The freedom from Hunger Campaign of FAO has made field trials of fertilizer in most of the agricultural areas. The results were promising. The analyses revealed significant responses of wheat, teff and barley to N, P, NP, and NPK. No significant difference was observed between NPK and NP. The overall results confirm the generally deficient nature of the plateau soil with regard to nitrogen and phosphorous and the presence of adequate potassium. Even though the farmers may have understood the usefulness of fertilizer, its adoption was slow due to the fact that fertilizer prices were high and difficulty was experienced in obtaining the necessary cash to invest in fertilizer.

The annual imports of insecticides, fungicides, and herbicides was less than 2,000 tons. These chemicals were used by plantation farms and a few private commercial farms.

Population Density in the Major Agricultural Areas

At present, most of the settlements in Ethiopia are concentrated in the Highland regions, mainly in the central and eastern plateau. Sufficient precipitation for dry land farming, temperate climate for healthy habitation, and accessibility were the major reasons for such concentration of settlement in the highland regions of Ethiopia.

A study of the population densities of the major agricultural regions (consisting of ninety-nine awrajas) revealed that nineteen of the awrajas had a population density of over fifty persons per square kilometer; five subprovinces had over one hundred persons per square kilometer, seven subprovinces had twenty-six to fifty persons per square kilometer, and five subprovinces had sixteen to twenty-five persons per square kilometer (Figure 2.2).[1] The Committee for Regional Planning suggested that a population density of more than twenty persons per square kilometer would be too high considering the yield conditions of Ethiopian agriculture.

A more informative picture is obtained from an investigation of the ratio of cultivated land to population. The following results were obtained from a study of fifty-eight awrajas in the major agricultural areas:[2]

(1) 28 of the 58 awrajas had more than 4.8 persons per hectare of cropped area (0.2 ha./person).

(2) 40 of the 58 awrajas had more than 3.9 persons per hectare of cropped area (0.25 ha./person)

(3) 52 of the 58 awrajas had more than 3 persons per hectare of cropped area (0.3 ha./person).

A conclusion of the Committee for Regional Planning was that about 75 to 80 percent of the awrajas covered by the study were at a very low subsistence level and inadequately nourished. This contention is supported by Eichberger.[3]

According to a preliminary investigation conducted by the Central

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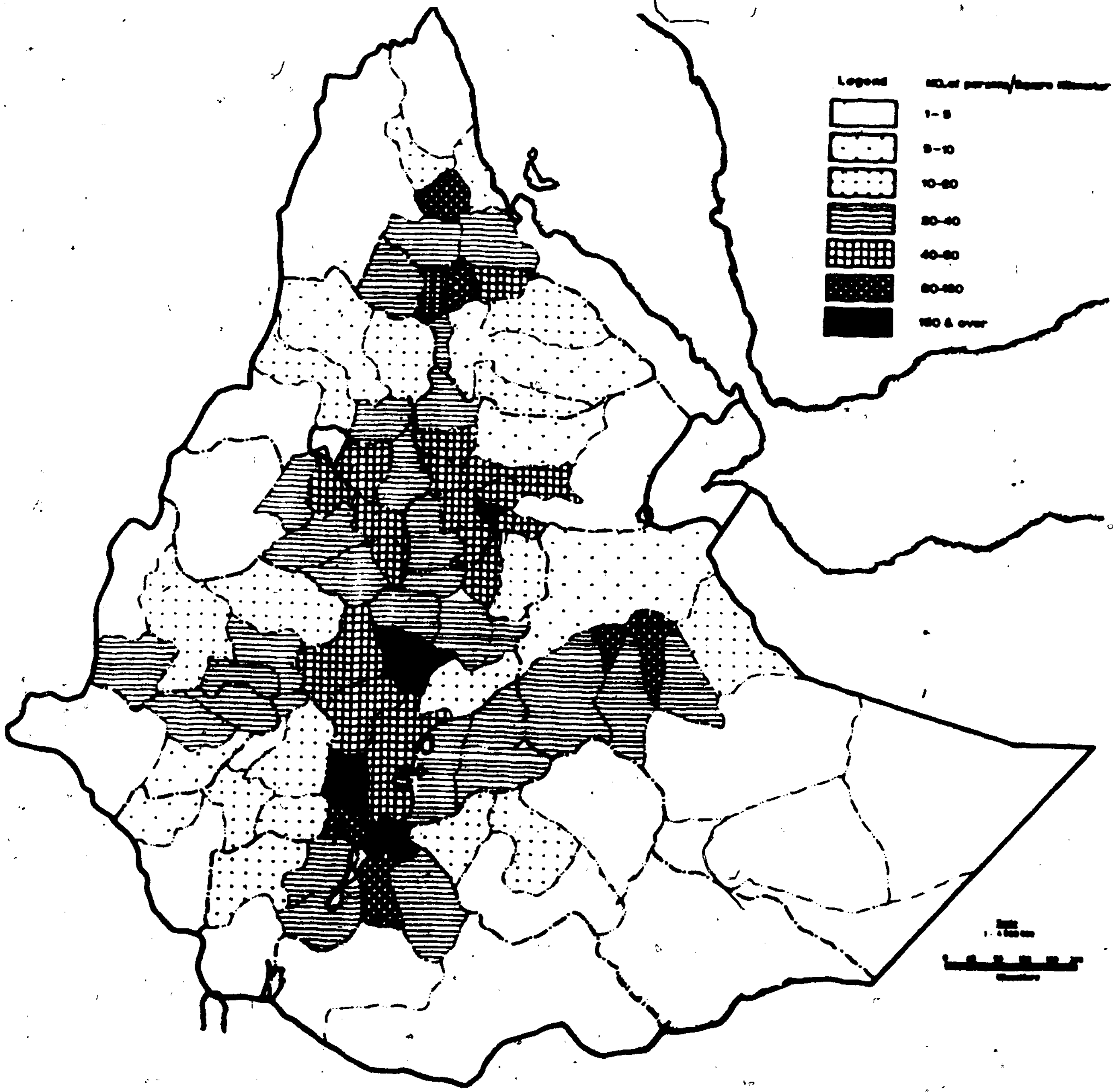
[1] IEG Ministry of Planning, Regional Aspect of National Planning in Ethiopia, Part I, p. 29.

[2] Ibid., p. 30.

[3] W.G. Eichberger, Food Production and Consumption in Ethiopia (Addis Ababa: IEG Ministry of Agriculture, n.d.).

FIGURE 2.2

POPULATION DENSITY BY AWRAJA, ETHIOPIA, 1966



Source: IEG, Ministry of Planning and Development, Regional Aspects of National Planning in Ethiopia, Part I (Addis Ababa: Ministry of Planning and Development, 1967), p. 16.

Statistics Office, the northern provinces consisting of Tigre, Eritrea, and northern Wollo appear to be severely in food deficit because of highly depleted land and overcrowding. The food balance situation of the fifty-eight awrajas studied appears in Table 2.10.[1]

The preceding information suggests that agricultural expansion in the highland regions of Ethiopia, where the majority of the peasant population settlement is found, is not possible by annexation of more land. The low population areas of the south and southwestern provinces are remote and inaccessible at present. Extension of cultivation into these areas requires heavy investment in infrastructure.

Spatial Distribution of Production

In 1966 the actual area of land devoted to the production of the five grain crops under investigation was estimated to be 6.56 million hectares (Table 2.11). Available land use information indicates that each of the producing districts produced some of every commodity. The information also gave some indication of regional specialization, in that the proportion of land areas devoted to certain crops was much larger in some areas than in others. In 1966 about 44.5 percent of all the land used for wheat production was concentrated in three major areas: Shao-Arussi, the Shoa-Wollo-Gojam border area, and Tigre province. Of this, 54 percent was in the Shoa-Arussi area (Figure 2.3a).

Barley production appeared to be more widely distributed than wheat. The major barley producing areas consisted of the central highland provinces of Tigre, Wollo, Begemdir, Gojam, Shoa, and Arussi

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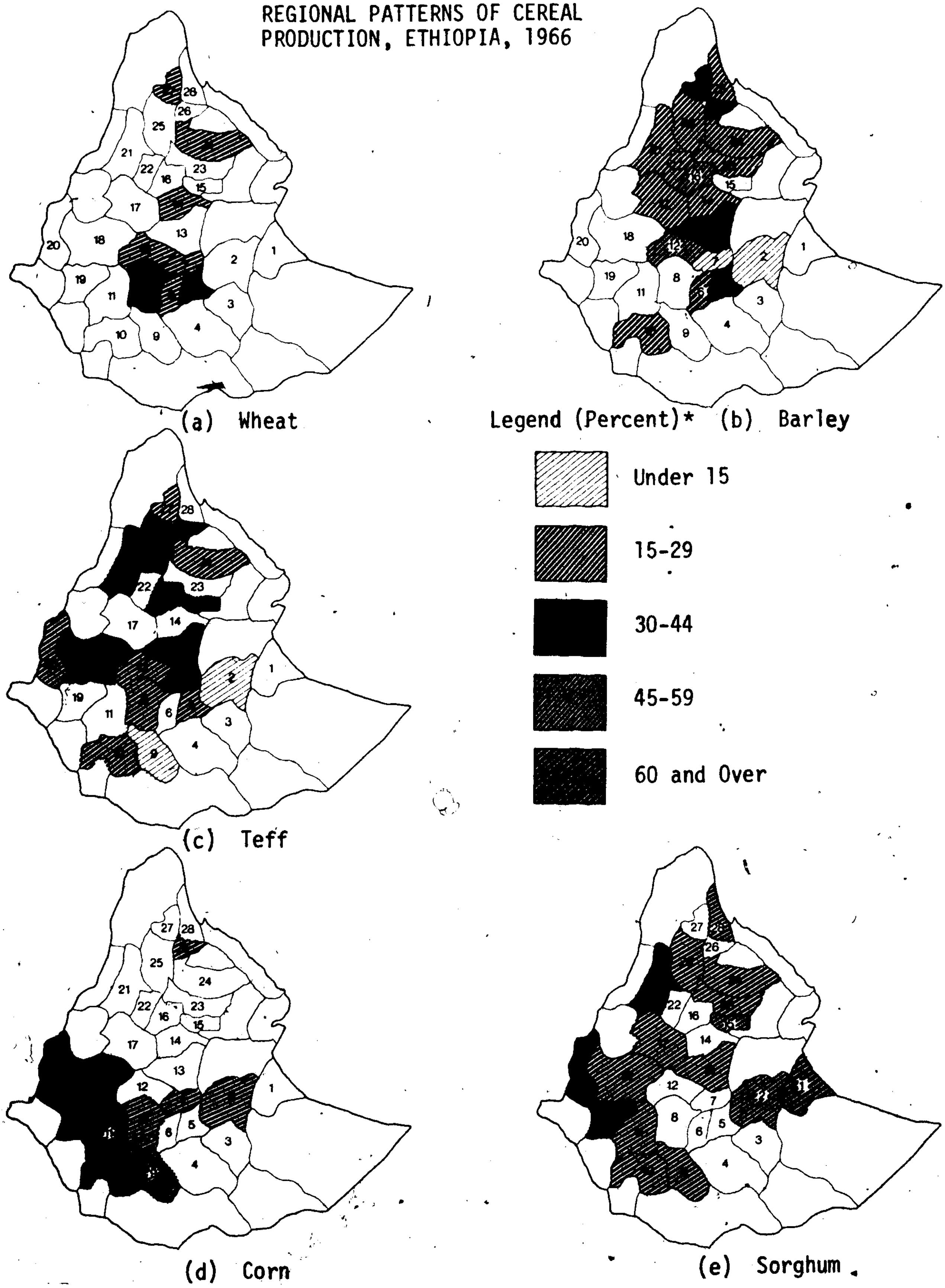
[1] IEG Ministry of Planning, Regional Aspect of Planning in Ethiopia, Part I, p. 35.

FIGURE 2.3

REGIONAL PATTERNS OF CEREAL PRODUCTION, ETHIOPIA, 1966



* Represent percent of total land in wheat, barley, teff, corn, and sorghum.

TABLE 2.10

FOOD BALANCE OF SELECTED SUBPROVINCES OF ETHIOPIA, 1966

Category	No. of Subprovinces	Percent	Explanation
1	5	9	Over populated, very low diet, severe shortage often acute.
2	7	12	Moderate to serious over-population, substantial deficit.
3	23	39	Moderate population, moderately to marginally deficit, low calorie level.
4	13	22	No apparent population problem, near balance food situation.
5	5	9	No population problem, moderate surplus.
6	5	9	Major surplus areas.

Source: IEG Ministry of Planning, Regional Aspect of National Planning in Ethiopia, Part I (Addis Ababa: Ministry of Planning, August, 1967), p. 35.

TABLE 2.11

AREAS IN GRAIN CROPS AND PULSES BY PRODUCING REGIONS, ETHIOPIA, 1966[a]

Region	Teff	Wheat	Barley	Sorghum Millet	Maize	All Pulses	Total
			(Thousands of Hectares)				
1	7.1*	2.9	2.2*	59.0*	20.6		91.8
2	61.0	40.5	66.0	259.0	97.8	64.0	588.4
3	4.5*	14.0*	7.0*	1.0*	1.0*	0.5*	28.0
4	4.5*	14.0*	7.0*	1.0*	1.0*	0.5*	28.0
5	24.0	43.0	46.6	12.1	15.8	11.9	153.4
6	3.7	52.4	153.4	1.5	11.5	29.0	251.5
7	48.2	46.5	19.2	16.5	30.0	54.6	215.0
8	83.8	102.5	29.3	15.3	72.2	55.5	358.6
9	38.1	11.1	20.4	73.8	157.6	22.0	323.0
10	33.5	5.6	44.3	55.8	83.6	8.6	231.4
11	17.3	7.0	14.4	36.5	115.3	15.1	205.6
12	70.7	37.1	116.8	12.7	17.4	53.9	308.6
13	87.5	31.9	82.6	48.2	2.5	89.2	341.9
14	117.9	56.0	68.2	14.5	7.0	109.4	373.0
15	52.3	1.2	4.5	67.4	2.0	18.8	146.2
16	86.8	24.0	120.4	15.1		66.8	312.1
17	464.9	59.6	250.3	154.9	35.7	107.4	1072.8
18	182.0		35.2	71.3	145.1	30.7	454.3
19	31.5	7.4	42.0	72.9	73.5	13.1	238.4
20	27.6		9.7	63.4	72.9	6.7	180.3
21	128.2	19.6	64.3	119.1		34.4	365.6
22	166.6	6.9	65.4	18.5		33.2	290.6
23	63.0	4.7	18.2	33.7		27.5	147.1
24	43.1	34.8	40.2	45.4	15.5	8.7	187.7
25	89.6	30.7	53.2	92.4	17.0	44.6	317.5
26	28.2	6.2	29.7	3.6	20.1	12.0	99.8
27	15.5	16.3	28.1	13.4	3.0	8.9+	85.2
28	4.2	3.6	14.1	35.2	11.9	8.1	77.6

* Represents estimates by the author.

[a] The estimates were based on information furnished by W.G. Eichberger, USAID, and by Central Statistics Office, Ethiopia (expansion survey to entire country).

Source: C.J. Miller, *et al.*, *Production of Grains and Pulses in Ethiopia*, Report No. 10 (Menlo Park, California: Stanford Research Institute, January, 1969), p. 127.

(Figure 2.3b). These regions accounted for about 66 percent of the total land area devoted to barley production in 1966. Teff production was concentrated in the highland portions of Begemdir, Wollo, Gojam and Shoa with close to 60 percent being produced in the Gojam-Begemdir area (Figure 2.3c). Major areas of corn production were Wollega, Kefa and northwest Sidamo region, and the Chercher Highland of Harargie Province. These regions account for 62 percent of the total area planted to corn in 1966 (Figure 2.3d).

Three major areas, namely the Chercher Highland in Harargie, the eastern half of Gojam, and the southwestern corner of Eritrea province, accounted for 49 percent of the land devoted to grain sorghum. More than 50 percent of the land area devoted to sorghum was in Harargie Province (Figure 2.3e).

Interregional Commodity Flows

Actual commodity flow information for 1966 was not available, but using the land use data available and assuming a fixed level of per capita demand for the respective commodities, a tentative surplus and deficit was calculated for each consuming region (Table 2.12).

The Ogaden region consists of land areas too dry for crop farming. Nomadic herding is the prevalent form of agriculture. Thus, this region shows substantial deficits for all the five crops under consideration. Bale, Arussi, west Chercher, Shoa south of Menagesh Awraja and Tigre produced surplus wheat while the rest of the country were in deficit. Barley was short of estimated demand in Sidamo, East Chercher, Dankil, central and north Shoa, Asab, and Eritrea. Teff production was less than the demand requirements in all regions but south Shoa, Wollega,

TABLE 2.12

SURPLUSES(S) AND DEFICITS(D) OF GRAINS IN ETHIOPIA BY CONSUMING REGIONS, 1966

Consuming Region	Wheat S	Wheat D	Barley S	Barley D	Teff S	Teff D	Corn S	Corn D	Grain Sorghum S	Grain Sorghum D
					(Thousand Quintals)					
1		200.61		111.03		478.17		510.85		752.97
2	259.25		122.82			144.20		122.7		165.98
3		354.76		68.69		652.36	1603.43			1004.81
4	760.79		2674.94			599.54		691.70		1003.53
5	44.45		490.87			490.48		0.73	3975.03	
6		209.42		134.62		704.54		632.04	660.09	
7		80.24		44.41		191.27		234.88		301.19
8		430.36		4009.41		867.025		2170.16		3052.31
9	669.25		185.07		534.75		839.03			678.30
10		201.16	249.69			235.36	780.13			404.49
11		139.30	28.66			365.94	2689.74			417.20
12		101.19	465.44			177.96	751.69		666.56	
13		434.29	375.67		956.01		2696.37		1063.90	
14		126.84	2467.14		2066.26			431.87	1293.12	
15		119.86	1920.60		934.89			2666.16		183.82
16		27.31	1389.97		789.43			1204.21	503.12	
17	80.02		1159.91			582.41		1208.09		479.36
18		7.94		4.54		18.55		22.87		29.08
19		480.12		5687.05		1017.05		1195.91	261.57	

Gojam, Wollo, and Begemdir. Corn production was greater than the demand in Sidamo, south Shoa, Gemu Gofa, Kefa, Illubabor, and Wollega. Grain sorghum production was in excess of demand in Chercher, Illubabor, Wollega, Gojam, Gondar, and Eritrea. Shoa and Eritrea which contain the metropolitan areas of Addis Ababa and Asmara respectively showed consistent deficits in all crops. A very preliminary investigation by the SRI suggested that due to the high cost of transportation the movement of cereals were from the immediate areas.

Land Tenure

A considerable proportion of the cultivated land area is under tenancy. According to a survey of eleven provinces conducted by the Central Statistics Office, more than 40 percent of the holdings were tenant-operated in the provinces of Arussi, Gemu, Gofa, Illubabor, Kefa, Shoa and Wollega and 37, 17, and 13 percent were tenant-operated in Sidamo, Wollo and Gojam provinces, respectively (Table 2.13).

The payments received by landlords vary from region to region and depend on the contribution the landlord makes to the operating capital (such as provision of oxen, seed grain, and other inputs). Normally in the case of crop-share arrangements, the shares vary from one-third for land only to one-half for the provision of oxen plus other variable costs. The prevailing mode of payment in the major agricultural areas of Arussi, Shoa, Wollo, Tigre, and Begemdir is crop share (Table 2.14). Cash payments appear to be important in the newly settled regions of the south (i.e., Gemu Gofa, Sidamo, Kefa, and Illubabor).

Communal ownership of land is a prevalent form of land tenure in

TABLE 2.13

DISTRIBUTION OF LAND HOLDINGS BY TYPE OF TENURE IN ELEVEN PROVINCES OF ETHIOPIA, 1969[a]

Province	Owned	Rented	Mixed	Total
		(Percent)		
Arussi	48	45	7	100
Begemdir	85	9	6	100
Gemu Gofa	53	43	4	100
Gojam	80	13	7	100
Illubabor	25	73	2	100
Kefa	38	59	3	100
Shoa	33	51	16	100
Sidamo	61	37	2	100
Tigre	75	7	18	100
Wollega	41	54	5	100
Wollo	60	17	23	100

[a] The statistics do not include all of the subprovinces in each province, but reflect a sample survey.

Source: IEG, Ministry of Land Reform and Administration, Report on Land Tenure Survey of Begemdir and Semen Province, (Addis Ababa: Department of Land Tenure, January, 1970), p. 42.

TABLE 2.14

DISTRIBUTION OF RENTED HOLDINGS
BY MODE OF PAYMENT OF RENT, ETHIOPIA, 1969

Province	Mode of Payment of Rent				
	Cash	Crop-Share	Crop and Cash	Others	Total
			(Percent)		
Shoa	15.0	72.0	3.0	-	100
Arussi	7.0	92.0	1.0	-	100
Wollega	48.6	36.8	11.9	2.7	100
Gemu Gofa	66.0	17.8	6.0	10.2	100
Wollo	8.5	84.2	6.0	1.3	100
Sidamo	84.6	12.3	3.1	-	100
Tigre	5.0	89.0	5.0	-	100
Kefa	63.9	31.2	4.9	-	100
Illubabor	65.8	25.1	19.1	-	100
Begemdir	30.0	66.0	3.0	1.0	100

Source: IEG, Ministry of Land Reform and Administration, Report on Land Tenure Survey of Begemdir and Semen Province (Addis Ababa: Department of Land Tenure, January, 1970), p. 24.

some parts of the country.[1] This form of ownership is generally more prevalent in the provinces of Gojam, Begemdir, Tigre, Eritrea, and in part of Wollo. This type of ownership is a result of centuries of inheritance practices in the old settlement areas of Ethiopia. There are many types of communal ownerships, usually varying from province to province. There is the village system of ownership, tribal ownership, extended family ownership, and others. The commonest form of communal ownership is the extended family system which vests the rights in the land to an extended family consisting of all living descendants of the family founder, "Akni Abat."[2] The rights are vested on a joint, but limited, basis. Each family member is granted a life interest. He may use a portion of the family lands for life, and the lands may be inherited by his heirs but they cannot be disposed of by gift or sale and they cannot be mortgaged to secure a loan of any kind. A newcomer who claims descendency can be awarded the right to communal ownership after proving his descendency.[3]

The second type of communal ownership most prevalent in the north permits a family member to work part of the family land for a certain number of years. After this time, there is a reassignment of the portion of land between family members, usually by elders in the community and/or

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[1] IEG, Ministry of Land Reform and Administration, Report on the Land Tenure Survey of Begemdir and Semin Province, (Addis Ababa: Department of Land Tenure, January, 1970), p. 5.

[2] Through marriage relationships a given family may own communal land in more than one community.

[3] In certain areas of the north (Eritrea, in particular), unless a will exists to the contrary, daughters do not have the right to inheritance. Communally owned land could also be disposed of by sale, mortgaged or given as gift. In case of sale, priority must be given to kin.

family and local government officials. The length of time that a farmer is allowed to cultivate the piece of land assigned to him may vary from three to seven years. This arrangement provides members with the opportunity to use land that is more productive than the one alloted to them at present or vice versa.

Nomadic grazing right is also a form of communal ownership usually encompassing a given tribe or community. All members of a tribe have the right to the grazing land in a given territory. Technically speaking, however, Ethiopian law does not bestow ownership of the land to the nomads but use right (usufructuary) only. With the extension of irrigation farming into the low land areas, this undefined form of tenure relationship may create some problems.

Tenancy Problems

The studies conducted by the land tenure department of the Ministry of Land Reform in various parts of the country showed the prevalence of tenancy. Tenant operation, both in terms of number of farmers and size of cropped land, accounted for more than 40 percent of the total, excepting those provinces with communal ownership (Table 2.13 and 2.15). Written agreements between tenants and landlords were exceptions rather than the rule. Almost all agreements were verbal.[1] In most instances, the tenant is at the mercy of the landlord. Eviction at the will of the landlord is common. The studies also point out that most landlord-tenant agreements, verbal or otherwise, are made for a duration of one growing

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[1] IEG, Ministry of Land Reform and Administration, Report on the Land Tenure Surveys of Begemdir and Semen Province, p. 20.

TABLE 2.15

DISTRIBUTION AND SIZE OF TOTAL
CROPPED AREA BY TENURE, ETHIOPIA, 1969

Province	Owned		Rented		Mixed		Total	Percent
	Hectare	Percent	Hectare	Percent	Hectare	Percent		
Shoa	314,836	28	618,409	55	191,144	17	1,124,379	100
Arussi	85,313	83	112,255	50	26,941	12	224,509	100
Wollega	103,034	46	100,795	45	20,159	9	223,988	100
Gemu Gofa	30,168	49	28,811	47	2,714	4	61,693	100
Wollo	239,654	61	56,109	14	96,596	25	392,354	100
Sidamo	125,728	64	68,453	35	2,302	1	196,483	100
Tigre	212,947	67	23,887	7	81,008	26	317,942	100
Kefa	106,926	53	86,752	43	8,071	4	201,749	100
Illubabor	23,162	30	52,500	68	1,544	2	77,206	100
Begemdir	252,069	98	3,077	1	1,282	1	256,428	100

Source: IEG, Ministry of Land Reform and Administration, Report on Land Tenure Survey of Begemdir and Semen Province (Addis Ababa: Department of Land Tenure, January, 1970), p. 43.

season. Aside from the constitution of the country which guarantees all citizens the due process of the law, there is no specific landlord-tenant relationship legislation. The constitution provides some protection against undue abuse by the landlord, but even then the tenant is too weak both economically and socially to insist on his rights. Even after reform measures are instituted, there are several tactics (legal and illegal) that the landlord could employ to maintain his prereform wealth position.[1] According to Cheung:

> A legal restriction on the rental percentage will induce a variety of contractual rearrangements between the contracting parties to restore the equilibrium that had been arrived at by the market terms of contracts unless these rearrangements are prohibited by law.[2]

The tenant cultivator with insecure tenure has little incentive to undertake long term improvements on the land he cultivates. Also, his capacity to invest is seriously limited by high rents and limited access to credit.

Crop-sharing tenancy also presents problems when costs are not shared between tenants and landlords or when shares are different for various enterprises. There is obviously incentive for missallocation of resources in such cases.

<u>Livestock Enterprises</u>

Since this study is concerned mainly with grain crops, only brief mention is made of livestock enterprises. This, however, should

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[1] Steven N.S. Cheung, The Theory of Share Tenancy: With Special Application to Asian Agriculture and the First Phase of Taiwan Land Reform (Chicago: University of Chicago Press, 1969), p. 88.

[2] Ibid., p. 88.

not be taken to mean that the livestock industry is unimportant to the Ethiopian economy. Future improvement in the diet of the people and increase in foreign trade will depend on the growth of the livestock industry as well as other agricultural developments.

The estimated cattle population is about 25 million head. About two-thirds of these are found in the highland regions where livestock are normally kept as a secondary enterprise. Since livestock prices are too low in relation to grain crops, livestock cannot compete favorably with grain crops for land and other resources. Each household in the highland regions keeps a few animals for milk production, power and transport. Livestock are also kept for contingency purposes to be sold for cash when cash crops are not available for sale. The majority of the peasant farmers keep one to eight animals per household. No particular attention is given to livestock grazing. Usually they are grazed on rough terrain and marginal land, fallowed land, and crop aftermath.

Pasture Land

A rough indication of grazing densities was made by the Committee for Regional Planning and Development.[1] In the estimation of grazing land, 0.7 to 0.8 hectares of graze per animal unit was assumed for the highland mixed farming area while the suggested area for the Rift Valley region was 1.3 to 1.6 hectares per animal unit.[2]

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[1] IEG, Ministry of Planning and Development, Regional Aspects of National Planning in Ethiopia, Part I, p. 40.

[2] Animal units were defined as follows:

Horses 1 animal unit	donkeys 0.5
Mules 1 animal unit	sheep 0.2
Camels 1 animal unit	goats 0.2
All cattle 1 animal unit.	

TABLE 2.16

CATTLE HERD SIZE BY PERCENT DISTRIBUTION IN SOME PROVINCES OF ETHIOPIA, 1966

Province	Number of Cattle Per Household			
	None	1-8	9-12	12+
		(Percent)		
Shoa	15	65	14	6
Arussi	15	59	13	13
Gemu Gofa	44	52	2	2
Wollo	2	91	5	2
Tigre	32	56	7	5
Gojam	24	66	6	4
Wollega	30	49	11	10

Source: Gerald E. Marousek, et al., Development of the Ethiopian Livestock Industry, Report No. 7 (Menlo Park, California: Stanford Research Institute, January, 1969), p. 20.

An index of grazing was prepared by the Planning Committee. The index expresses the total land area required for grazing as a proportion of the total land area (Appendix C, Table C-6). Assuming some 50 percent of the area not to be cropped, a figure of 50 percent indicates fully grazed pasture, depending on the carrying capacity of the soil, topography, etc. In the highland regions a large portion of the noncultivable land is also not fit for grazing. The effective grazing land is much smaller than that as indicated by the indicies of grazing.

Using such a rough guide, about 60 percent of the area covered by the survey was severely to moderately overgrazed and certainly faces a possible danger of overgrazing. It should be understood that these figures are too crude to be used as a policy guide. However, they indicate the seriousness of the problem, which needs to be studied in depth.

Summary

The fact that agriculture is the backbone of Ethiopia is indicated by the overwhelming dominance of agriculture in every sphere of life. In 1967, agriculture accounted for about 56 percent of the GDP of the country. Although the exact number of the labor force employed in agriculture is not known, the urban rural population ratio indicates that close to 90 percent of the labor force is directly or indirectly involved in agriculture. Ethiopia's foreign exchange is obtained almost exclusively from exports of agricultural commodities.

Ethiopian agriculture is primarily subsistence agriculture and farming practices are quite primitive. Investments in farm tools and equipment are in the order of less than fifty dollars per farm. Animals are the major source of power on the farms. As a limited study in Ada (Central Highland) and Alemaya (Chercher Highland) indicated, the total farm investments for both crop and livestock enterprises averaged $1,286.00 and $1,073.00, respectively.

The average per holding cultivated area is generally small, ranging from 0.50 to 1.94 hectares on a provincial basis. Fragmentation of holdings is also widespread, averaging from two to three parcels per holding. The consumption of chemical fertilizers, pesticides, herbicides, fungicides, improved seeds, and irrigation water is at a low level or nonexistent.

A considerable proportion of the land area cultivated is operated by tenants. On the average, about 40 percent of the farms were operated by full tenants in 1967. The prevailing mode of rental payments were crop-share. Varying from one-third to one-half of the crop, depending on the amount of inputs contributed by the respective parties. Communal ownerships dominate in the northern provinces. Nomadic grazing is the prevailing type of agriculture in the lowlands.

The position of tenants is extremely insecure. Written agreements are rare and when it exists, it usually protects the landlord's interest. Legislation specifying the landlord-tenant relationship does not exist at all.

While agriculture is very important to the Ethiopian economy, its backwardness is also a major cause for the plight of the people. The lot of the Ethiopian people cannot be improved if agriculture remains backward.

CHAPTER III

CHARACTERISTICS OF THE DEMAND FOR FOOD (WITH PROJECTIONS FOR 1980)

There are several important factors that affect the demand for agricultural commodities. The more important ones are population, income, urbanization, education, and prices of the product in question and substitutes.

In underdeveloped countries where per capita income is quite low, the demand for food increases in almost direct proportion to increases in per capita income. Population growth also increases the demand for food in direct proportion. Thus, in underdeveloped countries, the two effects reinforce each other. As a nation develops, however, the expansion in food demand due to income increases becomes less important. Food habits or expenditure patterns also change with increases in income. As their income increases, people in underdeveloped nations will shift more and more towards purchasing the meat, eggs, fish, milk, fruits and vegetables they wanted to buy when their incomes were low. Thus their diet will constitute less cereals. The absolute amount of cereal consumption might, however, increase due to population growth.

Regional Demand Estimates

The estimation of regional demands for the five commodities under consideration has a direct bearing upon the spatial allocation of production in the programming models. These demands are minimum requirements of the relevant products which must be produced and allocated by activities in the models. Activities are then selected which will fulfill all demands at a minimum cost.

For this study, regional demands were estimated for each commodity (Table 3.1). The demand for the commodities include personal consumption, industrial uses and net exports. Industrial demands were included in the region where the industries were located and exports were allocated to regions where sea ports are located. Industrial demands found to be significant were beverage processing located in Addis Ababa and Asmara and flour mills again concentrated in Addis Ababa and Asmara. Production in regions not included in a district were subtracted from the estimated demand. The producing districts included in each consuming region are shown in Table 3.2.

The demands for the various commodities were given in fixed quantities for each region. To determine the level of demand for each commodity the following important assumptions were made:

1. That the food habits of people in all regions are the same (i.e., the proportion of each crop consumed are the same for all consuming regions).
2. That relative prices remain constant.
3. No carry-over of commodities from one year to another.

Because of the difficulties mentioned above, the demand estimates were based on the national per capita disappearance of the various commodities in 1966.[1] The per capita disappearance figures were then multiplied by the number of people in each consuming region.

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[1] The researcher understands fully the shortcoming and crude nature of the method employed; but under the circumstances the only feasible way of estimating demand for the various commodities appear to be per capita disappearance.

TABLE 3.1

POPULATION NUMBER AND FOOD CONSUMPTION IN ETHIOPIA BY CONSUMING REGION, 1966[a]

Consuming Region	Population	Wheat	Barley	Teff	Corn	Grain Sorghum
		(Thousand Quintals)				
1	644,000	200.61	111.03	478.17	510.95	284.67
2	156,500	48.75	26.98	116.20	142,70	182.98
3	1,1490,600	464.32	249.02	1,079.84	1,282.23	1,742.81
4	1,088,000	338.91	187.57	807.84	992.04	1,272.09
5	1,288,000	400.12	202.13	949.20	1,098.05	1,037.63
6	1,030,400	341.17	157.72	757.93	863.17	736.44
7	257,600	80.24	44.41	191.27	234.88	301.19
8	3,274,000	1,297.02	6,436.13	2,430.95	2,985.23	3,827.96
9	711,000	221.48	122.58	52.79	648.29	831.30
10	823,200	256.43	141.92	611.23	750.59	962.49
11	669,000	208.39	115.34	496.73	609.99	782.20
12	642,700	200.20	110.80	477.21	586.01	751.45
13	1,394,200	434.29	240.36	1,035.19	1,271.23	1,630.10
14	1,543,700	480.86	266.13	1,146.20	1,407.55	1,804.89
15	3,055,500	951.79	526.77	2,242.11	2,782.71	2,950.11
16	1,320,700	363.40	207.93	923.00	1,204.21	1,423.76
17	2,259,800	608.79	210.14	1,630.98	1,944.49	2,458.96
18	24,981	7.94	4.54	18.55	77.87	29.08
19	1,502,419	513.20	6,125.51	1,115.55	1,344.91	325.83
TOTAL	23,176,300	7,417.91	15,487.01	16,560.94	20,682.10	23,335.94

[a] Consumption for various regions was based on the national per capita disappearance of commodities in 1966.

TABLE 3.2

CROP PRODUCING DISTRICTS WITHIN EACH CONSUMING REGION, ETHIOPIA, 1966

Consuming Region	Crop Producing District	Consuming Regions	Crop Producing District
1	-	11	11
2	3,4	12	19
3	9	13	18,20
4	5,6	14	12
5	2	15	14,15,16,23
6	1	16	21,22
7	-	17	24,25,26
8	12,13	18	-
9	8	19	27,28
10	10		

A demand function that takes not only population, but also income, relative prices, and regional consumption habits into consideration would have been preferable and might have produced a more reliable prediction. However, in a country where more than 80 percent of the amount consumed by greater than 80 percent of the population is home produced, the task becomes quite formidable, if not impossible. No reliable information is available to enable one to develop a demand function that will reflect the consumption and expenditure habits of the Ethiopian people.

Per Capita Demand Projections for 1980

Changes in the structure of demand are likely to occur with increases in the per capita income. However, it was assumed that the increase in the per capita demand for all cereal crops under consideration to 1980 would be a function of income changes alone, and would be the same for all regions, (i.e., the demand for all the cereal crops would increase by about the same percentage in all regions and for all five cereal grains). Thus, total output would need to be increased in about the same proportion.

In general, a consumption function can be expressed algebraically as follows:[1]

$$C_t = AY_t^n P_t^m \qquad (3.1)$$

where:

C_t = per capita food consumption for year t,

Y_t = per capita gross domestic product for year t,

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[1] There is really no strong methodological reason for selecting this functional form over other functions. In budget data analysis, however, the double logarithmic function has the practical advantage that the regression coefficient is equal to the elasticity coefficient.

P_t = relative food price in year t,

n = income elasticity of demand,

m = price elasticity of demand, and

A = constant or scale factor.

Rewriting equation (3.1) for the initial period, year 0:

$$C_o = AY_o^n P_o^m \qquad (3.2)$$

where:

Y_o = per capita gross domestic product for the initial period (1966),

C_o = average per capita consumption during the initial period (1966), and

C_t, Y_t, n, and m are as defined in equation (3.1).

Dividing equation (3.1) into equation (3.2) give the following relationship:

$$C_t = C_o\left(\frac{Y_t}{Y_o}\right)^n \left(\frac{P_t}{P_o}\right)^m \qquad (3.3)$$

Assuming that relative prices remain constant, equation (3.3) reduces to the following formulation:

$$C_t = C_o\left(\frac{Y_t}{Y_o}\right)^n \qquad (3.4)$$

Per capita domestic product was assumed to increase at a constant rate between period 0 and t (4.5 percent per annum; see Table 3.4). Industrial and export demands for cereals were assumed to increase by the same proportion as consumer demand. Income elasticities used in this projection were obtained from FAO estimates (Table 3.3). Given the above

TABLE 3.3

ESTIMATES OF INCOME ELASTICITIES FOR
WHEAT, BARLEY, TEFF, CORN, AND GRAIN SORGHUM, ETHIOPIA, 1968

Crop	Income Elasticity
Wheat	+0.70
Barley	+0.40
Teff[a]	+0.70
Corn	+0.40
Grain Sorghum	+0.40

[a] Estimate provided by the author.

Source: FAO, Agricultural Commodity Projections, 1970-1980, Vol. II (Rome: FAO, 1971), p. 194.

TABLE 3.4

PROJECTED PER CAPITA GROSS DOMESTIC PRODUCT FOR ETHIOPIA[a]

Year	Population	GDP	Per Capita GNP
	(Millions)	(Eth. $ Million)	(Eth. $)
1966	23.1	3,388	146.0
1975	27.7	4,851	175.0
1980	30.6	5,938	194.0

[a] Rate of growth in Gross Domestic Product was estimated to be 4.5 percent per annum.

conditions, equation (3.4) was used to project per capita demand for each cereal crop under consideration (Table 3.5).

Projections of Population and Aggregate Demand

There are as many estimates of population growth for Ethiopia in the 1970's and 1980's as there are estimators. The available data for the 1960's show that the population has been growing at an increasing rate. Estimates generally have ranged between 2.0 percent and 2.6 percent per year.

FAO estimated a 2.2 percent rate of population growth for the 1966-1975 period and a 2.4 percent rate for the 1975-1980 period. Such increases would probably be considered too high for a world that is preoccupied with the problems of popualtion explosion, but studying the characteristics of the Ehiopian population suggests that these probably are conservative estimates. About 52.4 percent of the total population was less than twenty years of age in 1963 (Table 3.6). For the next few decades at least, the number of women of child bearing age will be growing at an increasing rate. A high birth rate and the miracle of modern medicine could make the rate of population increase higher than expected. FAO estimates were used for this study (Table 3.7).

Projections of population and gross domestic product data were made using exponential growth functions. That is, 1966 data for population and gross domestic product were multiplied by constant national growth factors as indicated below in equations 3.5 and 3.6, respectively.

$$P_{iT} = P_{it}(1+r)^n \quad (3.5)$$

$$G_T = G_t(1+r)^n \quad (3.6)$$

TABLE 3.5

ESTIMATED PER CAPITA DEMAND OF CEREALS OF ETHIOPIA
FOR 1966, 1975, AND 1980

Crop	1966	1975	1980
		(Kilograms)	
Wheat	31.15	35.37	38.01
Barley	17.24	18.54	19.32
Teff	74.25	84.29	90.59
Corn	91.18	98.04	102.20
Grain Sorghum	116.92	125.70	131.00

TABLE 3.6

ESTIMATED POPULATION OF ETHIOPIA BY AGE GROUP AND SEX, 1967

Age Group	Total Population		Male		Female	
	Total	Percent	Number	Percent	Number	Percent
			(Thousands of People)			
0-4	4150.1	17.5	2116.0	17.7	2034.1	17.4
5-9	3948.1	16.7	2046.9	17.1	1901.4	16.3
10-14	2400.1	10.1	1331.8	11.1	1068.3	9.1
15-19	1914.4	8.1	1009.6	8.4	904.8	7.7
20-24	1757.4	7.4	736.3	6.2	1021.1	8.7
25-29	1977.8	8.4	855.0	7.1	1122.8	9.6
30-34	1823.4	7.7	824.7	6.9	998.7	8.5
35-39	1411.9	6.0	730.8	6.1	681.1	5.8
40-44	1238.6	5.2	586.3	4.9	652.3	5.6
45-49	735.3	3.1	414.2	3.5	321.1	2.8
50-54	812.7	3.4	417.9	3.5	394.8	3.4
55-59	415.9	1.8	272.4	2.3	143.5	1.2
60 and over	1081.5	4.6	623.1	5.2	458.4	3.9
TOTAL	22667.4	100.0	11965.0	100.0	11702.4	100.0

Source: IEG, Central Statistics Office, Ethiopia: Statistical Abstract of 1967 and 1968 (Addis Ababa: CSO, 1968), p. 27.

TABLE 3.7

ESTIMATED POPULATION BY CONSUMING REGION, ETHIOPIA, 1966, 1975, and 1980[a]

Region	1966	1975	1980
	(Thousands of People)		
1	644.0	784.1	882.8
2	156.5	190.5	214.5
3	1490.6	1816.0	2101.0
4	1088.0	1325.0	1491.0
5	1288.0	1572.0	1770.0
6	1030.4	1254.0	1412.0
7	257.6	314.9	354.5
8	3274.0	3986.0	4502.0
9	711.0	865.8	977.0
10	823.2	1000.0	1126.0
11	669.0	814.5	917.0
12	642.7	784.7	883.5
13	1394.2	1697.0	1911.0
14	1543.7	1879.0	2115.0
15	3055.5	3719.0	4188.0
16	1320.7	1608.0	1810.0
17	2259.8	2752.0	3098.0
18	25.0	30.4	34.2
19	1502.4	1829.0	2059.0
	20229.7	27468.6	31846.5

[a]Annual Growth Rates were obtained from FAO estimates:
1966 - 1975 = 2.2%
1975 - 1980 = 2.4%.

where:

P_{iT} is projected 1980 population in the ith consuming region,

P_{it} is the estimated 1966 population of the ith consuming region,

G_T is projected 1980 gross domestic product,

G_t is estimated 1966 gross domestic product,

n is the time interval between the initial period and the year for which projection is made, and

r is the annual national growth factor.

Aggregate demand was determined by multiplying the projected per capita demand of 1980 by the number of persons in each consuming region using the following equation (Table 3.8):

$$D_{ikT} = C_{kT}P_{iT} \qquad (3.7)$$

where:

D_{ikT} is aggregate demand in 1980 for the kth product for the ith consuming region,

C_{kT} is projected 1980 per capita consumption of the kth product, and,

P_{iT} is as defined above.

TABLE 3.8

PROJECTED DEMAND FOR WHEAT, BARLEY, TEFF, CORN, AND GRAIN SORGHUM BY CONSUMING REGIONS, ETHIOPIA, 1980

Region	Population 1980	Wheat	Barley	Teff	Corn	Grain Sorghum
		(Thousands of Hectares)				
1	882.8	335.55	170.56	799.73	902.22	1156.47
2	214.5	81.53	41.44	194.32	219.22	281.0
3	2101.0	798.59	405.91	1903.30	2147.22	2752.31
4	1491.0	566.73	288.06	1350.70	1523.80	1953.21
5	1770.0	672.78	341.96	1603.44	1808.94	2318.70
6	1412.0	562.16	272.80	1279.13	1443.06	1849.72
7	354.5	134.75	68.49	321.14	362.30	464.40
8	4502.0	2050.71	7444.79	4078.36	4601.04	5897.62
9	977.0	371.36	188.76	885.06	988.49	1279.87
10	1126.0	427.99	217.54	1020.04	1150.77	1475.06
11	917.0	348.55	177.16	830.71	937.17	1201.27
12	883.5	335.82	170.69	800.36	902.94	1157.39
13	1911.0	726.37	369.21	1731.17	1953.04	2503.41
14	2115.0	803.91	408.62	1915.98	2161.53	2770.65
15	4188.0	1591.86	809.12	3793.91	4280.14	5486.28
16	1810.0	687.98	349.69	1639.68	1849.82	2371.10
17	3098.0	1180.52	598.53	2806.48	3166.16	4058.38
18	34.2	13.00	6.60	30.98	34.95	44.80
19	2059.0	840.01	6972.80	1865.25	2104.30	2697.29
TOTAL	31846.5	12530.17	19302.73	28849.74	32537.11	41718.93

CHAPTER IV

REGIONAL PRODUCTION AND TRANSPORTATION

Producing Districts and the Criteria of Partitioning

The interaction of topography, climate, and soil largely determines the pattern of land use. The intensity and distribution of rainfall, soil fertility and structure, elevation, slope, temperature and day length all contribute to the ecological system of an area or region. In each region, the range of crops which may be grown is generally influenced by local conditions.

Producing districts are the basic units of analysis in interregional competition analysis. Resource restraints and producing activities are defined for each district. Production contributes to supply in the consuming region in which the producing district is located. A set of yield figures which were assumed to be fixed and known in quantity, were determined for each producing district. The country was divided into producing districts based on the following criteria: (1) soil fertility, (2) precipitation, and (3) general elevation.

Conceptually, each small community or farm in the nation can be considered a separate producing unit, and supply and demand for factors and products can be estimated for each farm.[1] An interregional competition model that involves a large number of small regions requires a lot of time, effort, and resources. Most programming analyses use large

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[1] Randolf Baker, "The Estimation of Regional Supply Functions," in Interregional Competiton Research Methods, edited by Richard A. King (Raleigh: N.C. State of UNC, 1963), p. 161.

geographical regions as producing units.[1] Production coefficients are derived for each producing district. The basic assumption is that these regions are internally homogenous.

For this study, each producing district was assumed to be potentially suitable for the production of all the crops under investigation. However, production activities were defined for each district only if land use data for 1966 showed some acreage devoted to the particular crop in that year or if experiment station trials indicated its adaptability to the area (Table 2.11). The total hectares used for the production of wheat, barley, teff, corn and sorghum in 1966 in each region were used as land resource constraints (Table 4.1).

The soil fertility indices used were obtained from the study done by the Ministry of Planning and Development.[2] Values of zero to ten were assigned as a rough approximation of the fertility of the soils in each Awraja (Figure 4.1). In assigning these values as fertility indicators of the soils in each Awraja, account was taken also of relief, irrigability, drainage and erosion.[3]

Information on rainfall and general elevation was considered in the regionalization of the country. This method of dividing the country into producing districts overlooks the influence of micro-climatic and physiogrpahic conditions which significantly affect crop production and

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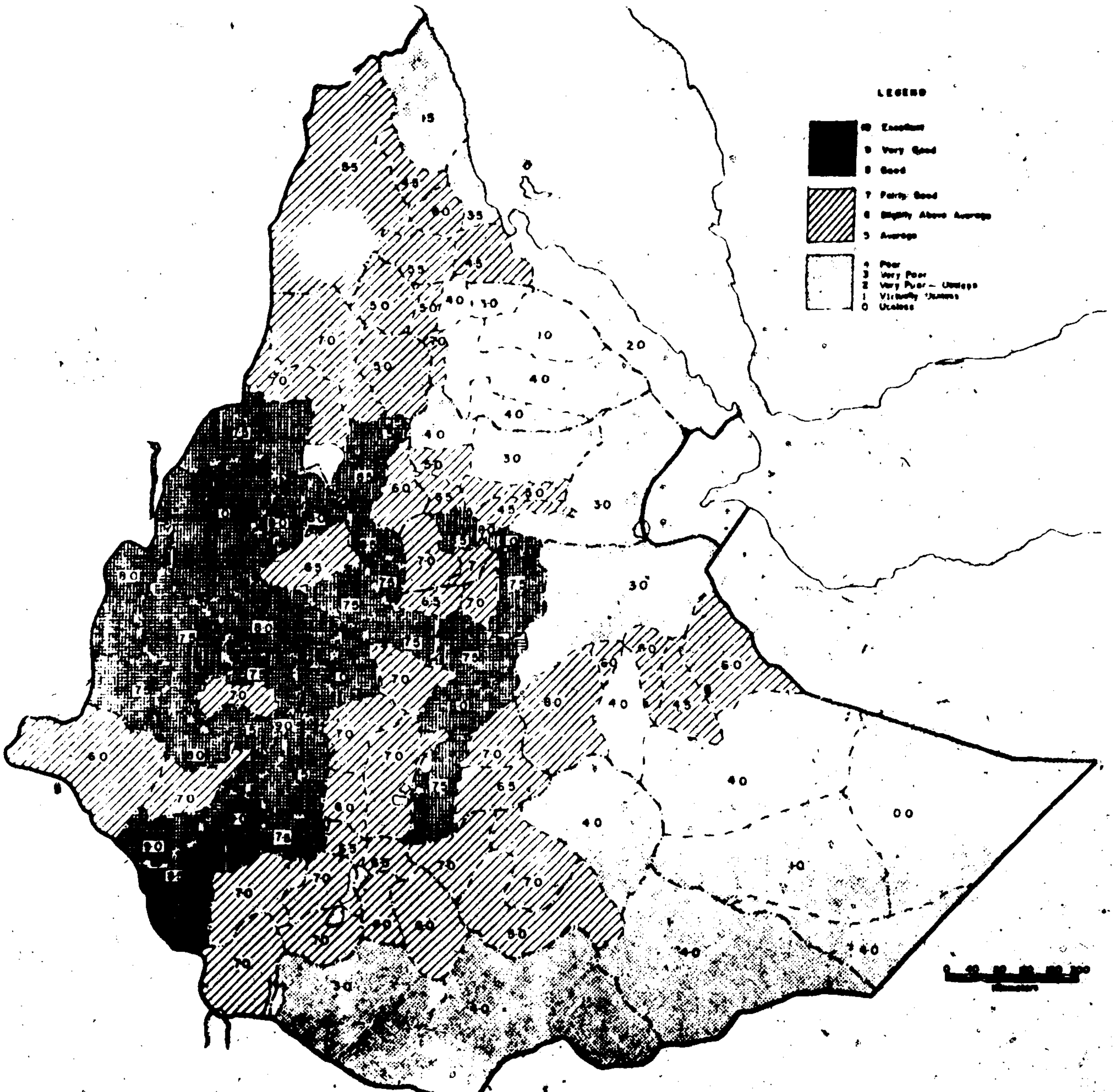
[1] Earl O. Heady, "Aggregation and Related Problems in Mo[illegible] Analysis of Interregional Competition," in Interregional Competition Research Methods, edited by Richard A. King (Raleigh: N.C. State of UNC, 1963), p. 29.

[2] IEG, Ministry of Planning and Development, Regional Aspects of National Planning in Ethiopia, Part I, p. 24.

[3] Ibid., p. 25.

FIGURE 4.1

SOIL FERTILITY INDEX BY AWRAJA, ETHIOPIA, 1966



Source: IEG, Ministry of Planning and Development, Regional Aspects of National Planning in Ethiopia, Part I (Addis Ababa: Ministry of Planning and Development, (1967), p. 25.

TABLE 4.1

HECTARES OF LAND IN WHEAT, BARLEY, TEFF, CORN AND GRAIN SORGHUM BY PRODUCING REGIONS, ETHIOPIA, 1966[a]

Producing Region	Area	Producing Region	Area
	(Thousands of Hectares)		
1	91.8	15	127.4
2	524.4	16	245.3
3	27.5	17	965.4
4	27.5	18	423.4
5	141.5	19	225.3
6	222.5	20	173.6
7	160.4	21	331.2
8	303.1	22	257.4
9	308.5	23	119.6
10	222.8	24	179.0
11	190.5	25	272.9
12	254.9	26	87.8
13	266.2	27	76.3
14	263.6	28	69.5

[a] The estimates were based on information furnished by W.G. Eichberger, US AID/E, and by Central Statistics Office, Ethiopia (expansion survey to entire country).

Source: C.J. Miller, *et al.*, *Production of Grains and Pulses in Ethiopia*, Report No. 10 (Menlo Park, California: Stanford Research Institute, January, 1969), p. 127.

adaptation. Unfortunately, studies which employ broad geographical areas usually overlook details that are otherwise important.

Reference Yield Determination

Yield information is one of the crucial coefficients in interregional competition analysis. The models used in this study were built on the assumption that each producing district differs in its agricultural characteristics from other producing districts. This fact is usually reflected either in per hectare yield differential or in per hectare cost differential for the same quantity of output.

The reference yield data were obtained from the results of the FAO Freedom from Hunger Campaign fertilizer trials conducted in the major agricultural areas of Ethiopia (Table 4.2). Since data for 1966 or prior to 1966 were not available, the reference yield represented a weighted average of the check yields of the three yearly trials between 1967 and 1970 (1967-68, 1968-69, 1969-70). The weights used were the number of observations in each district. In districts where trial results were not available for certain crops, yields from adjacent regions were used.

A word of caution is in order here. In using these data, it was assumed that the areas selected were representative of the region in which they were located. However, this assumption has not been tested.

Yields with Fertilizer Application

Improved cultural practices such as the application of fertilizer, use of improved seeds, application of pesticides, implementation of irrigation, and overall improvement of general farm management practices

TABLE 4.2

AVERAGE REFERENCE YIELD FOR WHEAT, BARLEY, TEFF, CORN AND GRAIN SORGHUM BY PRODUCING REGIONS, ETHIOPIA, 1966

Producing Regions	Wheat	Barley	Teff	Corn	Grain Sorghum
	(Quintals per Hectare)				
1	11.0	10.5	7.5	11.0	23.7
2	11.0	10.5	7.5	11.0	19.7
3	11.0	10.7	8.0	10.0	8.5
4	11.0	10.7	8.0	10.0	8.5
5	11.0	10.7	7.5	11.0	19.7
6	12.0	15.4	7.5	11.0	19.7
7	7.5	14.3	8.4	16.1	10.0
8	8.9	10.5	7.0	20.6	10.0
9	9.9	8.8	11.0	18.3	10.0
10	9.9	8.8	11.0	18.3	10.0
11	6.3	10.0	7.6	28.6	10.0
12	8.0	12.3	7.3	17.0	10.0
13	7.1	8.7	7.3	14.5	10.0
14	11.4	13.0	14.6	13.0	22.8
15	8.9	10.0	17.7	13.0	22.8
16	6.0	10.0	5.6	13.0	26.4
17	5.9	10.9	6.9	27.3	20.0
18	13.4	13.7	9.5	18.2	20.0
19	13.4	13.7	9.5	18.2	20.0
20	13.4	13.7	9.5	18.2	20.0
21	12.7	12.4	5.9	14.0	14.0
22	12.7	12.4	5.8	14.0	14.0
23	7.8	17.1	16.7	24.6	14.0
24	11.2	15.2	5.2	14.0	14.0
25	8.1	6.5	7.6	14.0	14.0
26	8.[illegible]	14.3	5.3	14.0	14.0
27	9.2	10.4	5.0	10.0	14.0
28	9.2	10.4	5.0	10.0	14.0

Source: IEG, Ministry of Agriculture, Extension Service and FAO, "Freedom from Hunger Campaign: Fertilizer Demonstrations Programs, 1967/68, 1968/69 and 1969/70," Addis Ababa, n.d. (Unpublished Reports.)

increase crop yields markedly. Experience in many countries has shown that such practices have more than doubled production of certain crops.

In Model II fertilizer responses were programmed to determine the impact of improvements in farming practices. Since information on responses to other improvements are very limited, no attempt was made to include such changes. The data on fertilizer application appeared to be more reliable.

The fertilizer response data were obtained from the same source as the reference yields (Table 4.3). The same three-year averages were used as coefficients of productivity. The optimum level of application cannot be determined as there was only one level of application. The tests were conducted for nitrogen, nitrogen-phosphorous, and nitrogen-phosphorous-potassium. Best results were obtained for 40-46-0 levels of fertilizer for wheat, barley, teff, and grain sorghum and 60-69-0 for corn. Nitrogen was applied in the form of urea and phosphorous was applied as triple super phosphate.

Cost of Production

The objective of the interregional model is the minimization of the linear summation of the cost of production plus transportation. These costs must be estimated as accurately as possible. Cost coefficients are the most critical data to be estimated before one proceeds with the analysis of interregional competition. To do a creditable job, some acceptable and consistent technique of estimating costs must be devised. In interregional competition analysis, the absolute value of costs is not as important as the relative values of the cost coefficients. One should try to maintain the proper relationships between costs of production

TABLE 4.3

YIELD OF WHEAT, BARLEY, TEFF, CORN, AND GRAIN SORGHUM WITH FERTILIZER APPLICATION, BY PRODUCING REGION, ETHIOPIA, 1967-70

Producing Regions	Wheat	Barley	Teff	Corn	Grain Sorghum
	(Quintals per Hectare)				
1	26.0	17	16	27	44
2	26.0	17	16	27	40
3	14.0	16	9	32	32
4	14.0	16	9	32	32
5	19.0	25	13	27	40
6	19.0	25	13	45	40
7	17.0	22	18	27	17
8	18.0	17	14	41	33
9	18.0	15	14	39	32
10	18.0	20	14	39	32
11	13.0	20	17	48	32
12	16.0	20	14	39	39
13	12.0	18	15	32	31
14	17.0	18	17	16	31
15	11.0	18	27	16	30
16	14.0	25	15	16	30
17	14.0	25	15	50	30
18	23.0	18	17	32	39
19	23.0	18	17	32	32
20	23.0	18	17	32	32
21	9.0	20	11	27	21
22	9.0	20	10	27	21
23	14.0	24	19	17	39
24	15.0	24	8	17	39
25	14.0	12	15	17	36
26	14.0	24	13	17	36
27	12.0	12	5	17	44
28	12.0	12	5	17	44

Source: IEG, Ministry of Agriculture, Extension Service, and FAO, "Freedom from Hunger Campaign: Fertilizer Demonstration Programs, 1967/68, 1968/69, and 1969/70, 1970/71," Addis Ababa, n.d. (Unpublished reports); IEG, Institute of Agricultural Research, Progress Report for the Period April, 1970 to March, 1971 (Addis Ababa: Bako Research Station, April, 1971); IEG, Institute of Agricultural Research, Progress Report for the Period April, 1969 to March, 1970 (Addis Ababa: Holeta Guenet Research Station, May, 1970).

of different districts and different crops.

Carleton D. Dennis[1] lists three approaches for estimating costs: (1) experimental, (2) statistical, and (3) synthetic. The first approach requires conducting controlled experiments and keeping records of the final product. The second approach uses time series data which are obtained from firms. The third method involves the synthesizing of an input-output relationship from production records and using engineering techniques to measure labor and equipment requirements. The following methods were used for this purpose: (1) budget analysis, (3) engineering cost functions, and (3) farm synthesis. The budget analysis involves the definition of the kinds and quantities of products to be processed and the development of a budget based on estimates of quantities and costs of inputs and expected outputs. The budget method uses input-output ratios in physical terms with appropriate prices applied to convert to costs. For this study, the budgeting procedure was used to arrive at cost figures for each crop enterprise and district. Detailed budgets were prepared for each district and crop for 1966 using whatever information was available.

The cost estimates for this study included annual charges of depreciation, equipment replacement costs, interest on capital invested, maintenance costs, labor and power costs, seed costs, costs of fertilizer and other factors of production used in each district. All these costs were converted on a per hectare basis.

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[1] Carleton D. Dennis, "Processing Cost Estimation in Studies of Interregional Competition," in Interregional Competition Methods, edited by Richard A. King (Raleigh, N.C.: N.C. State of UNC, 1963), p. 184.

The costs of production were divided by activities for ease of calculation and comparability. Production costs were subdivided further as yield dependent and yield independent.[1]

The yield independent crop production costs were:

1. Pre-planting cultivation costs,
2. Planting costs,
3. Cultivation cost, and
4. Crop management costs.

The cost contributing factors were the efforts required for each operation, the number of repeated operations, the associated wage scale and other costs for labor, the costs of equipment and animal utilization, and the cost of seeds and fertilizers.

The yield dependent crop production costs associated with peasant farming practices were:

1. Harvesting costs,
2. Threshing costs,
3. Sacking and handling costs,
4. Crop storage costs, and
5. Transportation cost.

Labor cost included both imputed and actual [illegible] calculating labor costs one can use opportunity cost, but in underdeveloped areas like Ethiopia, the opportunity cost of labor in agriculture is near zero because the opportunity for employment outside of agriculture is very limited. Therefore, from society's point of view, one can assign a zero

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[1] Miller, et al., Systems Analysis Methods for Ethiopian Agriculture, Vol. 1, pp. 211-218.

price for operator and family labor. But in interregional analysis, where interregional as well as intercrop comparisons are to be made, it is essential to include all actual and imputed costs since it can make a difference when comparing the comparative advantage of each region in the production of each crop. Since competition between crops exists, opportunity cost for intercrop comparison is not zero.

A charge of one dollar per day was made for all labor that was used in the production of crops in all districts. A charge of $1.50 per day was made for the services of a pair of oxen. This labor charge could be considered a subsistence wage without which labor cannot exist. Since a great deal of human labor and effort is used in crop production, the greater portion of the cost is labor cost and other noncash charges like depreciation and interest on investment. Cash expenses account for an insignificant proportion of the total cost of production under current practices. The study by the Stanford Research Institute showed that costs of purchased inputs averaged $44.30, ranging from $12.00 to $84.00 (Table 2.6).

Depreciation allowance per acre was calculated for each district on the basis of the average cultivated area per holding in each district (Table 4.4). A crucial assumption made here was that the typical farmer in each district would have the assets listed in Appendix C, Table C-3. The estimated depreciation charge per farm was divided by the cultivated area per holding.

$$D_i = \frac{\text{Estimated depreciation per holding}}{\text{Number of hectares cultivated}} .$$

The depreciation charge was assumed to be same for all crops in a given district. Repair and maintenance was estimated to be 3 percent of the

TABLE 4.4

CULTIVATED AREA PER HOLDING BY PRODUCING DISTRICTS, ETHIOPIA, 1966[a]

Producing Region	No. of Holdings	Hectares of Cultivated Area	Cultivated Area Per Holding (ha)	Producing Region	No. of Holdings	Hectares of Cultivated Area	Cultivated Area Per Holding (ha)
1	118,496	94,300	0.79	15	84,400	63,410	0.86
2	236,992	847,200	2.47	16	84,200	82,367	1.08
3	9,580	28,000	2.92	17	245,370	228,722	1.14
4	9,580	28,000	2.92	18	136,100	141,912	1.16
5	56,400	67,150	1.36	19	118,911	238,400	2.00
6	59,200	121,845	2.51	20	55,200	50,742	1.01
7	53,900	185,438	3.66	21		383,500	1.40
8	29,800	346,128	1.21	22		302,600	1.40
9		323,000	0.52	23	40,200	46,543	1.45
10		201,200	0.54	24	61,000	75,974	1.59
11	102,955	205,600	2.00	25	75,200	110,404	1.79
12	123,900	225,962	2.03	26	92,800	23,971	0.31
13	194,900	288,993	1.64	27	176,565	85,200	0.48
14	182,400	139,203	0.89	28	49,814	78,600	1.58

[a] The statistics do not include all of the sub-provinces in each province, but reflect a sample survey. Land under temporary or permanent crops, temporary meadows, and temporary fallows are included.

Source: Imperial Ethiopian Government, Central Statistics Office, Report on a Survey of Welleja Province (Addis Ababa: Central Statistics Office, 1967), p. 26, Table A6; _____, Report on a Survey of Shoa Province (Addis Ababa: Central Statistics Office, May, 1966), p. 27, Table A5; _____, Report on a Survey of Wollo Province (Addis Ababa: Central Statistics Office, May, 1967), p. 31, Table A6; _____, Report on a Survey of Tigre Province (Addis Ababa: Central Statistics Office, May, 1967), p. 25, Table A5; Harry J. Robinson, An Agricultural Credit Program for Ethiopia, Report No. 9 (Menlo Park, California: Stanford Research Institute, January, 1969), p. 28.

original cost of assets. Representative estimated reference costs of production are provided in Table 4.5.

Cost of Production With Fertilizer Application

The rate of increase in fertilizer use has been quite slow and without any obvious pattern. At present, all the supplies of commercial fertilizer are obtained from foreign sources. Dealers are located only in Addis Ababa and Asmara. According to the Stanford Research Institute study, imports consisted mainly of amonium sulfate, nitrate, urea, and mixed chemical fertilizers.[1] The report also indicated that prices at the port of entry were high but comparable with those countries dependent on imported materials. However, the high cost of internal transport significantly increased prices to inland growers.

The fact that the distribution centers are limited makes the procurement of fertilizer in small quantities by the peasant farmer quite difficult. With improved transportation and when the demand justifies, outlets could be widely spread in the country, thus making prices more attractice. The prices used here are imputed prices which were developed by Getachew Tecle Medhin for the various regions of Ethiopia and have been modified to fit this analysis (Table 4.6).[2] According to Tecle Medhin's analysis, the cheapest source of supply was Asmara (for the northern provinces of Eretrea, Tigre, Wollo and Begemdir). The remaining

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[1] H.M. Benedict and S.A. Cogswell, Potential Fertilizer Demand in Ethiopia, Report No. 1 (Menlo Park, California: Stanford Research Institute, April, 1968), p. 5.

[2] Getachew Tecle Medhin, "An Economic Appraisal of Fertilizer Use in Ethiopia" (unpublished Masters Thesis, University of Alberta, Edmonton, 1972), p. 65.

TABLE 4.5

REPRESENTATIVE REFERENCE COST OF PRODUCTION FOR WHEAT, BARLEY, TEFF, CORN, AND GRAIN SORGHUM BY REGION, ETHIOPIA, 1966

Producing Region	Wheat	Barley	Teff	Corn	Grain Sorghum
			(Eth. $ per Hectare)		
1	280	282	326	269	290
2	171	166	212	155	170
3	157	157	206	147	146
4	157	157	206	147	146
5	208	206	253	196	212
6	167	170	212	153	189
7	146	153	183	146	131
8	220	217	248	223	208
9	366	370	419	367	357
10	357	359	409	356	348
11	182	179	200	195	168
12	175	179	224	175	165
13	188	188	238	186	178
14	263	264	312	250	266
15	265	265	327	256	272
16	228	229	275	225	246
17	219	223	268	240	231
18	230	238	272	225	198
19	195	196	263	176	153
20	249	255	241	240	246
21	211	210	259	178	198
22	211	209	245	197	198
23	200	215	264	211	196
24	197	203	237	187	188
25	185	183	233	179	178
26	533	547	577	527	528
27	336	290	430	365	379
28	199	199	239	184	189

TABLE 4.6

PER HECTARE COST OF FERTILIZER BY PRODUCING DISTRICTS, ETHIOPIA, 1966[a]

Region	Corn	Other Crops
	(Eth. $)	
1	121.00	80.00
2	117.00	77.74
3	121.00	80.35
4	121.00	80.35
5	120.00	79.61
6	114.00	75.86
7	113.00	75.11
8	115.00	76.43
9	121.00	80.36
10	121.00	80.36
11	117.00	77.74
12	117.00	77.74
13	121.00	80.36
14	112.00	74.61
15	107.00	70.86
16	131.00	87.08
17	121.00	80.49
18	120.00	79.61
19	146.00	97.24
20	123.00	81.86
21	107.00	71.33
22	115.00	76.58
23	105.00	70.11
24	101.00	66.98
25	101.00	66.99
26	99.00	65.53
27	97.00	64.35
28	100.00	66.62

[a] Nitrogen and phosphorous were applied in the form of urea and triple super phosphate. The amounts were: 87.5 kg. of urea per hectar (r 40.00 kg. N/ha) and 100 kg. triple super phosphate per hectare (r 46.0 kg. P_2O_5) for wheat, barley, teff, and sorghum and 132 kg. of urea per hectare (260.0 kg. N/ha) and 150.0 kg. of triple super phosphate per hectare (r 69.00 kg. P_2O_5/ha) for corn.

Source: H.M. Benedict and S.A. Cogswell, Potential Fertilizer Demand in Ethiopia, Report No. 1 (Menlo Park, California: Stanford Research Institute, 1968), p. 41; Getachew Tecle Medhin, "Economic Appraisal of Fertilizer Use in Ethiopia" (unpublished Masters Thesis, University of Alberta, Edmonton, 1972), p. 66, Table 5.4.

provinces were in the Addis Ababa zone. In calculating the representative cost of production with fertilizer application, all adjustments of costs due to yield increases were made (Table 4.7).

Transportation

Transportation costs were defined for each commodity from/to consuming regions with surplus production to/from those with deficit. In general, three modes of transportation are used in Ethiopia: (1) truck transport, (2) railway, and (3) pack animals. For this study, truck transportation was used as it was assumed to be the most efficient and the most important means of transportation in Ethiopia, particularly for long hauls.

Flat rate transportation costs were assigned from a central location in a given demand region to a central location for all other demand regions (Table 4.8). The centers were selected with the objective of approximating consumption centers (Figure 1.1). Transportation rates were the same for all five crops. For regions where data were not available, distances were multiplied by rates of transportation on similar road types in adjacent regions. Generally the data obtained indicated that long hauls were cheaper per kilometer than short hauls on similar road types.

Transportation accounts for a big portion of the cost of agricultural products to the consumer. It is particularly so in Ethiopia where basic infrastructural developments are still lagging. According to a study conducted by the Stanford Research Institute, the internal cost of transportation of pulses from a location in Begemdir province amounted to 25 percent of the total value of one ton of pulses at the

TABLE 4.7

EXPECTED COST OF PRODUCTION WITH FERTILIZER APPLICATION BY PRODUCING REGIONS, ETHIOPIA, 1966

Producing Region	Wheat	Barley	Teff	Corn	Grain Sorghum
		(Eth. $ per Hectare)			
1	383	372	421	414	401
2	271	253	304	296	279
3	247	245	288	301	261
4	247	245	288	301	261
5	300	307	340	339	323
6	254	260	296	317	286
7	235	241	273	275	214
8	331	303	336	376	317
9	458	460	504	520	470
10	449	457	494	509	461
11	270	291	291	341	279
12	265	269	311	325	287
13	276	283	330	336	290
14	346	347	391	366	353
15	339	349	411	366	354
16	327	338	376	360	344
17	313	326	361	395	326
18	324	325	363	366	306
19	306	301	337	309	268
20	345	344	334	384	346
21	277	293	339	305	280
22	282	297	328	332	285
23	317	316	359	297	305
24	264	276	303	286	293
25	270	266	317	285	266
26	610	628	656	629	626
27	408	460	498	466	488
28	260	267	306	287	301

Source: IEG, Ministry of Agriculture, Extension Service and FAO, "Freedom from Hunger Campaign: Fertilizer Demonstration Program 1967/68, 1968/69, 1969/70," Addis Ababa, n.d. (Unpublished reports.)

TABLE 4.8

ESTIMATED COST OF TRANSPORTATING COMMODITIES BETWEEN REPRESENTATIVE POINTS OF NINETEEN DEMAND REGIONS, ETHIOPIA, 1966[a]

(Eth.$ per Quintal)

From \ To	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	13.00																	
3	12.55	3.30																
4	9.86	3.50	3.50															
5	8.00	5.00	4.55	1.86														
6	6.70	6.30	5.85	3.16	1.30													
7	11.00	6.00	6.00	3.00	3.00	4.30												
8	10.00	3.50	3.50	1.00	2.00	3.30	3.15											
9	11.10	4.00	4.00	2.10	3.10	4.40	4.25	1.10										
10	12.55	3.50	3.00	3.50	5.00	6.30	6.00	3.50	4.00									
11	12.00	5.00	5.00	3.00	4.00	5.30	5.15	2.00	1.00	5.00								
12	24.00	17.00	17.00	15.00	16.00	17.30	15.65	12.50	13.00	17.00	5.00							
13	13.03	6.53	6.53	4.03	5.03	6.33	6.18	3.03	4.13	6.53	5.03	5.20						
14	13.57	7.07	7.07	4.57	5.57	6.82	3.57	4.67	4.67	7.70	5.57	16.07	6.60					
15	12.38	7.40	7.40	4.90	4.38	5.68	2.65	3.90	5.00	7.40	5.90	16.40	6.93	6.47				
16	15.00	8.50	8.50	6.00	7.00	8.30	6.95	5.00	6.10	8.50	7.00	19.00	8.03	1.40	5.07			
17	14.00	7.25	7.25	4.75	6.03	7.33	4.12	3.75	4.85	7.25	5.75	16.25	6.78	7.45	1.80	5.07		
18	12.30	8.00	8.00	4.91	4.30	5.60	2.75	4.50	5.60	8.00	6.50	17.00	7.53	8.07	2.25	7.32	4.05	
19	15.64	7.50	7.50	5.00	7.84	9.14	6.04	4.00	5.10	7.50	8.00	16.50	7.03	5.05	4.13	4.65	2.33	4.65

[a]Information on cost of transportation is not readily available. Some information is available in Ethiopia: Statistical Abstract of 1967 and 1968. There is some data in the Grain Marketing Report by SRI and also in the IHA report "Progress in Highway Transport", a report prepared for the XIII World Road Congress, Tokyo, Japan, November 3 to 11, 1967.

Asmara terminal market.[1] A study by the Imperial Highway Authority estimated Eth. $1.44 per ton per kilometer as the cost of carrying goods by mule or camel.

An improvement in transportation and marketing facilities would no doubt enhance spatial allocation of production of agricultural products. Due to the ruggedness of the terrain of the country and the particularly wet conditions in the southwestern portion of the country, road building is quite expensive.

The Awraja communications study by the Planning and Development Committee revealed that, on the average, only 22 percent of the country was served by all-weather roads--assuming that areas lying within fifteen kilometers of such roads could be considered to have access to an all-weather road. The Committee, however, found considerable divergence from this median. For instance, Dire Dawa, the Addis Ababa region, Desse vicinity and Hamasien area had a high concentration of all-weather road facilities and over 100 percent accessibility, taking fifteen kilometers as a standard. On the other hand, the Committee noted that thirty-six Awrajas, most of them in the southwestern portion of the country, were without any all-weather road facilities.[2]

Particular problem areas are:

1. Western and southern Ethiopia (including parts of Gojam, Wollega, Illubabor, Kefa and Gemu Gofa provinces).

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[1] Alan R. Thodey, Marketing of Grains and Pulses in Ethiopia, Report No. 16 (Menlo Park, California: Stanford Research Institute, April, 1969), p. 143.

[2] IEG, Ministry of Planning, Regional Aspects of National Planning in Ethiopia, Parts I and II, p. 54.

2. Western Wollo and eastern Begemdir provinces.

3. Bale and Arussi provinces.

Most of these provinces fall in heavy rainfall areas where the use of dry weather trucks is restricted. Other provinces' areas are also less than 50 percent accessible by all-weather roads and only eleven have more than 75 percent accessibility.

Pack animals are still an important component of Ethiopian transportation. Thousands of pack animals are still used in Ethiopia. For example, according to a count made at Woldia (north of Dessie) by the Imperial Highway Authority (IHA) on a typical day in 1966, 500 pack animals were seen on a single westward trail.[1] A spot check on October, 1966 at certain rural locations found an appreciable number of laden pack animals on all-weather highways. The typical carrying charges for pack animals average about Eth. $0.62 per ton per kilometer or over six times the typical truck freight rate on all-weather highways.[2] Representative 1966 trucking tariffs charged for grain movements (when the route was not entirely an all-weather road) varied from Eth. $0.16 to Eth. $0.45 per ton per kilometer.[3]

The Ethiopian government, aided by some nations and international organizations, began a major program of highway improvement in 1950 and

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[1] Imperial Highway Authority (IHA), "Progress in Highway Transport" (paper presented at the XIII World Road Congress, Tokyo, Japan, November 3-11, 1967), p. 16.

[2] Ibid., p. 16.

[3] C.J. Miller, et al., Development of Agriculture and Agro-Industry in Ethiopia: Strategy and Programs, SRI Report (Menlo Park, California: Stanford Research Institute, April, 1969), p. 189.

established the Imperial Highway Authority (IHA) in 1951.[1] So far, the IHA has launched four highway programs; the fourth was initiated in 1968 with a completed expenditure of about Eth. $250 million. This sum is earmarked for construction of bituminous surfacing and for feasibility studies of a total of 1,400 kilometers of road.

Railways

Only two railway links exist in the country, one about 305 kilometers between Mitsiwa and Akordat, via Asmara, and the other between Addis Ababa and Djibouti, via Dire Dawa. Both railways are narrow gauge, the latter being one meter and the former, 0.95 meters. The railway between Addis Ababa and Djbouti, which is 781 kilometers long, is managed by a French company incorporated in Ethiopia.

The high cost of transporting goods both for internal market and export and the overall complexities and inefficiencies involved in marketing inhibits regional specialization. It also undermines the competitive position of the country in the world market.

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[1] Imperial Highway Authority, "Progress in Highway Transport," p. 4.

CHAPTER V

ANALYTICAL METHOD

Theoretical Framework

In 1776, Adam Smith wrote:

> ... if a foreign country can supply us with a commodity cheaper than we ourselves can make it, better buy it off them with some part of our own industry, employed in a way in which we have some advantage.[1]

David Ricardo and John Stuart Mill developed an explanation for regional specialization that was the first to be labeled the principle of comparative advantage. Von Thunen and Alfred Weber made significant contributions to what is now called location theory. Alfred Marshal brought the demand aspect into comparative advantage.

The modern theory of regional (international) trade has been built on the basis of the doctrine of comparative advantage originally expounded by David Ricardo.[2] Ricardo explained trade on the basis of labor productivity for two commodities and two countries. The underlying assumption of his proposal was that capital is mobile and returns to capital will be equilibrated between regions by appropriate capital movements.

Ricardo's labor productivity theory and other simplifying assumptions have been challenged in modern times and have been replaced by

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[1] Adam Smith, Wealth of Nations, Vol. 1, 2nd ed. (London: Methuen and Co. Ltd., 1920), p. 422.

[2] David Ricardo, On the Principles of Political Economy and Taxation, edited by Piero Sraffa and M.H. Dobb (London: Cambridge University Press, 1951), Chapter 8.

models that closely approximate the real world conditions. The modern version of comparative advantage explains trade in a general equilibrium setting. In general equilibrium analysis, trade is explained through the existence of a disequilibrium.

One version of the comparative advantage principle explains production and trade by employing the opportunity cost principle. According to this version, the optimum pattern of production and trade for a region (country) is determined from a comparison of the opportunity cost of producing a given commodity with the price at which the commodity can be imported or exported. In equilibrium, no commodity is produced which could be imported at a lower cost, and exports are expanded until marginal revenue equals marginal cost. This explanation assumes the existence of perfect competition and the absence of external economies, which makes some economists uncomfortable because the world is full of monopolies, oligopolies and other types of imperfections (as expalined by Haberler in detail).[1]

The Heckscher-Ohlin version of the comparative advantage doctrine states that a country will benefit from trade by producing commodities that use more of its relatively abundant factor of production.[2] This concept does not depend on the existence of perfect competition and initial equilibrium. However, it assumes that factors of production are

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[1] G. Haberler, "An Assessment of the Current Relevance of the Theory of Comparative Advantage to Agricultural Production and Trade," Proceedings of the International Conference of Agricultural Economists, 1964 (London: Oxford University Press, 1966), p. 18.

[2] Hollis B. Chenery, "Comparative Advantage and Development Policy," Surveys of Economic Theory, Vol. II (New York: St. Martin's Press, 1966), p. 225.

qualitatively the same or comparable in different countries (that is, production functions are the same). Such controversies aside, experts generally accept the merits of specialization according to the principle of comparative advantage and free trade.

In its simplest form, specialization according to the principle of comparative advantage means that each region will engage in the production of the commodity or commodities for which it has the greatest comparative advantage or, conversely, the least comparative disadvantage. The assumption behind this principle is that regions are variously endowed with natural resources, technology and institutions. Although regions could try to produce something of every commodity, it is obvious that they would not succeed or, if they did succeed, it would be only at a high cost.

According to the principle of comparative advantage, even if region (country) A is more efficient than region (country) B in the production of every type of good, as long as there are differences in the relative efficiencies of producing the different goods in the two regions, both regions could have a comparative advantage in the production of one or more goods. The absolutely efficient region, A, will specialize in the commodity in which it has the greatest efficiency (greatest comparative advantage) and B, in the one in which it has the greatest efficiency (least comparative disadvantage). Specialization and trade based on comparative advantage is beneficial if the difference in productivity is sufficient to more than offset transportation and associated costs.

The interregional competition model used in this study was based on the assumption that every region is endowed differently with respect to soil, rainfall, temperature, and other factors which make certain regions better suited for the production of some crops than others.

Models for Interregional Competition Study

The overriding concern in interregional competition analysis is the optimal spatial distribution of production of the commodities under consideration. Resources are to be allocated in such a way that an objective function representing net return is maximized or one representing net costs is minimized, whichever is the case, without violating the constraints imposed by national conditions, institutions, and technology. Factors that affect optimal distribution alter with changes in institutions, technology, population distribution, tastes and preferences, etc. More important, in an agricultural development plan, the basic aim is to introduce new techniques of production and new institutions which are supposed to markedly affect input-output relationships. It is therefore important to select a model which incorporates such changes easily.

The following models are used by researchers in interregional competition studies:[1]

(1) Formal budgeting,

(2) Regression analysis

(3) Transportation programming,

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[1] Earl O. Heady, et al., Agricultural Supply Functions: Estimating Techniques and Interpretations (Ames: Iowa State University Press, 1961) and Roland L. Mighell and John D. Black, Interregional Competition in Agriculture (Cambridge: Harvard University Press, 1951).

(4) Input-output, and

(5) Programming.

Each of these models is useful for specific purposes. The selection of a model depends on the purpose of investigation. The selection of a model for interregional competition analysis is based on the objectives discussed above (that is, ease of incorporating changes that affect the coefficients and restraints). Changes which cause structural variation are of concern in agriculture. Changes in techniques of production, increases in investment, institutional changes, and variations in tradition are instigated to break the link that caused stagnation. These changes can be easily specified in a programming model.

In the programming model, technology changes which affect supply structures could be represented by making appropriate changes in the respective coefficients of the model and changes in the level of commodity demands can be represented by simply changing the level of demand constraints. The procedure involves defining regional production patterns, given the existing conditions. A new programming matrix is set up in which appropriate substitutions are made to accommodate the changes. The results will show us how production patterns, interregional commodity flows, and factor returns would be altered due to the changes specified in the model.

Assumptions of the Model

The following simplifying assumptions are implicit in the construction of the interregional competition model:

1. Minimization of aggregate national cost is the national goal.

2. The country can be divided into n producing districts and each district is internally homogeneous with respect to land and other production factors and their combination in use.

3. Constant returns to scale in each agricultural producing district for the production of each crop over the range of production volume is expected.

4. Each producing district is assumed to have the potential for growing wheat, barley, teff, corn, and grain sorghum.

5. Land and foreign exchange are the only resource constraints; other resources are adequately supplied within a district or are sufficiently mobile between districts to have no restrictive effect upon production.

6. The country can be divided into m spatially separated demand regions each having a demand for the five crops.

7. Costs of transportation of products between points of consumption can be adequately reflected by a flat truck rate and are the same for all crops.

8. Regional demand relations for the various crops are exogenously determined and known and consumption habits are assumed not to vary from one consuming region to another.

The above assumptions can be relaxed and adjustments made wherever needed, but such changes may make the program much more complicated than the results justify. A programming model without the above simplifying assumptions requires voluminous and refined data that are not available in many cases. Furthermore, the utility of further refinement has not been established. The cost of obtaining more detailed data would be considerable. Therefore, in a country like Ethiopia, a simplified model could be more useful than one that is complicated. In addition to the preceding assumptions, the usual linear programming assumptions of additivity, divisibility, finiteness, and single-value expectations apply to this model.

Basic Structure of the Model

As indicated in Chapter I, the mathematical model used for this study is linear programming. The basic components of a linear programming analysis are an objective function, resource constraints and the non-negativity constraints. In this model, the objective function was the minimization of the cost of production and transportation, and the resource constraints were land and foreign exchange. In matrix notation, the basic format of the model would be as follows:

$$\text{Min } f(X) = CX \tag{5.1}$$

Subject:

$$AX \leq B \tag{5.2}$$

$$X \geq 0 \tag{5.3}$$

where:

$C = W + F + T$ is a row vector representing cost coefficients composed of W = cost coefficients of unfertilized crop production (Eth. \$/ha); F = cost coefficients of fertilized crop production (Eth. \$/ha); and T = transportation costs per quintal of grain.

$A = A_w + A_f + S$ is a matrix of unit requirements of activity X composed of A_w = conventional practice; A_f = fertilized crop activity; and S = foreign exchange requirements.

$B = D + E + G + H + U$ is a column vector of constraints composed of D = vector of regional demand of order $n \times q$; E = vector of district acreages available for cereal production of order p; G = vector of minimum acreages to be planted in all districts of order p; H = vector of maximum acreage to be planted in corn and sorghum of order p; and U = a single national foreign exchange constraint, and

$X = Q + X_w + Z$ is a vector of levels of activity of minimum order $[PQ + PX_f + n(n-1)]$, composed of Q traditional production activities in each of the P producing districts; X_w = crop production activities under fertilization; Z = transportation activities of order $n(n-1)$ linking all of the n consuming regions to each other in both directions.

Specific Models

This study was mainly concerned with the determination of the pattern of regional production and interregional flow of cereals in Ethiopia during 1966 and 1980. Four models were programmed to accomplish the above objective. Models I, II, and III employed 1966 data while Model IV used 1980 projected data. The alternatives programmed in the respective models were: (1) conventional farming practices with land as the only resource constraint, (2) conventional and fertilizer activities with land and foreign exchange as resource constraints, (3) conventional and fertilizer activities with land as the only resource constraint (foreign exchange was assumed to be available in sufficient quantity), and (4) conventional and fertilizer activities with land as the resource constraint, plus 1980 data.[1] Each of these models have different policy implications.

Detailed formats of these models are given below. However, since the formats of Models III and IV are the same as Model II, there is no need to describe Models III and IV in detail. Models III and IV can be obtained from Model II by simply substituting the appropriate foreign exchange and demand constraints.

Model I: Regional Specialization With Conventional Practices, 1966

The aim of this model was to find the extent of production relocation and the subsequent savings in resource use as a result of specialization as dictated by the regional comparative advantage and the imposed constraints. The essential parts of the model are summarized below:

$$\text{Min. } \Sigma_j \Sigma_k c_{jk} x_{jk} + \Sigma_i \Sigma_m \Sigma_k t_{im} y_{imk} \quad (5.4)$$

(Objective function)

i = 1 ... n, index of consuming region;

j = 1 ... p, index of producing district;

k = 1 ... q, index of crop; and

m = 1 ... n; $m \neq i$ index of receiving regions.

Subject to four classes of constraints:

$$\Sigma_{j(i)} a_{jk} k_{jk} + \Sigma_m (y_{imk} - y_{mik}) \geq d_{ik} \quad (5.5)$$

(A set of n x q constraints)

j = 1 ... r (districts in consuming region i only);

[1] The only feasible solution for Model IV was obtained when the foreign exchange constraint was removed. A total of Eth. $278 million worth of foreign exchange is needed to apply fertilizer where it is profitable.

$\Sigma_k x_{jk} \leq e_j$ (5.6)

(A set of p constraints);

$\Sigma_k x_{jk} \geq f_j$ (5.7)

(A set of g constraints);

$\Sigma_k X_{jk} \leq g_j$ (5.8)

k = 4, 5 (corn, sorghum only).

And the non-negativity constraint (5.3):

c_{jk} = elements of sub-vector w, representing per hectare cost of producing crop k in producing district j;

t_{im} = element of sub-vector t, cost of truck transportation of one quintal of grain from region i to region m (it is assumed that shipment costs between districts within the same region are zero);

x_{jk} = element of sub-vector q, hectares of crop k to be planted in district j by conventional means;

y_{imk} = element of sub-vector y, quintals of crop k to be shipped from region i to region m;

u_{mik} = shipment of crop k from region m to region i;

a_{jk} = element of matrix A associated with conventional cropping activities, representing yield (quintals per hectare) of crop k in district j;

d_{ik} = element of sub-vector D, demand for crop k in region i (quintals) net of unprogrammed minor production;

e_j = element of sub-vector E, area available for grain crops in district j;

f_j = element of sub-vector G, minimum area to be planted in grains in district j;

g_j = element of sub-vector H, maximum area in corn and sorghum in district j.

In Model I the objective function is the linear summation of the costs of production and transporation (Equation 5.4). The only resource constraint was land. The optimum solution to this model would provide the regional production and resource use patterns, commodity flows among regions, regional equilibrium prices for the commodities under investigation, and the rental value (shadow prices of the fixed resource). The analysis would also provide the amount of excess land that could be withdrawn from use for the crops under consideration.

Equation 5.5 represents a demand constraint. The sum of production and net imports of each crop must not be less than the demand for each crop in each consuming region (Table 5.1 and 5.2). Equation 5.6 limits the activities or crops planted to the area of land available in each producing district (Table 5.3). All other resources were assumed to be present in sufficient quantity. Equation 5.7 sets a lower limit to land use in each producing district. These limits were set at 60 percent of the initial level (actual 1966 land use). In a programming model where there is no minimum land use constraint, the optimal solution to the production and distribution problem results in some districts producing quantities at zero level, or below their capactiy, while other districts completely utilize all crop land available.

Farmers are generally conservative and would not change to new practices readily. The minimum land use constraint was set to reflect this attitude. In addition, production for home use is not likely to be

TABLE 5.1

FOOD DEMAND CONSTRAINT BY CONSUMING REGIONS, ETHIOPIA, 1966

Consuming Region	Wheat	Barley	Teff	Corn	Grain Sorghum
			(Thousand Quintals)		
1	200.61	111.03	478.17	510.95	284.67
2	48.75	26.98	116.20	142.70	182.98
3	464.32	249.02	1,079.84	1,282.23	1,742.81
4	338.91	187.57	807.84	992.04	1,272.09
5	400.12	202.13	949.20	1,098.05	1,037.63
6	341.17	157.72	757.93	863.17	736.44
7	80.24	44.41	191.27	234.88	301.19
8	1,297.02	6,436.13	2,430.95	2,985.23	3,827.96
9	221.48	122.58	52.79	648.29	831.30
10	256.43	141.92	611.23	750.59	962.49
11	208.39	115.34	496.73	609.99	782.20
12	200.20	110.80	477.21	856.01	751.45
13	434.29	240.36	1,035.19	1,271.23	1,630.10
14	480.86	266.13	1,146.20	1,407.55	1,804.89
15	951.79	526.77	2,242.11	2,782.71	2,950.11
16	363.40	207.93	923.00	1,204.21	1,423.76
17	608.79	210.14	1,630.98	1,944.49	2,458.96
18	7.94	4.54	18.55	22.87	29.08
19	513.20	6,125.51	1,115.5[illegible]	1,344.91	325.83
TOTAL	7,417.91	15,487.01	16,560.94	20,682.10	23,335.94

TABLE 5.2

FOOD DEMAND CONSTRAINT BY CONSUMING REGION, ETHIOPIA, 1980

Consuming Region	Wheat	Barley	Teff	Corn	Grain Sorghum
			(Thousand Quintals)		
1	335.55	170.56	799.73	902.22	1,156.47
2	81.53	41.44	194.32	219.22	281.00
3	798.59	405.91	1,903.30	2,147.22	2,752.21
4	566.73	288.06	1,350.70	1,523.80	1,953.21
5	672.78	341.96	1,603.44	1,808.94	2,318.70
6	562.16	272.80	1,279.13	1,443.06	1,849.72
7	134.75	68.49	321.14	362.30	464.40
8	2,050.71	7,444.79	4,078.36	4,601.04	5,897.62
9	371.36	188.76	885.06	988.49	1,279.87
10	427.99	217.54	1,020.04	1,150.77	1,475.06
11	348.55	177.16	830.71	937.17	1,201.27
12	335.82	170.69	800.36	902.94	1,157.39
13	726.37	369.21	1,731.17	1,953.04	2,503.41
14	803.91	408.62	1,915.98	2,161.53	2,770.65
15	1,591.86	809.12	3,793.91	4,280.14	5,486.28
16	687.98	349.69	1,639.68	1,849.82	2,371.10
17	1,180.52	598.53	2,806.48	3,166.16	4,058.38
18	13.00	6.60	30.98	34.95	44.80
19	840.01	6,972.80	1,865.25	2,104.30	2,697.29
TOTAL	12,530.17	19,302.73	28,849.74	32,537.11	41,718.93

abandoned in favor of purchases unless safe earning opportunities exist. The lower land use limit also avoids extreme income disparities between producing districts when all land, or a large portion of the land, is withdrawn from its initial uses and is not replaced by other uses.

Equation 5.8 sets an upper limit on the amount of land to be used for corn and sorghum in districts where land use for the two crops accounted for less than 50 percent of the land use in a given area in 1966 (Table 5.3). The land use data for 1966 indicated that sorghum and corn were minor crops in some areas of the Ethiopian highland. It is unrealistic to assume that all five crops are equally competitive for land in all districts. For this reason the program was constrained so that cultivation of corn and sorghum would not exceed 150 percent of the 1966 level of land use for the two crops in producing districts where the combined actual land use for corn and sorghum in 1966 was less than 50 percent of the total land use for that year.

Model II. Regional Specialization With Conventional and Fertilizer Activities, 1966

A fertilizer activity was introduced in this model necessitating the addition of a foreign exchange constraint. The discussions in Chapters I and II indicated that the possibility of increasing agricultural output through annexation of more land is limited due to the tremendous expenditure required to create new settlements and the socio-economic factors that hinder mobility. Agricultural output can be increased through more intensive cultivation of the land area presently cultivated. To determine the effect of intensification of production, a fertilizer activity was

TABLE 5.3

LAND CONSTRAINTS BY PRODUCING DISTRICTS, ETHIOPIA, 1966

Producing Regions	Lower Limit All Cereals	Upper Limit All Cereals	Upper Limit Corn & Sorghum*
		(Thousnads of Hectares)	
1	55.00	91.8	
2	277.62	524.4	
3	16.40	27.5	3
4	16.40	27.5	3
5	84.80	141.5	41.88
6	133.50	222.5	19.50
7	96.24	160.4	69.75
8	181.86	303.1	131.25
9	192.36	308.5	
10	133.68	222.8	
11	114.30	190.5	
12	135.18	254.9	45.15
13	173.22	266.2	76.05
14	158.16	263.6	32.25
15	76.44	127.4	
16	147.18	245.3	22.60
17	579.18	965.4	285.90
18	254.16	423.4	
19	--	225.3	
2-	104.16	178.6	
21	198.72	331.2	
22	154.44	257.4	27.75
23	71.76	119.6	50.55
24	107.40	179.0	91.35
25	163.74	272.9	164.10
26	52.68	87.8	35.55
27	45.78	76.3	24.60
28	41.70	69.5	

* Blank space indicates no upper limit.

programmed in Model II. The essential parts of this model are presented below:

$$\text{Min. } \Sigma_j\Sigma_k c_{jk}x_{jk} + \Sigma_j\Sigma_k f_{jk}z_{jk} + \Sigma_i\Sigma_m\Sigma_k t_{im}y_{imk} \quad (5.8)$$

(Indexes same as in Model I).

Subject to:

$$\Sigma_{j(i)}a_{jk}x_{jk} + \Sigma_{j(i)}a_{jkf}z_{jk} + \Sigma(y_{imk}-y_{mik}) \geq d_{ik} \quad (5.9)$$

(A set of n x q constraints)

j = 1 ... r (districts in consuming region i only),

$$\Sigma_k x_{jk} + z_{jk} \leq e_j \quad (5.10)$$

(A set of p constraints),

$$\Sigma_k x_{jk} + \Sigma z_{jk} \leq g_j \quad (5.11)$$

k = 4, 5 (corn, sorghum only),

(A set of p constraints),

$$\Sigma_j\Sigma_k s_{jk}z_{jk} \leq h \quad (5.12)$$

z_{jk} is the element of sub-vector Z representing hectares of crop k to be planted in district j by fertilizer application;

s_{jk} is an element of sub-matrix S identifying the amount of foreign exchange needed to finance fertilizer required for activity z in district j for crop k;

h is foreign exchange limit for importation of fertilizer;

f_{jk} is an element of sub-vector F representing the per hectare cost of producing crop k in the jth producing region with fertilizer activity.

The remaining notations are the same as in Model I. The objective function in Model II was the minimization of the sum of the costs of production under conventional and fertilized crop activities and transportation as indicated in Equation 5.9. Equation 5.13 limits the level of fertilizer activity to the amount of foreign exchange allowed for this purpose. Eth. $100 million foreign exchange was allocated for the importation of chemical fertilizers. (The areas where fertilizer should be applied are shown in Appendix D. Table D.1.) The rest of the constraints are the same as in Model I.

<u>Model III: Regional Specialization With Unconstrained Fertilizer Usage, 1966</u>

The format of this model is the same as Model II. The only difference is in the magnitude of foreign exchange allowed for the importation of fertilizer. The model was programmed to allow the application of fertilizer wherever it was profitable. Using parametric programming the optimum level of foreign exchange was determined to be Eth. $127 million.

<u>Model IV: Regional Specialization With Unconstrained Fertilizer Usage, 1980</u>

In this model an attempt was made to analyse the potential for satisfying the food needs of the Ethiopian population by the 1980's. This analysis involved projection of population, income, and per capita demand to 1980. The analysis was made for both conventional and fertilized crop activities using a modified demand constraint. The format of the model is identical to Model III, but changes were made in the level of demand constraint to reflect 1980 consumption needs. The foreign exchange necessary to purchase fertilizer was found to be Eth. $278 million.

Solution Techniques

The interregional competition model used for this study provides information on regional production patterns, interregional commodity flows, rental value of the limiting resources, and equilibrium commodity prices. This information was obtained from the primal and the dual of a linear programming solution. Regional production patterns and interregional commodity flows were obtained from the primal solution and the rental value and commodity prices were obtained from the dual solution of the linear programming models used.

The simplex method, a computational routine for obtaining the optimal solution for a linear programming problem, was developed by Dantzig.[1] This method is essentially an iterative elimination procedure yielding basic solutions at each stage. The procedure consists of taking a point (extreme) in a feasible set and evaluating the objective function at that point, then taking another extreme point, and so on, until an optimum value is reached. The simplex method provides a systematic rule which prevents examination of some points that yield lower values for the objective function than the point selected. When an optimum solution is obtained employing this procedure, it is a global optimum. No other point in the feasible set can yield a greater value for the objective function. Table 5.4 gives a summary of the simplex table without the identity matrix.

Interpretation of Shadow Prices

The dual solution to a linear programming problem gives the

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[1] D. Gale, The Theory of Linear Economic Models (New York: McGraw Hill, 1966), pp. 97-128.

TABLE 5.4

SUMMARY OF THE SIMPLEX TABLE WITHOUT THE IDENTITY MATRIX MODELS II, III, AND IV

Row Name	Type of Restraint	Producing										Transportation					
		Unfertilized					Fertilized										
		W	B	T	C	S	W	B	T	C	S	W	B	T	C	S	28
Land																	
Total	≤	1	1	1	1	1	1	1	1	1	1						28
W	≤	1					1										28
B	≤		1					1									28
T	≤			1					1								28
C	≤				1					1							28
S	≤					1					1						28
W	≥	1					1										28
B	≥		1					1									28
T	≥			1					1								28
C	≥				1					1							28
S	≥					1					1						28
C+S	≤				1	1				1	1						17
Foreign Ex.	≤	1	1	1	1	1	1	1	1	1	1						1
Demand	≥																
W	≥	a										-b					19
B	≥		a										-b				19
T	≥			a										-b			19
C	≥				a										-b		19
S	≥					a										-b	19
W	≥											b					19
B	≥												b				19
T	≥													b			19
C	≥														b		19
S	≥															b	19
Cost	=	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	1
Number of Activities		28	28	28	28	28	28	28	28	28	28	342	342	342	342	342	

shadow prices (imputed rents) of the restricting resources. Shadow prices are defined as rents or valuations of the worth of the limiting resource. These figures provide an estimate of the relative value of an additional (marginal) unit of crop land in each producing district.

The economic interpretation and policy implications of shadow prices are slightly different for mobile and non-mobile resources. When trying to analyse the role of shadow prices of limiting resources, it would be useful to separate the resources into mobile and non-mobile resources. In a competitive model it is presumed that resources will move from district to district or that producers will shift from the use of one resource to another to equalize their marginal returns if such mobility is not restricted. Therefore, where mobile factors are involved, the differential shadow price for factors in different districts indicates misallocation of the resource in question.

For illustrative purposes, assume that a given amount of foreign exchange is allocated to each producing district. Also assume that the foreign exchange constraint is effective. A rational planner would allocate this scarce but mobile resource in such a way that the marginal returns from foreign exchange in each producing district are equalized. The net benefit to the nation would be increased by shifting foreign exchange from a district with a lower shadow price to one with a higher shadow price. The transfer will continue until the shadow prices in each producing district are equalized.

Land rents are dependent on the productivity of the resource under consideration and on the demand for the product produced by the resource in queston. Rents for land are estimates of rental values of land and these values provide an indication of returns to land from the production of the commodity in question.

Rents are always defined at the margin (that is, they apply only to the first unit change in a production restraint, whether it be an increase or a decrease). A restraint change greater than this amount can result in a change in the rent for land. By decreasing a maximum restraint (such as cropland) in this study, the rent of that resource would be increased if it were a limiting factor of production and the rent would be decreased if the resource in question is increased.

Any resource with excess capacity in an optimal solution has a zero rent. In a programming solution such resources are free resources in a sense that they do not limit production in an optimum plan. On the other hand, scarce resources are those that put a limit to production in the optimum solution. They are scarce relative to the amount the producer requires. In this program free resources mean that, in a region where slack resources are available, the resources in question can be reduced by the amount of slack without affecting the profit of the operator. The land rent in a cost minimization solution also indicates how much cost of production (aggregate cost) could be reduced if one more unit of land is available for the production of the particular crop in each producing region.

Computation of Land Rent

The variables that affect the rent of land in a given producing district are as follows:

1. Imputed price of the commodity in the consuming region containing the producing district in question,

2. The per hectare yield of the crop using the last unit of land, and

3. The per hectare cost of producing that crop.

The rent of land may be shown as follows:

$$L_{kj} = (Q_{kj} \cdot P_{km}) - C_{kj} \qquad (5.14)$$

where:

L_{kj} = rent of land per hectare used by the kth crop in the jth producing district,

Q_{kj} = yield per hectare of the kth crop in the jth producing district,

P_{km} = the per unit price of the kth crop in the mth consuming region containing the jth producing district, and

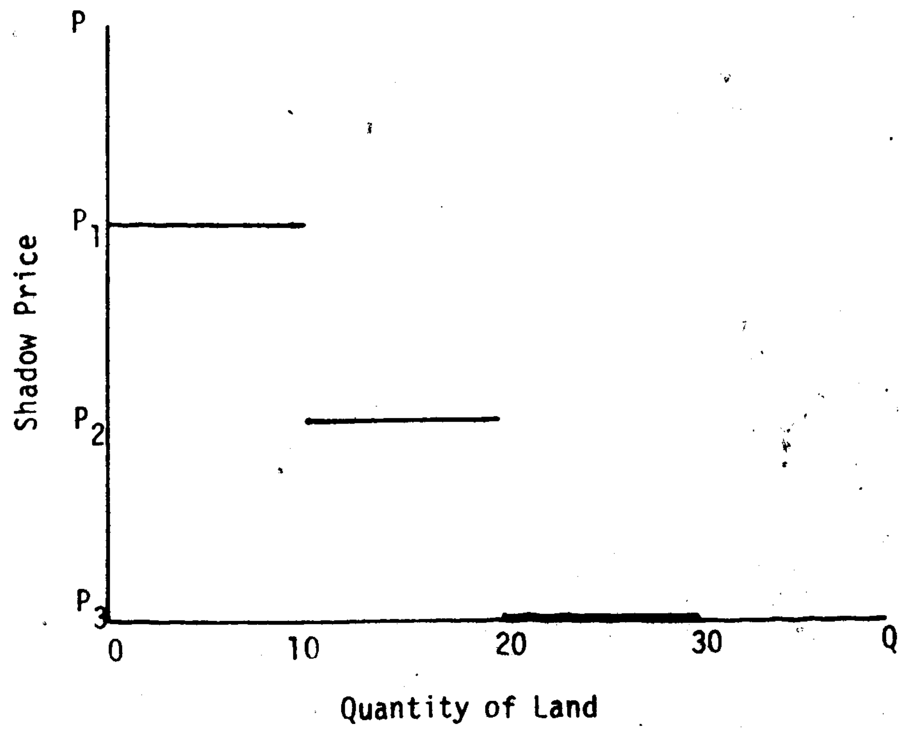
C_{kj} = the hectare cost of production of the kth crop in the jth producing district.

Where a cost minimization criterion is employed, land rent indicates how much aggregate cost could be reduced if the restriction is relaxed by one hectare of land (that is, in a district where the lower limit is the effective restraint, land rent indicates how much cost could be lowered if the lower limit is relaxed by one hectare). Generally, as the constraint is relaxed, the land rent decreases.

A hypothetical illustration of how land rent declines as more land resource is made available is shown in Figure 5.1. The first constraint in Figure 5.1 was ten hectares of land. If all ten hectares of land are used completely, it commands a land rent of P_1. If the constraint is relaxed by adding another ten hectares of land, the rent on the last unit of land would be P_2. If the land resource constraint is further relaxed

FIGURE 5.1

A HYPOTHETICAL DEMAND CURVE SHOWING THE VARIATION IN THE RENT (SHADOW PRICE) OF LAND AS IT IS AUGMENTED



by an additional ten hectares but is not used completely, it commands a zero rent. When all thirty hectares of land are completely utilized, a rent greater than zero will emerge. Rent for a second resource constraint (for example, foreign exchange) whose total quantity may remain unchanged when the supply of land is augmented will behave as illustrated in Figure 5.2 when plotted against the change in the land resource constraint.

Equilibirium Product Prices

The equilibrium price for each crop in a given consuming region is a reflection of the price required to cover the cost of production and shipping of the quantity demanded. If the demand is met by production within the demand region, the equilibrium price is equal to the unit cost of production of the highest cost-producing region within the consuming region. If the consuming region is importing some or all of the product, the equilibrium price is the sum of the per unit cost of production of the product in a source region plus the per unit cost of transporting the product from the region in question. If, on the other hand, the consuming region is an exporter of the product it consumes, then the equilibrium price equals the price of the product in the consuming region to which it exports minus the cost of transportation. All three cases are analized below.

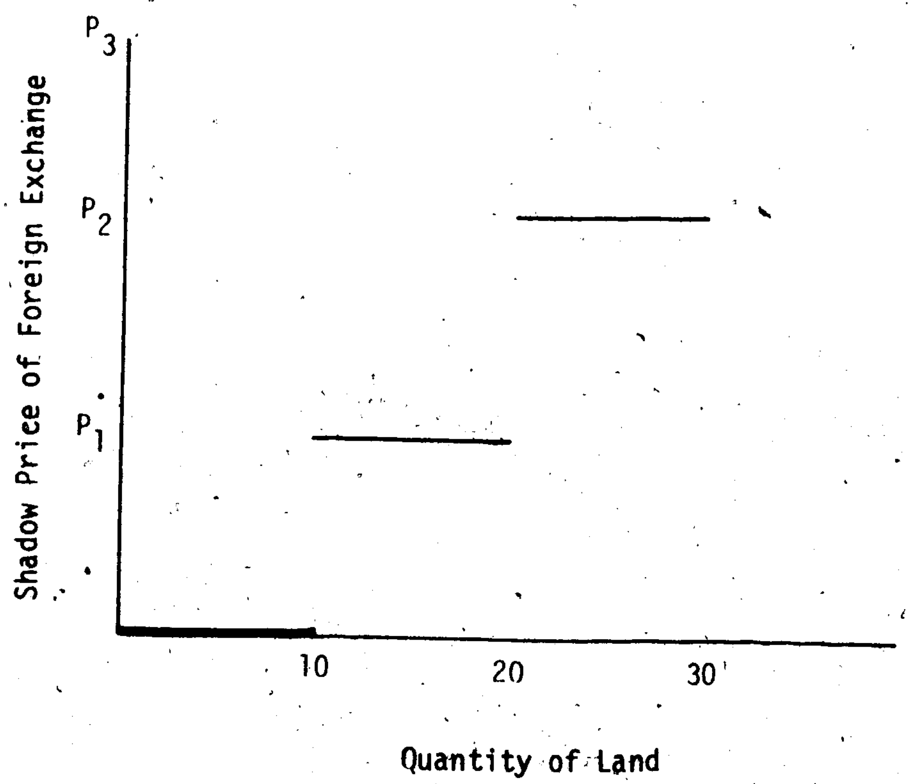
1. For a region that neither imports nor exports, the equilibrium price would be given as:

$$P_{km} = \frac{C_{kj} + L_{kj} + F_x}{Q_{kj}} \tag{5.15}$$

where:

FIGURE 5.2

A HYPOTHETICAL CURVE SHOWING THE VARIATION OF SHADOW PRICE OF FOREIGN EXCHANGE WHEN THE SUPPLY OF LAND IS INCREASED



P_{km} = price of the kth product in the mth consuming region,

C_{kj} = refers to the per unit cost of production of the kth crop in the jth producing region within the consuming region--highest cost-producing region,

L_{kj} = land rent used by the kth crop in the jth region,

F_x = price of foreign exchange, and

Q_{kj} = per hectare yield of the kth crop in the jth region.

2. For a region importing from another consuming region, the cost of transportation is added from the latter to the former as:

$$P_{kj} = \frac{C_{kj} + L_{kj} + F_x + t_{km}}{Q_{kj}} \tag{5.16}$$

where t_{km} is the cost of transporting the kth product from the mth to the ith consuming region. The rest of the variables are the same as in Equation 5.15.

3. For a consuming region that exports to another region, the price would simply be the equilibrium price in the importing region minus transportation cost. A given consuming region may import the same product from several regions in which case the price would be determined based on the highest cost source.

The supply for a given commodity would be forthcoming from the various regions in order of their productive efficiency (that is, before any resource in a less productive region is used, the limiting resource in the most efficient region must be exhausted). The unit price of the commodity in each producing region contained in a consuming region would be determined using the ratio of the cost of production to the yield in that region.

$$P_1 = \frac{C_1}{Q_1}$$

$$P_2 = \frac{C_2}{Q_2}$$

$$P_n = \frac{C_n}{Q_n}$$

where: $P_1 < P_2 < \ldots < P_n$,

$P_1, P_2, P_3, \ldots, P_n$ = prices of the commodity for producing districts 1 ... n with decreasing productivity, respectively, and

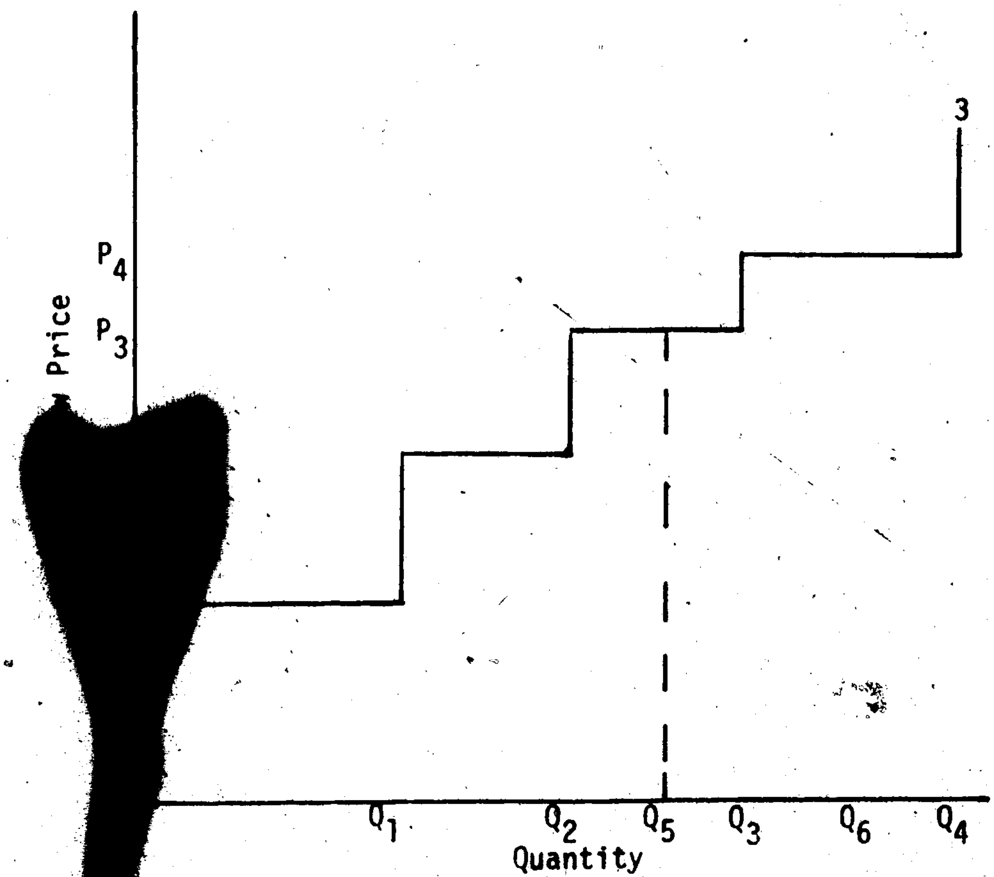
C_j, Q_j = cost of production and yield for regions i, ..., n, respectively.

A simple hypothetical example illustrates how the supply curve for a commodity in a given consuming region would be determined. Assume that there are four producing districts arranged in order of ascending production costs in a given consuming region. Also assume that a fixed quantity of demand, Q_5, exists (Figure 5.7). To satisfy the fixed level of demand, resources in Producing District 3 must be utilized. If the region is neither an exporter nor an importer, the price in this consuming region would be determined by the highest cost-producing district (in this case, District 3). There would be positive rents for Producing Districts 1 and 2 but not for Producing Districts 3 and 4 since all land is not used up in these regions.

Suppose the consuming region in Figure 5.3 exports $Q_6 - Q_5$ units of output to other consuming regions so that total production in the hypothetical consuming region would be Q_6. In this case, all the land resource in Producing District 3 and some land in District 4 must be used. Under the above conditions, the price of the commodity in the exporting

FIGURE 5.3

A HYPOTHETICAL PRODUCT SUPPLY CURVE FOR A
CONSUMING REGION CONTAINING FOUR PRODUCING DISTRICTS



region and importing region would be determined by the conditions in the importing region. As a consequence of the change in level of demand for the commodity in question, land rent would appear for land resources in Producing District 3. If the commodity in question can be supplied by another region at a lower price than P_1, all land resources would be taken out of production and the consuming region which was an exporter would import all its requirements, unless minimum average restraints would uphold production.

CHAPTER VI

ANALYSIS AND INTERPRETATION OF RESULTS

Activity analysis can provide valuable information on patterns of production,transportation, and prices of resources and commodities. Knowledge of this nature is very important in formulating policies on a nationwide basis or for individual regions. Such information is essential for regional planning, determination of kinds and priorities of research activities, extension of credit, and the development of marketing facilities. However, it is very important to mention at this point that solutions for a linear programming problem do not necessarily reflect what is actually being done. Rather,they give a normative solution (what should have been done under the specified circumstances and objective(s) instead of what is being done). Their usefulness is in providing clues as to the direction one should take. By introducing certain restrictions it is possible to make a programming solution approximate the real life condition.

Production Patterns

The major objective of this study was the investigation of the spatial distribution of production and interregional flows of the various commodities under the assumed alternative programs and levels of demand. From the production pattern it is possible to estimate the direction and magnitude of land use shifts resulting from the application of these program alternatives.

The result of the programming model used in this study also gives information on the amount and location of unused resources existing under each program alternative. Unused resources (land) in this case indicate the extent of excess capacity for the nation as a whole as well as for individual regions.

According to the minimum cost solutions for Models I, II, III and IV, approximately 5.5, 4.1, 4.0 and 5.3 million hectares of land, respectively, would be used to satisfy the estimated consumption requirements of 1966 and 1980 (Table 6.1). Compared with the actual use of 6.6 million hectares in 1966, these results represent a net saving of approximately 15 percent for Model I, 36 percent for Model II, 41 percent for Model III and 20 percent for Model IV. The land thus saved could be converted to other uses such as grazing and production of crops for export. Lands that are too steep to farm are being cultivated in many parts of the Ethiopian highland. Withdrawal of such farms from cultivation would be beneficial from the standpoint of conservation.

The change in the objective functions of each model indicates the national cost saving resulting from the particular policy. The value of the objective functions declined for Models II and III, indicating the worth of the policy. According to the solutions for the models, cost of production and transportation should decrease by approximately Eth. $212 million if fertilizer is used extensively (Table 6.2). However, it should be realized that the reduction of costs shown in the objective function does not include the value of land that could be withdrawn due to the change in policy. To find the total benefit resulting from the policy measure, the net return of the land in its new use should be added to the cost saving.

TABLE 6.1

TOTAL HARVESTED CEREAL LAND BY PRODUCING DISTRICTS IN ETHIOPIA, ACTUAL 1966 AND PROGRAMMED 1966 AND 1980

Producing District	Actual, 1966	Programmed, 1966			Programmed, 1980
		Model I	Model II	Model III	Model IV
		(Thousands of Hectares)			
1	91.84	62.92	55.00	55.00	91.84
2	524.40	524.40	277.62	277.62	524.40
3	27.50	27.50	16.40	16.40	27.50
4	27.05	27.50	16.40	16.40	27.50
5	141.50	141.50	84.80	84.80	141.50
6	222.50	222.50	222.50	133.50	222.50
7	160.40	160.40	160.40	160.40	160.40
8	303.10	181.86	181.86	181.86	264.41
9	308.50	192.36	192.36	192.36	192.36
10	222.80	133.68	133.68	133.68	133.68
11	190.50	190.50	114.30	114.30	190.50
12	254.90	254.90	135.18	153.15	254.90
13	266.20	266.20	173.22	173.22	266.20
14	263.60	263.60	158.16	158.16	263.60
15	127.40	127.40	108.49	81.52	127.40
16	245.30	147.18	147.18	147.18	147.18
17	965.40	579.18	579.18	579.18	579.18
18	423.60	423.60	254.16	254.16	254.16
19	225.33	143.04	114.53	135.18	159.89
20	173.60	173.60	104.16	104.16	173.00
21	331.20	331.20	198.72	198.72	198.72
22	257.40	203.54	154.44	154.44	154.44
23	119.60	119.60	119.60	71.76	119.60
24	179.00	179.00	107.40	107.40	179.00
25	272.90	272.90	163.74	163.74	272.90
26	87.80	52.68	52.68	52.68	52.68
27	76.30	45.78	45.78	45.78	45.78
28	69.50	69.50	41.70	41.70	69.50
TOTAL	6559.57	5518.02	4113.64	3958.45	5294.22

TABLE 6.2

ESTIMATES OF NATIONAL COST SAVING DUE TO SPECIALIZATION AND FERTILIZER USE, ETHIOPIA, 1966 AND 1980

Model	Value of Objective Function		Cost Per Quintal of Cereals	
	1966	1980	1966	1980
	(Eth. $ Million)		(Eth. $ Per Quintals)	
Model I	1450	-	17.45	-
Model II	1244	-	15.00	-
Model III	1238	-	14.92	-
Model IV		1870		13.50

The results indicated that the per quintal cost of supplying cereals decreased with the application of fertilizer. Application of more fertilizer also resulted in increased efficiency. According to the solutions of Models I and IV, the per quintal cost of providing cereals in 1980 could be lower than that of 1966.

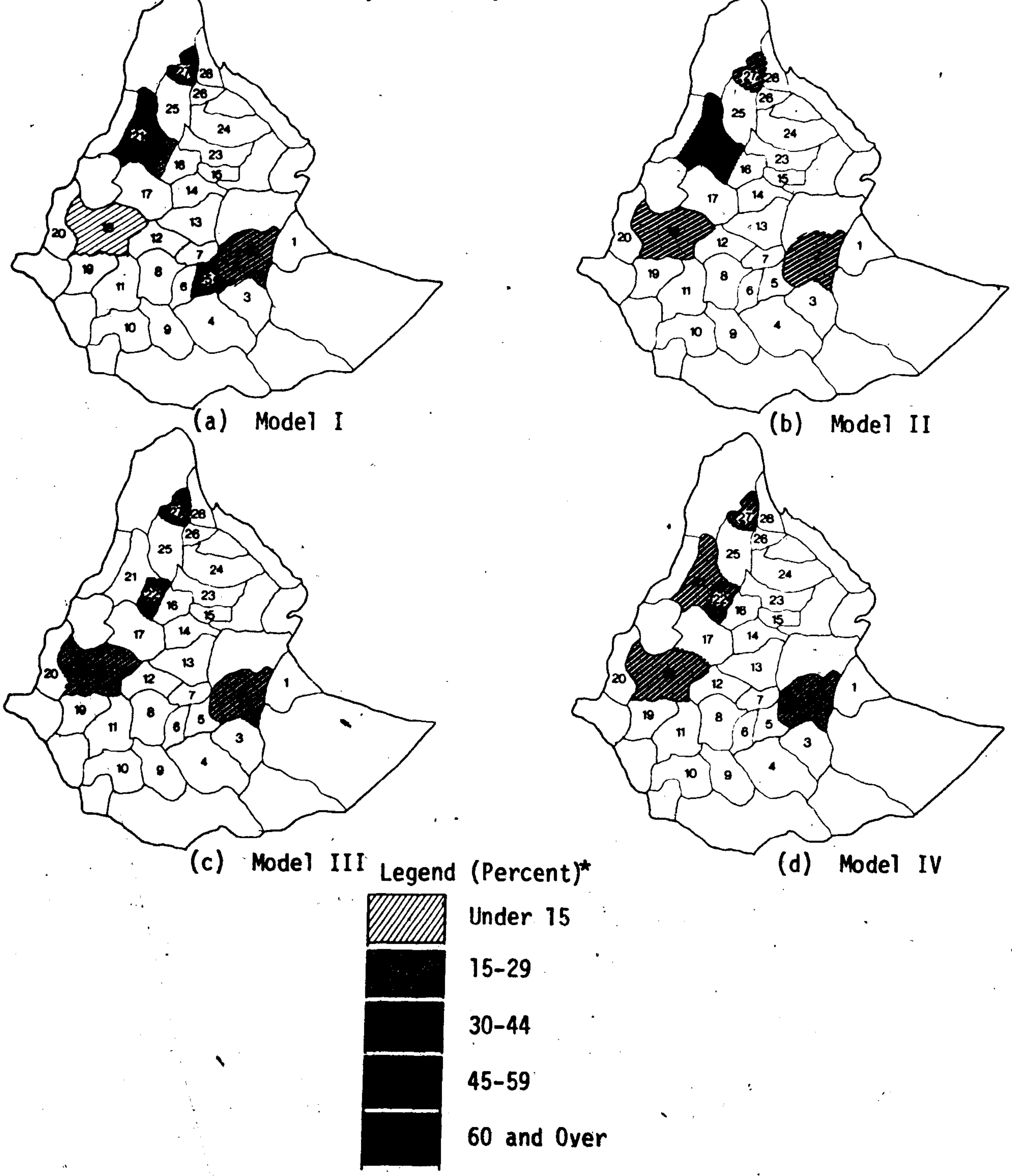
Regional Patterns of Wheat Production

The minimum cost solutions for all the programmed models indicated that wheat production should be concentrated in fewer producing districts than the actual 1966 land use data indicated. The results also indicated substantial shifts in the regional pattern of wheat production. According to the 1966 land use data (Figure 2.3a), Producing Districts 5, 8, 12, 14, 23 and 27 were by far the most important wheat areas. However, the solutions for the programmed models indicated that Producing Districts 2, 18, 21 and 22 should be the most important wheat areas (Figure 6.1).

The solution for Model I indicated that 81 percent of the land

FIGURE 6.1

REGIONAL PATTERNS OF WHEAT PRODUCTION FOR MODELS I-IV, ETHIOPIA, 1966 AND 1980



* Percent of total land allocated to cereal production.

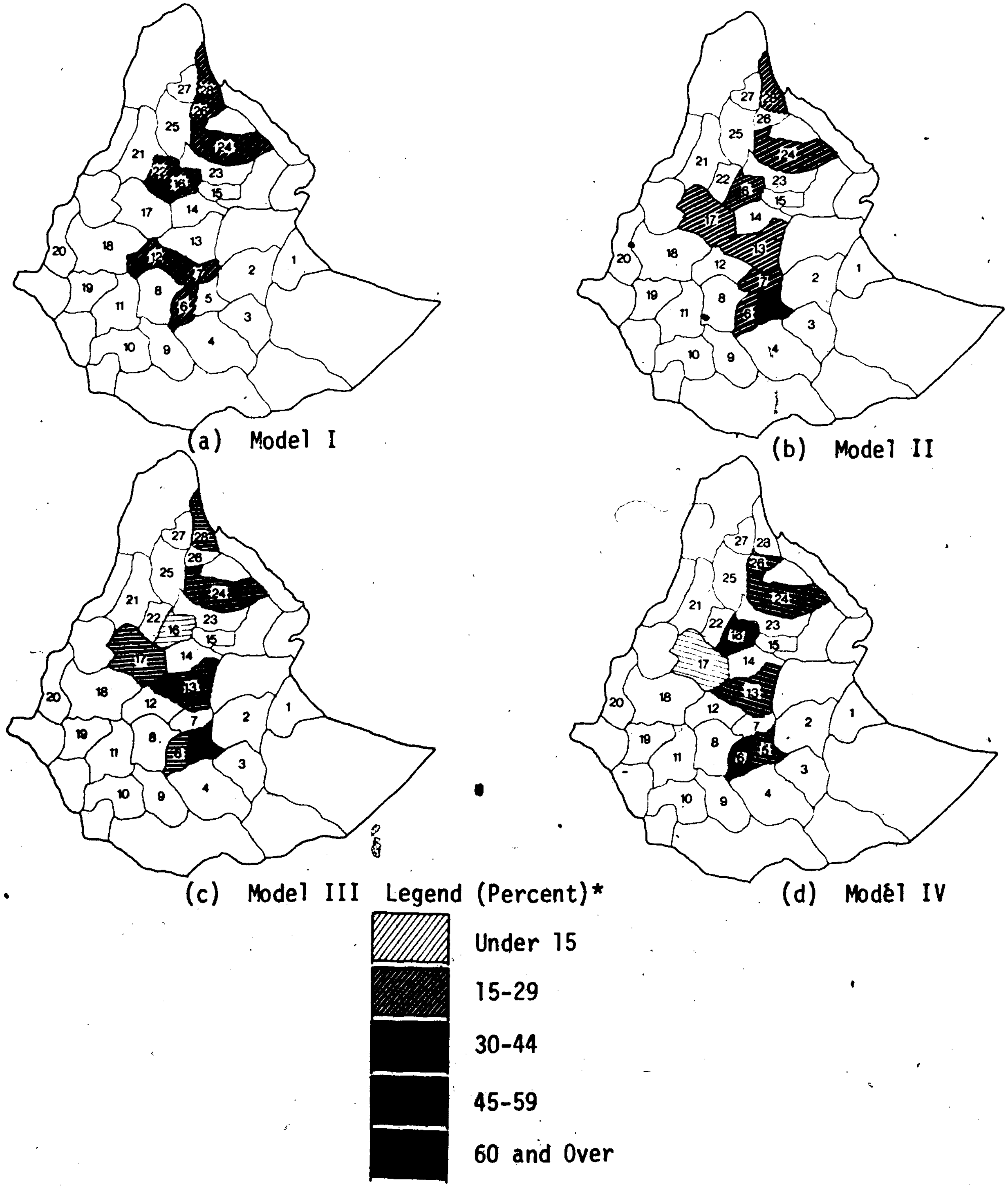
devoted to wheat should be located in Producing Districts 2, 5, 18, 21 and 22. District 21 alone would account for almost 32 percent of the land devoted to wheat, while districts 2 and 5 would account for an additional 30 percent. The results obtained from the solution for Model II suggested that about 94 percent of the land allocated for wheat should be located in Producing Districts 2, 18, 21 and 22. According to Model III, wheat should be produced in Producing Districts 1, 2, 10, 18, 19, 22 and 27, with about 71 percent of the land allocated for wheat being in Producing Districts 2, 18 and 22. The optimal solution for Model IV also indicated that 85 percent of the land area allocated to wheat should be located in Producing Districts 2, 18, 21 and 22. Districts 2 and 22 alone should account for about 60 percent of the land area allocated to wheat. The results of all the programmed models were fairly consistent. In every case, Producing Districts 2, 18 and 22 were primary wheat areas.

Regional Patterns of Barley Production

The least-cost solutions for all of the models indicated a substantial shift in the regional patterns of barley production compared to the actual 1966 land use information. According to the 1966 land use data, substantial amounts of barley were produced in Arussi (districts 5, 6), Shoa (districts 7, 12, 13) and throughout the highlands of the provinces of Gojam (district 17), Wollo (districts 14, 16, 23), Begemdir (districts 21, 22), Tigre (districts 24, 25, 26), and Eritrea (districts 27, 28). (See Figure 2.3b.) However, the optimal solutions for the four programmed models indicated that Producing Districts 5, 6, 7, 12, 13, 16, 17 and 24 should be the most important producers of barley (Figure 6.2). These producing districts were among the important barley areas in 1966 also.

FIGURE 6.2

REGIONAL PATTERNS OF BARLEY PRODUCTION FOR MODELS I-IV, ETHIOPIA, 1966 AND 1980



* Percent of total land allocated to cereal production.

The difference between the actual and programmed models was that of degree of concentration. In the programmed model solutions the concentration of barley production in each producing district was high.

According to the solution Model I, about 88 percent of the total land area allocated to barley should be located in Producing Districts 6, 7, 12, 16, 22 and 24, and the optimal solution for Model II indicated that about 79 percent of the land area allocated to barley should be in Producing Districts 5, 6, 13, 16, 17, and 24. The results for Model III suggested that about 76 percent of the barley lands should be in Producing Districts 5, 6, 13, 17, and 24. The solution for Model IV suggested that about 90 percent of the land area allocated to barley should be located in Producing Districts 5, 6, 13, 16, 17, and 24. When comparing the model with conventional practice to the ones that included fertilizer activity, a distinct shift appears to have taken place due to fertilizer application. Producing Districts 7, 12, and 22 became less competitive in terms of barley production in Models II, III and IV.

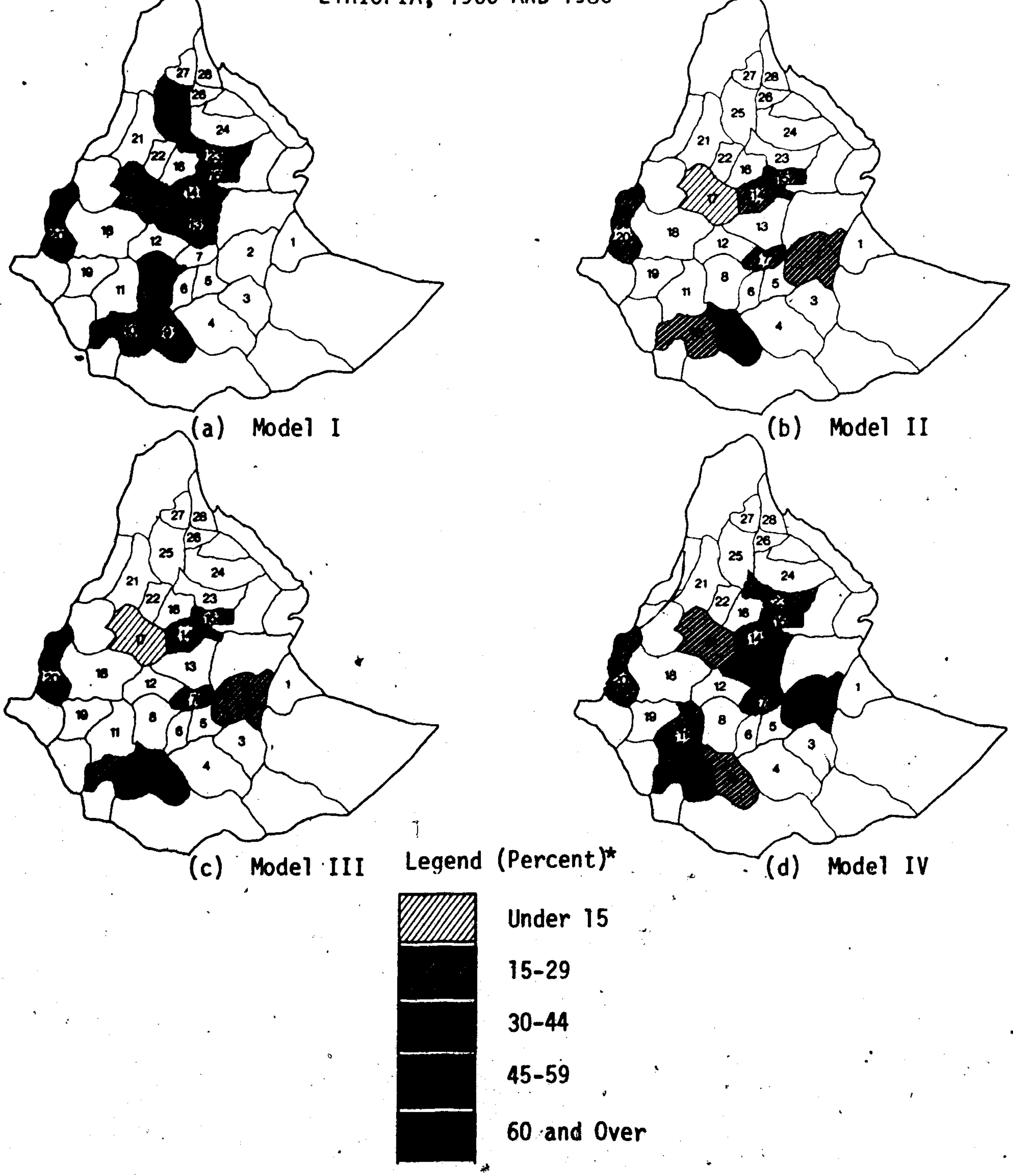
Regional Patterns of Teff Production

The least-cost solutions for all the programmed models indicated a definite shift in the regional patterns of teff production when compared to actual 1966 land use data. However, most of the producing districts that allocated a substantial amount of land to teff production in the various models were important traditional teff areas (Figure 2.3c). According to the solutions for the various models, Producing Districts 2, 7, 14, 15, 17 and 20 should be among the important teff areas (Figure 6.3).

The optimal solution for Model I suggested that teff production should be concentrated in Producing Districts 8, 9, 10, 13, 14, 15, 17,

FIGURE 6.3

REGIONAL PATTERNS OF TEFF PRODUCTION FOR MODELS I-IV,
ETHIOPIA, 1966 AND 1980



* Percent of total land allocated to cereal production.

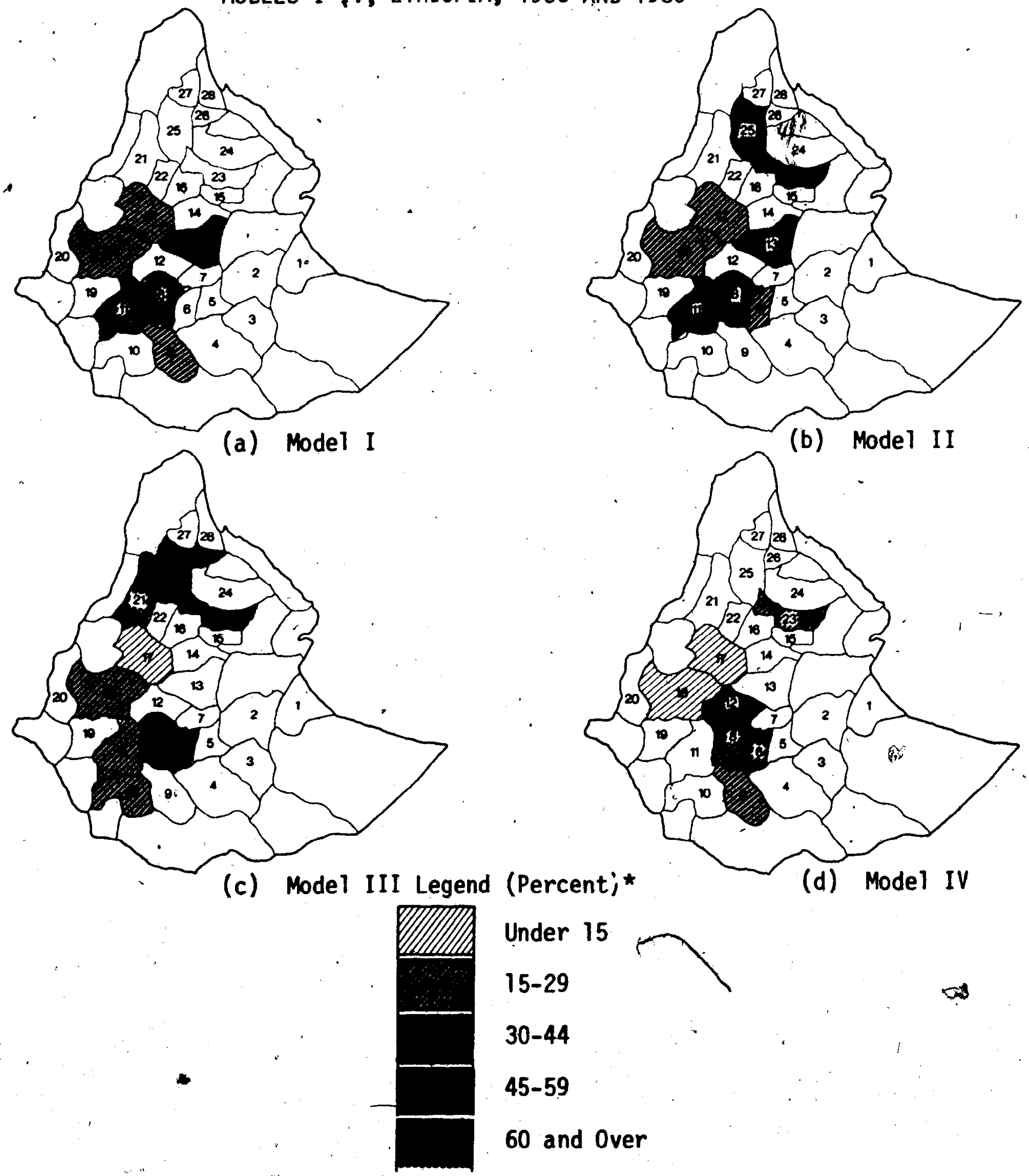
20, 23 and 25. These districts were important traditional teff areas. The solutions for Models II and III indicated almost identical results. According to the solution for Model II, about 89 percent of the land area allocated for teff should be located in Producing Districts 2, 7, 9, 10, 14, 15, 17 and 20. These same districts accounted for 92 percent of the allocated teff land in the solution for Model III. The solution Model IV suggested that about 90 percent of the land area allocated to teff should be located in districts 2, 7, 11, 14, 17 and 20. Comparison of the model with conventional means to those with fertilizer activity indicated that fertilizer application should have a significant influence on the regional patterns of teff production. According to the results for Model I, Producing Districts 8, 19, 23 and 25 were among the most important teff areas, but solutions for Models II, III and IV did not include these districts.

Regional Patterns of Corn Production

The least-cost solutions for the programmed models indicated that Producing Districts 6, 8, 9, 11, 13, 17, 18, 21, 23, and 25 should allocate substantial amounts of land for corn production (Figure 6.4). When compared to actual 1966 land use data, these results indicate a substantial shift in the regional pattern of corn production. According to the 1966 land use data, the southwestern provinces of Ethiopia, namely Wellega, Illubabor, Kefa, Gema Gofa and Sidamo, allocated sizeable areas for corn production (Figure 2.3d). The solutions for the programmed models did not show such concentration exclusively in the southwestern provinces although this area was an important corn area in most of the solutions (Figure 6.4).

FIGURE 6.4

REGIONAL PATTERNS OF CORN PRODUCTION FOR MODELS I-IV, ETHIOPIA, 1966 AND 1980



* Percent of total land allocated to cereal production.

The solution for Model I suggested that about 79 percent of the land area used for corn production should be located in Producing Districts 8, 9, 11, 13, 17 and 18. This allocation represents a marked shift in the regional pattern of corn production when compared to the acual 1966 land use. The solution for Model II indicated that about 80 percent of the total land area required for corn production should be located in Producing Districts 6, 8, 11, 13, 17, 18, 23 and 25. Districts 8 and 17 alone should account for about 36 percent of the land area allocated to corn by the model. The solution for Model III indicated that about 82 percent of the total land area allotted to corn production should be located in Producing Districts 6, 8, 11, 17, 18, 21, 23 and 25. The solution for Model IV suggested that about 86 percent of the total land area allocated to corn production should be located in Producing Districts 6, 8, 9, 12, 17, 18 and 23. According to the solutions for the programmed models, fertilizer application should create only slight shifts in the regional patterns of corn production.

Regional Patterns of Sorghum Production

The optimal solutions for the programmed models suggested that there should be substantial shifts in the regional patterns of sorghum production compared to actual 1966 land use. According to the 1966 land use data, the highland regions of the south and southwestern provinces (namely, Harargie, Wollo, Tigre and eastern Eritrea) allocated a substantial amount of land to sorghum production (Figure 2.3e).

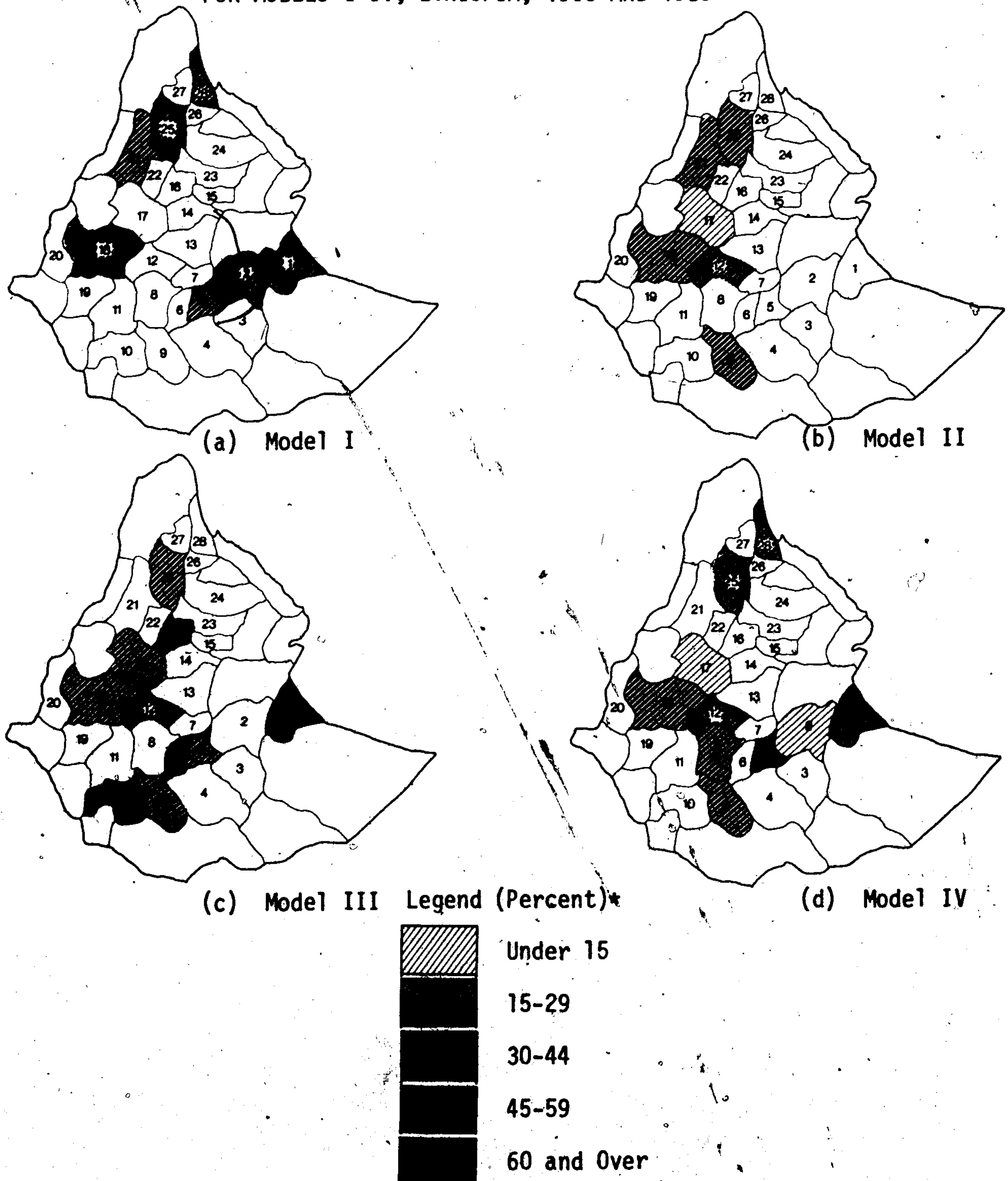
According to the solutions for Model I, about 82 percent of the total land area allocated for sorghum production should be located in Producing Districts 1, 2, 17, 21 and 25. Producing District 2 alone [illegible]ld a[illegible] about 35 percent of the land area allocated for sorghum [illegible]cti[illegible]ese districts were also important sorghum areas according t[illegible] a[illegible] 1966 land use data. The results of Model II indicated that so[illegible]uction should be spread among seventeen producing districts, but [illegible]ent of the total land area allocated should be located in Prod[illegible] Districts 9, 12, 17, 18, 21 and 25. The results of Model III indic[illegible] that about 80 percent of the land used for sorghum production should [illegible]n Producing Districts 9, 12, 16, 17, 18, 19 and 25. The solutions [illegible]odel IV suggested that 85 percent of the land area allocated for sorghum should be in districts 1, 2, 9, 12, 17, 18, 21, 25, and 28. According [illegible] Model IV's solutions, Producing Districts 1, 12, 25 and 28 should b[illegible]portant producers of sorghum. Analysis of the results of the [illegible]grammed models indicate that fertilizer application should shift regional patterns of sorghum production (Figure 6.5).

Interregional Commodity Flows

Specialization of production usually necessitates trade among regions. The mathematical model used in this study includes a transportation function to allow product flows from a designated center in one consuming region to a designated center in a different consuming region. The attempt to find an optimal allocation of production to satisfy spatially separated demand requirements also provides solutions to transportation routes and quantity flows. This information could be quite useful in trying to improve marketing facilities. Transportation costs are important determinants of interregional flows of commdoties. With improved transportation and marketing facilities, interregional flows and specialization could be enhanced.

FIGURE 6.5

REGIONAL PATTERNS OF SORGHUM PRODUCTION
FOR MODELS I-IV, ETHIOPIA, 1966 AND 1980



* Percent of total land allocated to cereal production.

The analysis allocated zero levels of activities to certain regions for one or more crops where the cost of production and transportation puts such regions in a relatively poor competitive position. Demand for the commodities studied has to be satisfied by imports from other consuming regions. Some consuming regions do not contain any producing regions; thus, they too must obtain all their requirements from surplus producing districts.

According to the results of the programmed models, there would not be very many long hauls of cereals. The absence of long-distance transportation is probably due to the high cost of handling and transporting goods. Interregional flows of cereals will be discussed in detail in the following sections (with the exception of the result of Model III which is quite similar to the results of Model II in terms of interregional flows).

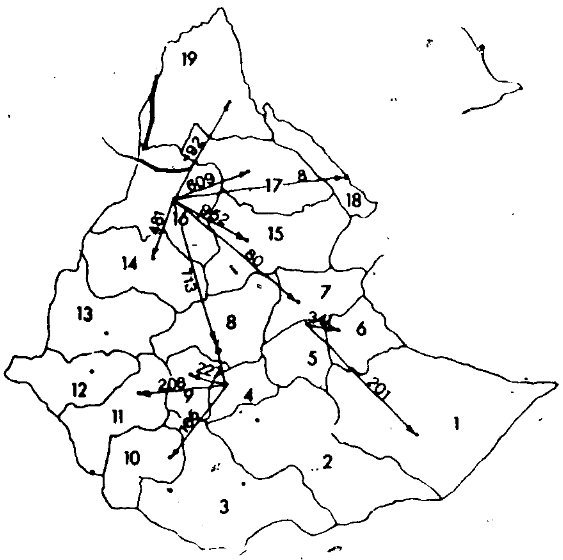
<u>Interregional Flows of Wheat</u>

According to the results of Model I, wheat shipments should be made from Begemdir, Arussi and West Chercher. The directions of flow should be from Begemdir to Garaguracha Central and North Shoa, Gojam, Wollo, Tigre, Aseb and Eritrea; from Arussi to Shoa, Gemu Gofa, and Kefa; and from West Chercher to East Chercher and the Ogaden (Figure 6.6a).

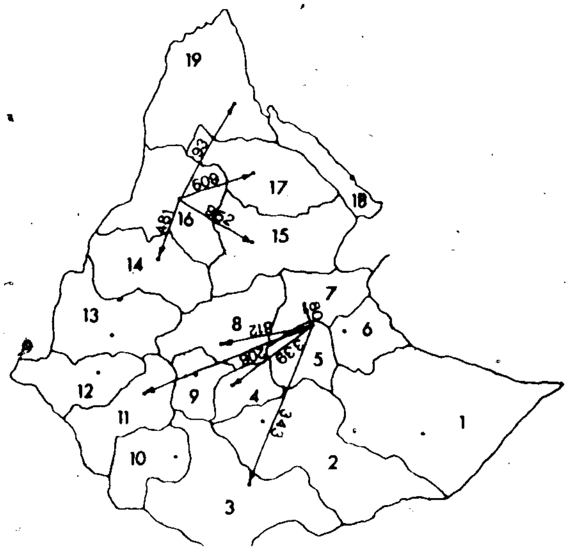
The solution for Model II suggested that substantial amounts of wheat should be exported from West Chercher and Begemdir. The directions of flow should be from West Chercher to Sidamo, Arussi, Garaguracha, Central and North Shoa, Kefa and Aseb; from Begemdir to Gojam, Wollo, Tigre and Eritrea. Small quantities should also be exported from Bale to Sidamo and Gemu Gofa; and from Wollega to Shoa (Figure 6.6b).

FIGURE 6.6

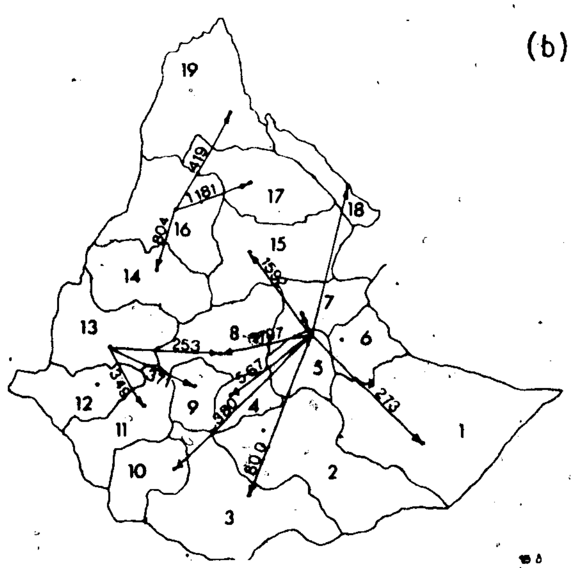
INTERREGIONAL FLOWS OF WHEAT FOR MODELS
I, II AND IV, ETHIOPIA, 1966 AND 1980



(a) Model I



(b) Model II



(c) Model IV

According to the solution for Model IV, West Chercher, Wollega, and Begemdir should be the most important sources of wheat. The indicated directions of movement were from West Chercher to the Ogaden, Sidamo, Arussi, Garaguracha, Central and North Shoa, Gemu Gofa, Wollo and Aseb; and from Wollega to South, Central and North Shoa, and Kefa. Begemdir should export to Gojam, Tigre, and Eritrea (Figure 6.6c).

Interregional Flows of Barley

According to the least-cost solution for Model I, the province of Arussi should be the most important source of barley, while limited amounts of barley should come from Central and North Shoa, Wollo, Begemdir, and Tigre. The suggested directions of flow were from Arussi to Begemdir, Bale, Sidamo, East and West Chercher, Garaguracha, Central and North Shoa and Eritrea. Begemdir and Tigre should export to Eritrea (Figure 6.7a).

According to the results for Model II, Arussi, Gojam, Wollo, and Tigre should be important sources of barley. The suggested directions of flow were from Arussi to Sidamo, East Chercher, and Aseb; from Gojam to Central and North Shoa, and Eritrea; and from Wollo to Eritrea and Garaguracha (Figure 6.7b).

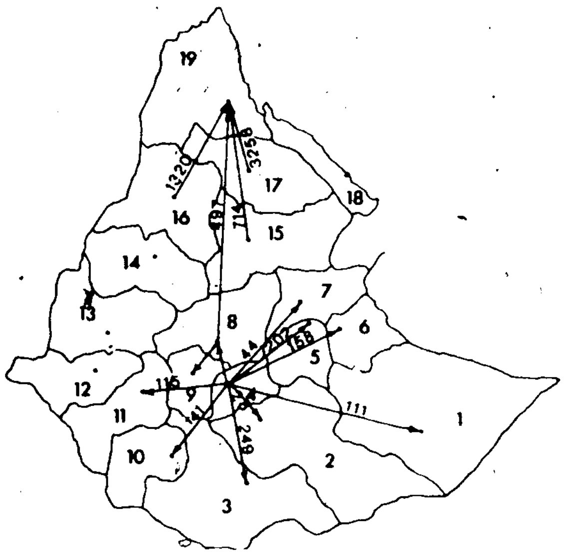
The solutions for Model IV suggested that Arussi, Gojam, Begemdir and Tigre should export barley. The shipments should be from Arussi to the Ogaden, Sidamo, West and East Chercher, and Central and North Shoa; from Gojam to Shoa and Eritrea; and from Wollo to Garaguracha, Tigre and Aseb (Figure 6.7c).

Interregional Flows of Teff

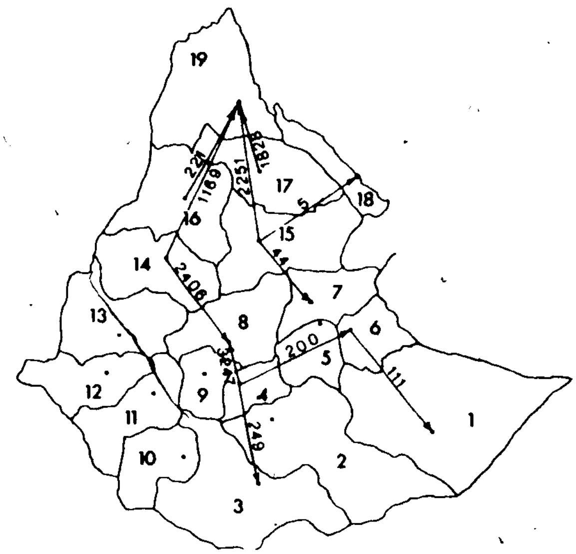
According to the least-cost solution for Model I, Wollo province

FIGURE 6.7

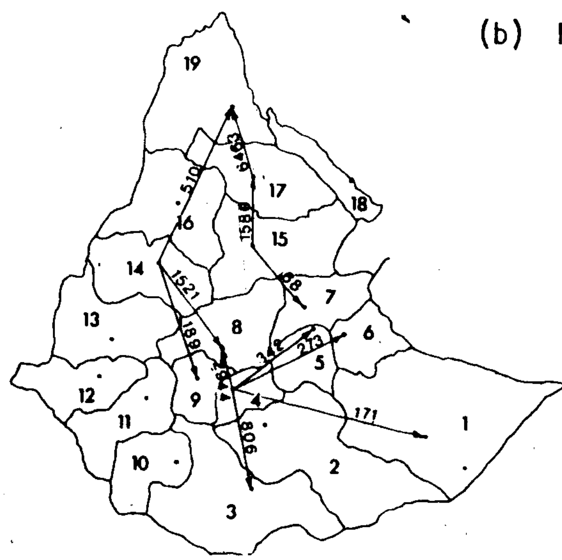
INTERREGIONAL FLOWS OF BARLEY FOR MODELS I, II AND IV, ETHIOPIA, 1966 AND 1980



(a) Model I



(b) Model II



(c) Model IV

should be the most important producer and exporter of teff. The shipments should be from Wollo to Arussi, West Chercher, Garaguracha, Central and North Shoa, Kefa, Begemdir, Tigre and Aseb. Sidamo should ship to Bale and Arussi and West Chercher should ship to the Ogaden and East Chercher. Kefa, Arussi, Central and North Shoa, Begemdir and Eritrea should receive additional supplies from South Shoa, Gemu Gofa, Wollega, Gojam and Tigre, respectively (Figure 6.8a).

The results of Model II indicated that most consuming regions should produce enough teff to satisfy their own consumption requirements. The few transfers that take place should be among adjacent regions. Shipments should be from Wollo to Tigre, Eritrea, and Garaguracha and from Gojam and West Chercher to Begemdir and East Chercher, respectively (Figure 6.8b).

The solution for Model IV suggested that interregional flows of teff should be as follows: from West Chercher to the Ogaden and East Chercher; from Wollega to Sidamo and Central and North Shoa; from Wollo to Garaguracha, Tigre, and Aseb; and from Central and North Shoa to Arussi; from Kefa to Bale and from Gojam to Begemdir (Figure 6.8c).

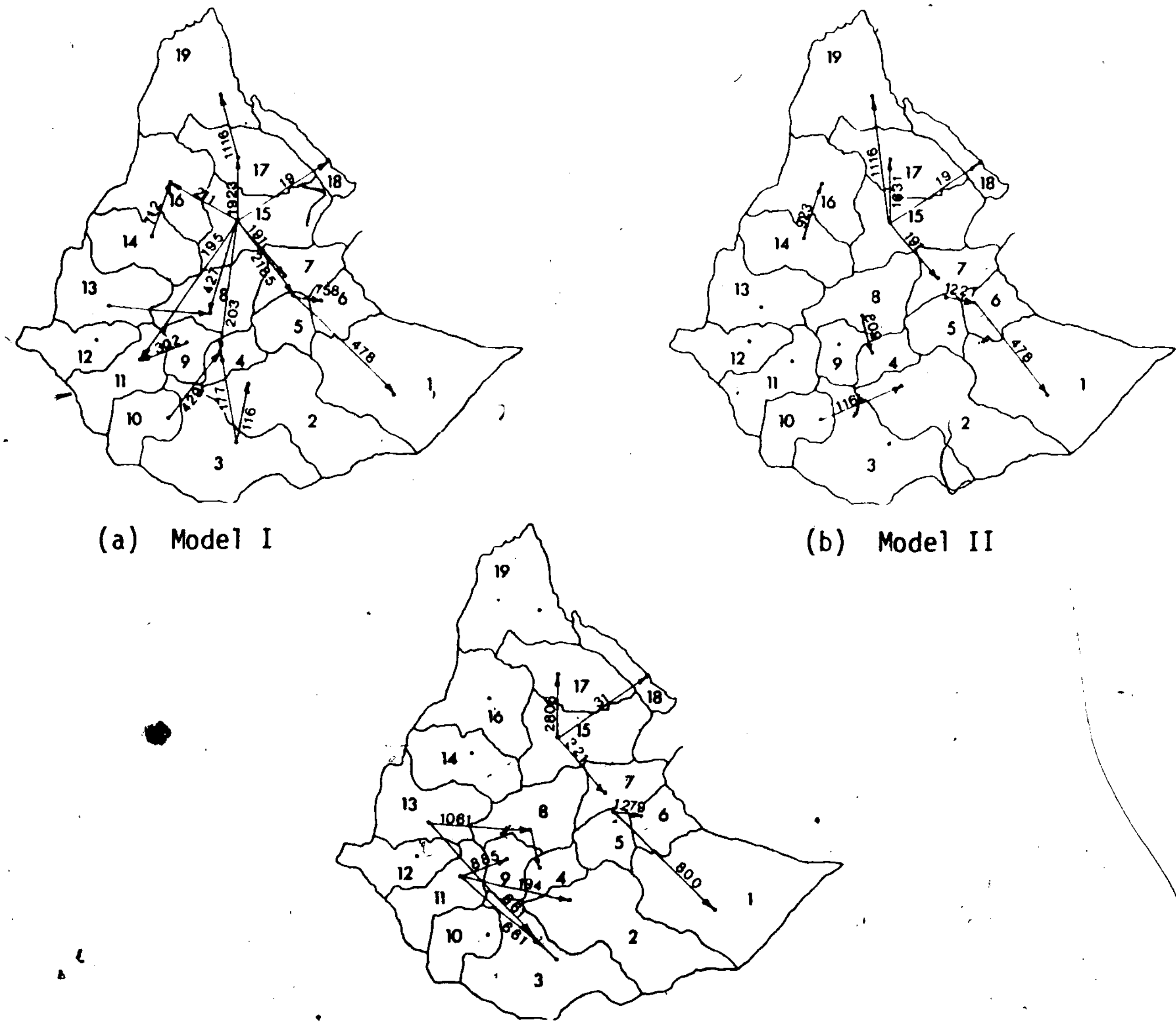
Interregional Flows of Corn

The solution for Model I indicates that Kefa should ship corn to the Ogaden, Arussi, West Chercher, Garaguracha, Tigre, and Aseb; and South Shoa should ship to Bale, East Chercher, and Central and North Shoa. Gojam should also ship a substantial amount of corn to Wollo, Begemdir and Eritrea (Figure 6.9a).

The solution for Model II suggested that large quantities of corn should be shipped from Gojam to Wollo, Begemdir, and Eritrea; from

FIGURE 6.8

INTERREGIONAL FLOWS OF TEFF FOR MODELS I, II AND IV, ETHIOPIA, 1966 AND 1980



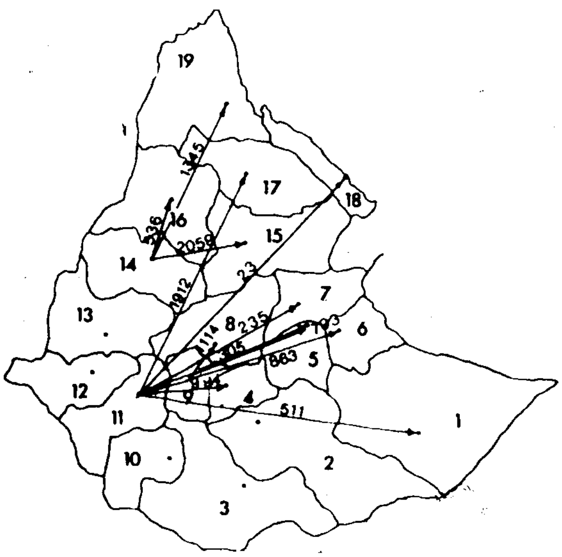
(a) Model I

(b) Model II

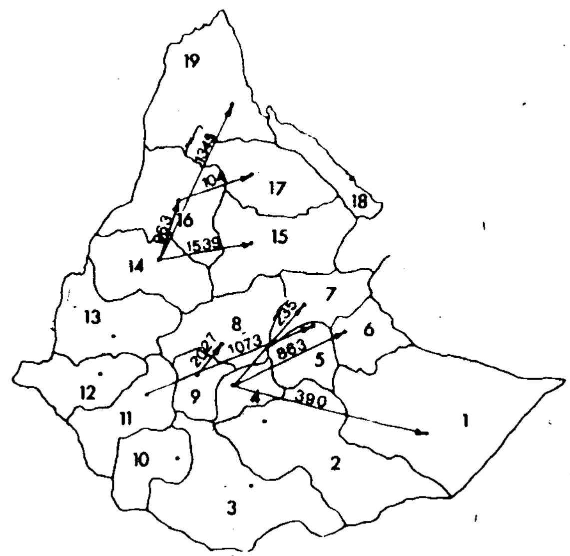
(c) Model IV

FIGURE 6.9

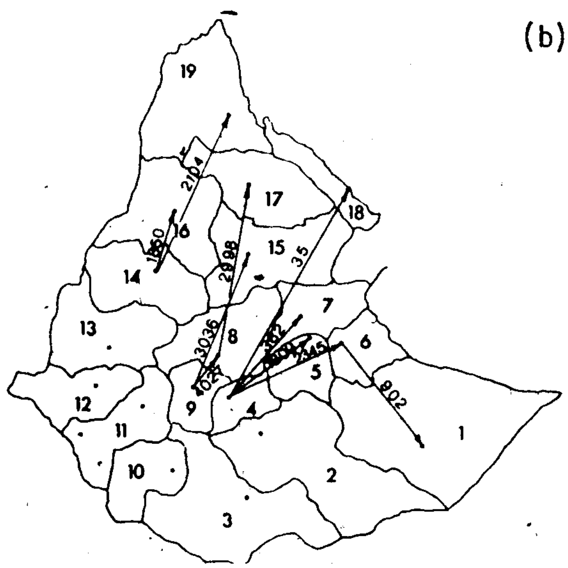
INTERREGIONAL FLOWS OF CORN FOR MODELS
I, II AND IV, ETHIOPIA, 1966 AND 1980



(a) Model I



(b) Model II



(c) Model IV

Arussi to the Ogaden, East Chercher and Garaguracha; and from South Shoa and Kefa to Central and North Shoa, and West Chercher (Figure 6.9b).

The suggested patterns of interregional flows for Model IV were from Arussi to Harargie and Aseb; from South Shoa to Central and North Shoa and Wollo; from Gojam to Begemdir and Eritrea; and from Central and North Shoa to Tigre (Figure 6.9c).

Interregional Flows of Sorghum

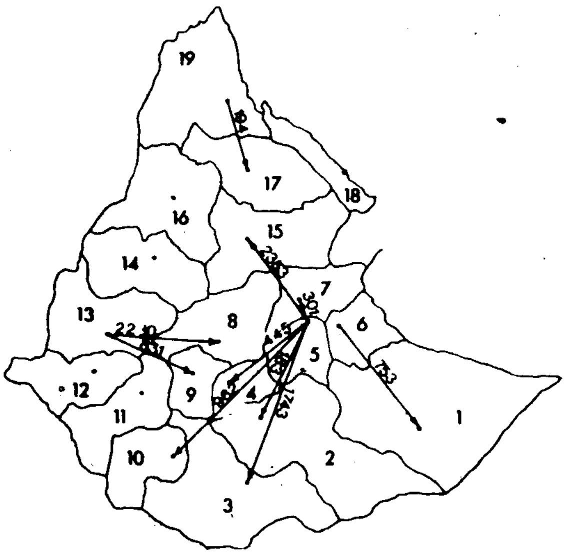
The interregional flow patterns of sorghum suggested by the solution for Model I were: from West Chercher to Bale, Sidamo, Arussi, Garaguracha, Central and North Shoa, Wollo and Aseb. Wollega should ship to Shoa,and Eritrea should ship to Tigre (Figure 6.10a).

Very few interregional flows of sorghum were suggested by the results of Model II. Almost all consuming regions produce enough sorghum for their own consumption needs. the limited interregional flows should occur from Gojam, Wollo, West Chercher, East Chercher, Central and North Shoa and South Shoa to Begemdir, Aseb, Garaguracha, the Ogaden, Gemu Gofa and Kefa respectively (Figure 6.10b).

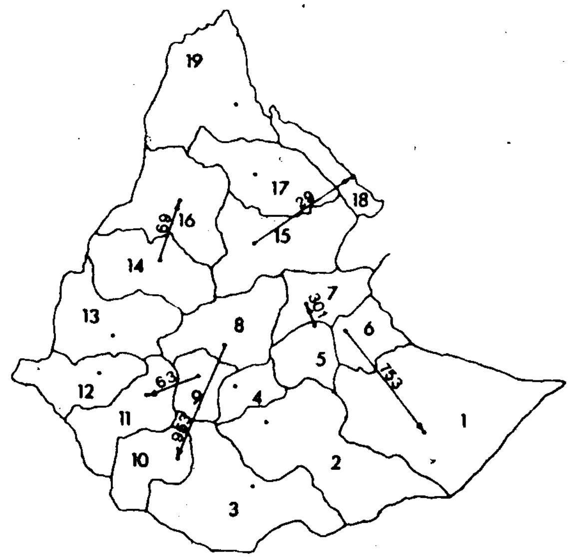
The solution for Model IV indicated that all but three consuming regions should produce enough sorghum to satisfy their own consumption needs. A few consuming regions import sorghum to fill the gap between production within the region and consumption requirements. The interregional flow patterns suggested by the model were from Bale and Central and North Shoa to Gemu Gofa; from South Shoa to Kefa; from West Chercher to the Ogaden; and from Gojam and Eritrea to Begemdir. Tigre should export to Garaguracha, Wollo, and Aseb (Figure 6.10c).

FIGURE 6.10

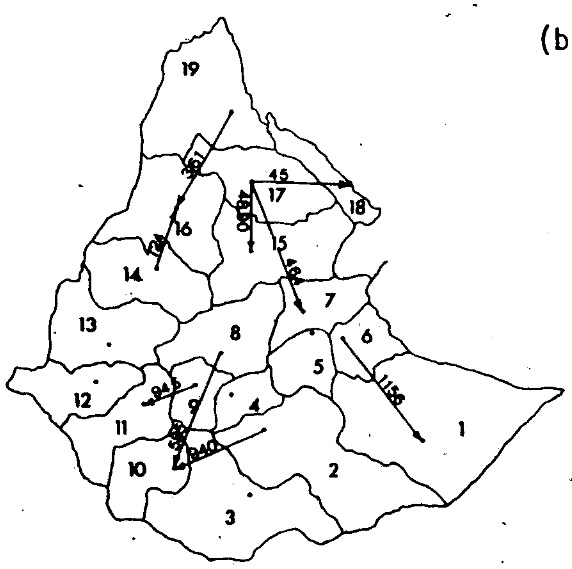
INTERREGIONAL FLOWS OF SORGHUM FOR
MODELS I, II AND IV, ETHIOPIA, 1966 AND 1980



(a) Model I



(b) Model II



(c) Model IV

Land Rent

As indicated in Chapter V, where land is not a constraining resource land rents would be zero. Only when land was a constraining resource would there be a greater than zero land rent. It was also mentioned in Chapter V that land rents would depend on the productivity of the land, price of the commodity in question, and the per hectare cost of production. Regardless of the productivity of land or price of the commodity, if slack land appears in the solution of the program, land rent would be zero.

Since upper and lower limits on land use were employed in this study, only very few producing activities remain unaffected by either a minimum or a maximum land constraint. Land rents are different in all four models because different constraints were employed in each model (Table 6.3).

Equilibrium Price of Cereals

Shadow prices for cereals represent the competitive equilibrium prices of cereals in each consuming region. As indicated in Chapter V, shadow prices (also called imputed or accounting prices) are a function of productivity, cost of production and transportation, and the demand for cereals in each consuming region. When productivity is increased (ceteris paribus), prices would decrease. When fertilizers were applied in Model II, equilibrium prices went down substantially (compare Tables 6.4 and 6.5). When the foreign exchange constraint was relaxed in Model III, a further reduction in the equilibrium price of cereals was observed (Table 6.5). Since Model IV was programmed to satisfy higher demand

TABLE 6.3

COMPUTED ECONOMIC RENT OF LAND BY PRODUCING DISTRICTS FOR PROGRAMMED MODELS, ETHIOPIA, 1966 AND 1980

Producing District	Programmed, 1966			Programmed, 1980
	Model I	Model II	Model III	Model IV
	(Eth. $ per Hectare)			
1	0.00	114.43	138.81	15.12
2	64.52	18.46	42.85	93.27
3	70.04	22.52	46.95	35.18
4	70.04	22.52	46.95	35.18
5	19.04	40.16	63.93	61.93
6	85.39	17.86	16.93	108.93
7	97.59	48.76	3.62	141.26
8	8.59	79.72	114.43	0.00
9	74.69	189.68	223.70	119.63
10	64.69	201.79	239.68	114.51
11	146.83	9.72	64.17	70.00
12	36.80	17.01	45.53	75.82
13	4.60	73.24	84.75	8.45
14	114.12	71.52	89.61	20.98
15	191.67	0.00	0.00	204.38
16	54.57	106.85	121.87	3.45
17	40.96	117.94	142.80	14.54
18	19.01	96.79	126.51	21.03
19	0.00	0.00	153.00	0.00
20	45.49	80.22	122.73	7.97
21	0.00	85.24	108.61	32.28
22	0.00	85.24	108.61	32.28
23	224.21	11.51	9.21	117.50
24	88.92	15.79	40.06	80.28
25	2.33	15.26	38.63	16.14
26	272.02	366.67	388.95	267.03
27	140.34	202.12	219.06	163.74
28	25.14	46.57	70.70	15.24

TABLE 6.4

IMPUTED PRICE OF CEREALS BY CONSUMING REGIONS, MODEL I, ETHIOPIA, 1966

Producing Region	Wheat	Barley	Teff	Corn	Sorghum
		(Eth. $ per Quintal)			
1	29.51	26.43	41.67	23.95	18.95
2	20.64	20.07	33.99	16.85	16.88
3	23.94	20.07	30.69	15.96	16.42
4	20.64	16.57	34.19	14.95	13.74
5	21.51	18.43	33.67	15.95	11.88
6	22.81	19.73	34.97	17.25	12.25
7	23.59	19.57	31.95	17.10	14.88
8	21.64	17.57	33.19	13.95	13.88
9	22.74	18.67	34.19	12.85	14.98
10	24.14	20.07	30.69	15.91	16.88
11	23.64	19.57	35.19	11.95	15.88
12	14.57	14.29	27.68	9.67	7.65
13	18.61	18.73	30.16	13.41	10.95
14	18.14	16.67	32.86	11.21	14.87
15	21.71	17.44	29.29	17.68	16.26
16	16.64	16.92	34.36	12.71	14.14
17	21.71	19.24	31.09	17.70	17.63
18	23.96	19.69	31.54	18.45	16.18
19	21.29	21.57	33.42	16.26	15.30

TABLE 6.5

IMPUTED PRICES OF CEREALS BY CONSUMING REGIONS, MODEL II, ETHIOPIA, 1966

Producing District	Wheat	Barley	Teff	Corn	Sorghum
			(Eth. $ per Quintal)		
1	18.30	22.05	27.71	18.48	13.92
2	12.23	12.57	21.97	10.27	8.50
3	15.53	15.69	20.44	9.68	9.80
4	12.85	12.19	20.88	8.62	7.86
5	10.99	14.05	19.71	10.48	7.30
6	11.60	15.35	21.01	11.78	7.22
7	13.99	13.20	19.19	11.62	10.30
8	12.99	13.19	19.88	8.48	7.74
9	14.09	13.07	19.90	7.38	8.46
10	15.73	14.27	18.47	8.42	11.24
11	14.99	14.07	18.90	6.48	9.46
12	14.52	14.29	21.83	9.67	7.65
13	9.96	10.29	16.92	7.04	5.06
14	11.42	9.62	18.33	5.13	6.55
15	14.99	10.54	16.53	11.60	8.95
16	9.92	10.02	19.83	6.63	8.05
17	14.99	12.34	18.33	11.70	7.84
18	15.29	12.79	18.78	12.98	11.20
19	14.57	14.67	20.66	10.18	6.93

TABLE 6.6

IMPUTED PRICES OF CEREALS BY CONSUMING REGIONS, MODEL III, ETHIOPIA, 1966

Producing District	Wheat	Barley	Teff	Corn	Sorghum
			(Eth. $ per Quintal)		
1	16.08	19.73	24.14	16.57	12.62
2	10.00	10.00	18.59	7.94	6.69
3	13.30	13.37	17.41	7.54	7.70
4	10.62	9.87	16.48	6.71	6.43
5	8.76	11.73	16.14	8.57	5.87
6	9.38	13.03	17.44	9.87	5.92
7	11.76	11.27	17.94	9.71	8.87
8	10.76	10.87	15.48	6.57	6.16
9	11.86	9.77	14.62	5.47	6.33
10	11.89	10.74	15.09	6.35	9.66
11	12.76	10.77	13.62	4.57	6.71
12	3.14	3.13	10.84	1.26	2.30
13	7.74	8.13	12.45	5.41	3.57
14	9.57	7.30	14.47	3.56	4.41
15	13.14	8.61	15.28	10.03	7.37
16	8.07	8.13	15.97	4.96	5.91
17	13.14	10.02	17.08	10.03	6.27
18	13.06	10.86	17.53	11.07	9.62
19	12.72	12.35	19.41	8.61	5.23

TABLE 6.7

IMPUTED PRICE OF CEREALS BY CONSUMING REGION, MODEL IV, ETHIOPIA, 1980

Producing District	Wheat	Barley	Teff	Corn	Sorghum
	(Eth. $ per Quintal)				
1	21.99	24.84	32.55	19.39	16.09
2	17.47	17.51	26.68	10.51	9.26
3	18.53	18.49	26.68	10.19	19.95
4	15.85	14.98	24.18	9.53	9.56
5	13.99	16.84	24.55	11.39	9.25
6	15.29	18.14	25.85	12.69	9.39
7	16.99	15.99	25.55	12.53	11.90
8	15.99	15.98	23.18	10.19	9.26
9	17.09	17.08	22.68	9.09	9.91
10	18.99	16.93	26.25	10.04	12.76
11	17.99	17.64	21.68	8.52	10.91
12	13.09	14.29	19.86	9.60	7.65
13	12.96	15.81	20.15	10.71	7.27
14	15.59	12.41	22.94	7.63	10.34
15	18.37	13.33	22.89	14.09	9.58
16	14.09	13.04	24.47	9.13	11.84
17	19.16	15.13	24.69	13.94	7.78
18	18.29	15.58	25.14	14.44	11.83
19	18.46	17.46	27.02	12.68	7.19

requirements for the various cereals, the equilibrium prices of cereals went up, indicating the influence of demand on shadow prices of cereals (Table 6.7).

The reason for the decline in the equilibrium prices of cereals when technological improvements are introduced is not hard to find. The unit prices in each consuming region are determined by the ratio of costs of production to crop yield. As the technique of production was improved in Models II, III, and IV, output increased proportionately more than the cost of production, resulting in lower prices for cereals in every consuming region.

Several variables are crucial in an agricultural revolution. The variables programmed in the models, although important, can not provide ready-made solutions for the problems of Ethiopian agriculture. The variables programmed in these models are intended as an indication of how changes in some key factors can affect agricultural production and efficiency. For an effective agricultural change several variables not programmed in these models should also be included.

CHAPTER VII

IMPLEMENTATION OF SPATIAL ALLOCATION PROGRAMS

The solution obtained from a linear programming model is not a prediction but a norm, or a goal such as to obtain a least-cost pattern of crop production. A considerable difference may exist between the theoretical optimum and the actual situation. The normative solution is obtained to explore possible methods of realizing the goal of cereal supply in Ethiopia at the lowest possible cost. It remains to be seen whether the solution is realistic or merely a result of the many simplifications that separate a model and reality. Also, observations must be made as to whether the indicated reallocation of crop production is feasible in practice and what the implications would be for the producers.

The results of this study suggested that a national benefit would result from specialization and fertilizer use in Ethiopian agriculture. Specifically, the policy measures suggested by the results of the study were:

1. That regional specialization should be encouraged, and
2. That fertilizer use should be increased.

The question that arises is: How can such changes be facilitated in an economy where the planning agency is not directly involved in the production and distribution of cereals? In a market economy such changes are achieved through the operation of pricing mechanisms. What the planner does, if anything, is provide the appropriate atmosphere (incentive) so that people, of their own accord and in their own self-interest, will do those things which contribute to the overall goal. In a developing economy such as Ethiopia, direct involvement in the provision of necessary services and in the production of certain key goods and services is essential. The mere creation of incentives is insufficient because the incentive programs could be made ineffective or misdirected by market imperfections.

The proposed policy measures in this study are presented under two general headings:

1. Those policy measures directly related to the results of the study, and
2. Those that are complementary.

The adoption of both categories of policy proposals is very important if Ethiopian agriculture is to develop.

Policy Measures Suggested by the Study

Market Developments

For successful regional specialization of production an efficient and reliable marketing service is extremely important. The Ethiopian farmer produces cereals mainly for home use. The cereal grains considered in this study are important components of the diet of the majority of the Ethiopian people. The land use records of 1966 indicated that every producing district allocated some land to the production of each crop. The overriding concern of the farmer is that all essential crops are produced on the farm if at all possible. This has been a long established practice in Ethiopia. Before they will part company with age-old traditions and methods, farmers need positive proof of gain (large and sure gain) resulting from a change.

Market developments entail several changes in the existing marketing mechanism and the establishment of new institutions such as:

1. Establishment of grades and standards,
2. Establishment of marketing cooperatives,
3. Creation of a mechanism for relaying information,
4. Standardization of unit of measures,
5. Creation of a price stabilization mechanism, and
6. Construction of feeder roads.

The existing production pattern clearly indicates that production is concentrated near major markets even though production costs might be more favorable further away. Generally, commodity flows are restricted to adjacent regions. This is an indication of the high cost of marketing agricultural products. Improved marketing systems and lower marketing costs are essential conditions in moving toward regional specialization and interregional flow of commodities. The reduction of costs and margins in the marketing system is one of the best ways of stimulating desirable production change, since the farmer's price will be raised and the consumer's price will be lowered. If the consumer's price is lowered, the consumption of agricultural produce is likely to expand, thus benefiting the farmer.

It is extremely difficult to improve the marketing system as long as farmers are not producing primarily for the market. Reductions in marketing costs may come about when farmers begin to specialize their production but are unlikely to occur as long as farming is on a semi-subsistence basis with innumerable small producers yielding surpluses for the market almost as an accidental by-product. The costs of collection of very small quantities over a large geographic area will inevitably remain high.

The improvement of the efficiency of the marketing system is definitely a precondition for regional specialization. For the price system to perform effectively, the system must be of such a nature that information on demand and supply can efficiently flow back and forth between the farmer and the consumer.

Specific proposals are briefly discussed below. These proposals represent the very minimum required to enhance the efficiency of the marketing channels.

Grades and Standards -- The establishment of grades and standards is a precondition for efficient market operation. The absence of grades and standards makes the operation of the market too costly and inefficient. It introduces a great deal of uncertainty in the marketing of agricultural products. Because of the absence of grades and standards, market transactions require the on-site inspection of products by the buyer. Buying by description is impracticable.

Rudimentary regulations setting minimum standards do exist but their enforcement has not been effective. The establishment of an agency to set standards and to enforce their observation should be given urgent attention. The Stanford Research Institute study recommended the reactivation of the Ethiopian Grain Board for this purpose.[1] The Board suffered financial and personnel problems and had been ineffective since

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[1] Thodey, Marketing of Grains and Pulses in Ethiopia, p. 102 and 154.

its creation in 1950. The reactivated board should be given full authority to set and regulate grades and standards.

Weights and Measures -- Standardization of weights and measures are also important for an effective market performance. A proclamation establishing systems of weights and measures was issued in 1967.[1] However, the kinds and shapes of all types of units of measures still in use in Ethiopia are evidence of lack of enforcement. Volume measures of all kinds (especially tin cans) are used to measure cereal grains in small transactions. Kilograms are used for transactions involving large quantities. The need for standardization of units of measure cannot be overemphasized. A new Department of Standardization of Units of Measure should be established. The responsibilities should cover all areas including industrial goods. It is difficult to visualize an improvement in the efficiency of the Ethiopian marketing system without standardized units of measure.

Market Information -- Dissemination of adequate and reliable information is crucial to the effective performance of a market. The farmer must have adequate knowledge if he is to make rational allocations of the resources under his control and also take advantage of favorable market conditions. Lack of adequate knowledge and reliable information results in unequal bargaining power, poor producer prices, and a low level of market consonance. The dearth of market information makes the market less competitive and leaves the farmer vulnerable to exploitation by the cunning and relatively well-informed merchant. At present, there is no formal mechanism through which information of supply and demand

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[1] Ibid., p. 103.

and anticipated changes could be transmitted to the farmer. The extent of the farmer's knowledge regarding market conditions is limited to what he learns from his neighbors and his own observations in the market place.

Supplying farmers with information and educating them at the same time would be very useful in the implementation of agricultural changes. The fact that the overwhelming majority of the Ethiopian people are illiterate eliminates the use of publications and newspapers. Radio programs could be used effectively only if the people had radios and most do not. To provide farmers with transistor radios at a reduced price may perhaps be the most feasible solution. Then radio programs which contain pertinent market information and developmental programs could be broadcast regularly.

Cooperative Societies -- Throughout the world farmers tend to suffer from the disadvantage of their sheer number in proportion to the number of buyers. With hundreds of his fellows the individual farmer is often selling in unregulated competition to a handful of buyers who are in a position to restrict competition among themselves. This imbalance in market power results in the farmer not realizing the full impact of an incentive program designed to induce him to make certain changes in his operation. All the benefits could be absorbed by the middleman. Under these circumstances the farmer would not respond to the stimulus provided by government. It is this sort of situation which leads to the formation of farmers' collective selling organizations (such as cooperatives or marketing associations). These organizations give farmers the bargaining power which results from membership in an organization which speaks with one voice. The Ministry of National Community

Development is assisting farmers in organizing cooperative societies. In order to achieve rapid progress, the Ministry should allocate more resources to assist in the formation of these societies.

Price Stabilization -- Price stabilization schemes are also important components in the development and improvement of marketing services. A farmer's income is a direct consequence of the quantity he sells and the per unit price he obtains for his product. Ceteris paribus, if one component improves, so does the farmer's income or vise versa. Farmers generally prefer a guaranteed lower income to a high but uncertain income. This attitude is particularly prevalent among farmers in less developed countries whose ability to absorb risk is extremely limited.

Price stabilization schemes are a must if agriculture is to grow and prosper. The benefit of protecting agricultural prices from falling below a certain level is not limited to the farm family alone but to the whole economy, particularly in countries such as Ethiopia where agriculture dominates. The transition of agriculture from a sector traditionally oriented towards producing primarily for subsistence to a market economy can be facilitated by a reasonably stable pricing scheme for both export and domestically consumed commodities.

Specialization of production will encourage the establishment of new commercial farms and heavy dependence on the market. Since the emerging commercial farms have unstable financial foundations, their ability to withstand adverse price conditions is very low. Consequently, they will soon be forced to either leave farming or revert to the traditional and conservative way of farming. The benefit of stabilization is not necessarily the high price farmers get, but the stability it gives the market so that people will develop confidence in the marketing system.

The existing condition in Ethiopia is one of unrestricted fluctuation. A Stanford Research Institute study indicated that the average seasonal range of price fluctuation for the major agricultural products in four important markets is about 31.3 percent.[1] For certain products the range was over 50 percent. Such changes in price are not conducive to increasing surplus production for the market.

Construction of Feeder Roads -- In the central highlands where population concentration is the highest, the need for feeder roads is urgent. Assuming that a given road can service fifteen kilometers on each side, only 22 percent of the country was accessible by all-weather roads in 1966. The lack of roads makes transportation by donkeys, camels, mules, and even humans (estimated to be six times more costly than truck transportation) inevitable.[2] With such conditions prevailing, spatial distribution of production will not be realized.

Reducing transportation costs and the subsequent improvement of marketing efficiency encourages the production of more marketable surplus. This reduction in transportation cost and increased efficiency of marketing definitely provides the basis for better spatial distribution of production.

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[1] Thodey, Marketing of Grains and Pulses in Ethiopia, p. 232.

[2] These estimates do not include costs of building and maintaining roads for truck transportation. The social cost of truck transportation is perhaps greater than the cost to the individual user.

Fertilizer Use

Very little fertilizer is used in Ethiopia at present. Fertilizer import records show that amounts varied between 2,000 and 4,000 tons annually. Studies by various agencies and individuals have shown that yield responses to the application of chemical fertilizers is quite high. An FAO nationwide fertilizer response trial has been in progress since 1967. The results obtained so far indicated a definite need for fertilizer use therefore suggesting that fertilizer application should be encouraged. Since chemical fertilizers have to be imported, a sizeable amount of foreign exchange needs to be allocated for fertilizer importation. The alternative would be to construct fertilizer processing plants within the country. Since deposits of phosphate rocks or sulfur are not commercially available in Ethiopia, the importation of the raw materials would be necessary.

The Stanford Research Institute suggested the construction of two fertilizer processing plants--one at Massawa and another at Aseb, each with a capacity of about 5,000 tons per year. Although the capacity of the two plants could not produce enough fertilizer to satisfy the projected demand, the move would be very desirable.[1] If and when the projected demand materializes, the plants could be expanded.

The absence of a widespread distribution system for fertilizer is a serious handicap. Addis Ababa and Asmara are the only distribution centers at present. If the demand for fertilizer increases as suggested by the results of this study, one or more distribution centers for each

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[1] The Stanford Research Institute estimated fertilizer consumption in Ethiopia for the next 15 years to be 16,400 tons annually in 5 years; 41,500 tons annually in 10 years; and 86,800 tons annually in 15 years.

producing district is necessary. Government support in terms of subsidies or long-term credit is highly desirable.

Pilot Programs

Production and transportation costs are important variables in determining the regional patterns of cereal production. The value of the results of a model cannot be better than the information used in constructing the model. As new and better (reliable) information is available, it is prudent to recompute and modify policies and models accordingly.

According to the results of this study, it is desirable to encourage regional specialization, use of fertilizer, and improvement of the marketing system. But, in practical terms, how can the government or the planning agency promote the shifts suggested in this study? A positive step in the right direction can be achieved by selecting a few producing districts where regional savings would be the greatest and to adopt the changes recommended. A controlled study of the effects of these changes could then be made in limited areas of the country. Specifically, the responses of farmers to changes in transportation facilities, marketing efficiency, technology such as the use of fertilizers, and other incentive programs could be studied. Connected with this program would be a strict monitoring of costs and benefits to the farmer as well as to the nation. This information can be used to recompute the regional model in order to confirm or modify the policy proposals.

The interregional commodity flow information in Chapter VI shows the magnitude of shipments of cereals between regions. As a starting point, those routes on which heavy traffic is indicated could be selected for improvement and cost studies. The fertilizer response data also indicate the producing districts that were most responsive to the application of chemical fertilizers. In selecting the districts for closer observation, the attitudes of the people of the district towards change and development should be considered.

The Swedish and United States governments and the World Bank in cooperation with the Ethiopian government, are undertaking regional development programs in Producing Districts 6, 7, and 9. Those agencies provide the so-called "package" program in the respective districts. The package includes research, education, extension, marketing, credit, seeds, fertilizers, and other technical knowledge. The Swedish project, which has been in operation for almost ten years, has already shown promising results. The move appears to be towards specialization in the production of few crops. The experiences of these programs could provide useful guides to future initiative with respect to specialization.

Complementary Measures

Ethiopian agriculture is characterized by:

1. Small and uneconomic farm units,
2. Fragmented holdings,
3. Non-monetized (non market-oriented),
4. Feudalistic landlord-tenant relationships,
5. A high degree of tenancy,
6. Lack of basic service institutions, and
7. Outmoded land ownership systems.

Piecemeal changes, perhaps useful to remove some short-run problems, could not be expected to provide a force big enough to break away from the stagnant traditional ways of doing things. A comprehensive reform program which replaces the traditional institutions with elements that reflect the needs and realities of contemporary Ethiopia is needed.

Land Reform -- Land reform is long overdue in Ethiopia. A gesture was made in 1965 when the Ministry of Land Reform and Administration was established. However, the Ministry's lack of success in passing any significant legislation is an indication that it has met some stiff resistance from vested interests who also happen to be policy makers. Three legislative programs, namely:

1. Cadastral survey,
2. Tenancy relationships, and
3. Progressive taxation on land ownership,

were proposed by the Ministry. To the author's knowledge, none of these legislative proposals were passed.

Three essential stages may be involved in a land reform program. These are:

1. Redistribution of ownership of land resources and consolidation of holdings,
2. Institution of measures designed to redistribute income derived from the land, and
3. The provision of complementary measures designed to increase production, employment and income through improvements of marketing, credit, communication, and administrative machinery.

Land redistribution may involve the expropriation of private land, the division of public lands, and the amalgamation of fragmented units in order to lead to a better distribution of land ownership and, consequently, income. The process of land redistribution is not an easy problem to tackle. The determination of the optimum size now and in the future, the determination of the proper compensation for expropriated land and how compensation is to be paid, and the prevention of a reoccurrence of the present situation are formidable tasks. These are fundamental problems of a land reform program. If peoperly instituted, a land redistribution program could provide farmers with the incentive to increase production for both domestic uses and marketable surplus.

It is very unlikely that farmers with very small and uneconomic holdings and tenure situations open to exploitation would have the incentives to specialize and to increase production. Land redistribution programs not only provide incentives to invest human and material resources but are also beneficial from the point of view of equity of distribution of the national wealth.

Consolidation of fragmented holdings is closely related to the question of land expropriation and redistribution. It is imperative that a program of expropriation and redistribution be accompanied by a movement towards consolidation and the formation of viable farm units. The small fragmented holdings in Ethiopia are the result of a long historical process. The inheritance laws, customs and traditions, and the high population pressure (particularly in the Highlands, where land has been settled for centuries with very limited opportunity for remunerative employment outside of agriculture) have forced division and fragmentation of holdings which seriously hampers production, both per man hour and per acre. If holdings are too small and fragmented, the result is not merely that mechanical cultivation is out of the question, but that the technique of farming gradually degenerates to the hoe culture. There will be a low fixed ceiling on the peasants' income and probably enforced idleness throughout much of the year. A land consolidation program is a step in the direction of improvement in agriculture and in the spatial allocation of production.

<u>Land Settlement</u> -- There are fairly extensive areas of unutilized land in Ethiopia, particularly in the south and southwestern provinces and in the lowland regions. Opportunities exist for large-scale land settlement and the establishment of farms more conducive to regional specialization provided that these areas are made accessible and irrigation facilities are provided where possible. The lowland regions hold the most promise for Ethiopia in the future. Land settlement programs will also remove some of the pressure from the presently overpopulated areas of the highland regions. However, it is not enough to rely on settlement alone to solve land reform problems. A few planned settlements have been attempted in Ethiopia in the past, but the results were not as expected.

<u>Tenancy Improvements</u> -- Complete elimination of tenancy is not possible, nor is it desirable. The problem with tenancy is faulty and inequitable contractual arrangements between the tenant and the landlord. In Ethiopia, most contractual arrangements are verbal and when written arrangements are made, they usually tend to favor the landlord. At present there is no specific legislation that defines the rights and privileges of the parties concerned.

In areas where population pressure is high, the tenancy situation is extremely bad. The tendency towards commercialization has displaced a great number of tenants in the past few years.

In regions where hard core resistance to land redistribution exists, a limited improvement is possible through changes in tenancy conditions. Improvements could be made regarding security of tenure, rental rates, share of variable expenses and, compensation for improvements. These changes are essential steps toward the ultimate goal of conferring basic entrepreneurial rights and incentives of economic production to cultivators. It is not enough to legislate, enforcement is an important part of the package. The landlord is often in a position to bend the law in his favor. Therefore, the process cannot be complete without impartial enforcement of the legislation.

Land Taxation -- A properly designed tax structure may accomplish several important ends. The most important results that taxation could bring are:

1. To force large and absentee land owners to sell their land to cultivators,
2. To contribute to the cost of a balanced agrarian reform program,
3. To transfer income from agriculture to help finance industrial growth, and
4. To mobilize differential rents that accrue to land owners by reason of privilege, location and other fortuitous circumstances and to make them available for financing much needed social infrastructure investments.

Progressive taxation on large land holdings and a tax on unutilized holdings could be expected to force large land holders to sell their land to tenants and/or to bring all the land they own into production. Such taxes would make the mere ownership of land a burden.

A low tax on agricultural land tends to make investment in land more lucrative than alternative investment opportunities. The low rate of taxation, high population pressure, and the prestige and security associated with ownership of land combined to make land value extremely high in the past. A high market value for agricultural land can make the transfer of land to tenants extremely expensive. A properly timed and well coordinated land taxation could facilitate transfer.

Credit Facilities -- In any scheme of agrarian reform the effective subsequent provision of credit is a vital factor. Chapter II indicated clearly that the Ethiopian farmer is poor, measured by any standard. All of the changes suggested in this chapter require cash expenditures. New incentives to invest family labor may be of little value if the farmer has no new tools and processes with which to work. Without a credit scheme, an agrarian reform program cannot be expected to produce the expected results. Thus, for success to be achieved, a credit scheme that is easy to supervise must be instituted.

Cooperative societies could play a leading role in this respect. As the Agricultural Development Bank of Ethiopia painfully learned, it is extremely difficult and costly to supervise and collect loans made to small farms. However, if the small farmers could form legal cooperatives, it will be possible to take advantage of the benefits of large scale.

Agricultural Research -- Agricultural research is essential to an agricultural development effort. The search for improved methods of production and distribution must be an integral part of any development effort. It is difficult to achieve success in the agricultural sphere without a high level of research in the agricultural sciences. Improvement in traditional tools and equipment, improvements in cultural methods, and improvements in livestock breeds cannot come without research in the agricultural sciences.

A very large fund of knowledge is available in the developed countries. Less developed countries could benefit from the experiences of the developed nations without much expense. What has taken years to develop can be obtained with relative ease, but since conditions in the donor and the recipient countries are almost always different, a complete transfer of technology is not possible. There is always a temptation for people from less developed countries to attempt to borrow the latest of machines and the most sophisticated technologies. Unfortunately, in most cases, these technologies are incompatible with the conditions and the needs of the less developed countries. The challenge for people from the less developed world is to discriminate between what is available and what is compatible with their conditions.

Mellor[1] categorizes research into four classes in descending order of transferability. These are basic research, developmental research, adaptive research, and test demonstrations.

Basic research deals with the development of the principles and concepts which lead to major technological advance. This kind of research provides the foundation on which innovations are based. Unless conditions are drastically different between the place where the basic research is

[1] John W. Mellor, The Economics of Agricultural Development, pp. 283-284.

conducted and the place it is intended to be used, there is no need to spend limited resources on basic research. Thus, basic research could be borrowed in its entirety from a developed country or could be conducted in a limited geographical area within the country (that is, one national research station doing all basic research).

Basic research is expensive in both time and material resources. Highly qualified researchers dedicated to the profession are needed. Less developed countries do not have the luxury of time nor the material resources to do basic research.

Developmental research is the application of basic research to immediate agricultural problems. This research is also transferable from one country to another unless conditions are highly variable. It is suggested that this research may have to be conducted in the less developed countries themselves but still on a national basis.

Adaptive research and test demonstrations are the two important research activities that must be conducted within the less developed countries in a decentralized fashion. To assure success, adaptive research must be "region specific". Test demonstrations must be made on specific geographical regions. Ideally, this kind of research should be done under local conditions. The idea is to show and educate the farmers about the benefits of new techniques of farming. The latter two types of research should not be expensive.

The provision of such facilities is extremely important for the implementation of an agricultural change program. Unfortunately, the importance of agricultural research is rarely understood by less developed countries. In Ethiopia it was only recently that research in agriculture was given some attention.

Extension Facilities -- Extension services have a dual function:

1. To disseminate information (that is, convey results of research to the consumers or farmers), and
2. To communicate farmers' problems to the researcher so that the researcher can design a research project that will solve the particular problem.

This communication is facilitated only when extension services are highly integrated with the agricultural research program. If findings of scientists are not transmitted to the farmers, it is a wasted effort. In an illiterate society, the best means of passing information to the farmer is personal contact. This can be done more efficiently with teams of researchers and extension people working together.

Infrastructural Development

Highway Construction

Extending major highways into regions that are currently inaccessible should enhance the possibility of regional specialization. New settlements could be organized into farm sizes that are more conducive to large scale operations and specialization. Old settlements are extremely difficult, if not impossible, to reorganize into modern farm units. On the other hand, people who migrate are those who seek new opportunities and challenge, making them more responsive [illegible] farming ideas and new ways of living.

The south and southwestern provinces severely lack communication. Building major highways into these areas could open up extensive agricultural lands for cultivation.

High transportation costs generally put areas that are distant from market at a disadvantage even though they may otherwise have comparative advantage. This is particularly so for the production of bulky and perishable products. The extension of highways into such areas would enhance comparative advantage and, consequently, foster specialization.

Construction of Dams, Drainages and Irrigation Facilities

Vast areas of the lowlands of Ethiopia are not used for crop production primarily due to shortage of moisture and, in some areas poor drainage accounts for a good part of the unused land. Preliminary observations have shown that some of the lowland soils are among the most fertile. The major river systems of Ethiopia meander through most of these lowlands. So far, only a few river basins (that is, Awash, Blue Nile and Wabi Shebele) have been studied or are being studied. Agricultural development is currently underway in the Awash river basin. Construction of dams, drainages and irrigation facilities can bring these vast resources into agricultural use. The expansion of agricultural production into such areas will no doubt encourage commercial agriculture and spatial redistribution of production. Such facilities are not generally compatible with small scale farming.

Health Facilities

One of the explanations for the heavy concentration of settlement in the highland region of Ethiopia is that of health hazards existing in the lowland regions. Malaria was a serious problem in the past and still is troublesome in some places; the tsetse fly is a serious problem in the south and southwestern provinces. For a successful settlement, it is important to bring in health facilities. The provision of education and health facilities will assure the long-run success of an agricultural development program.

Economic Change

The evolution of subsistence agriculture into commercial agriculture has some important characteristics. These are:

1. The economy is monetized (oriented to production for sale)
2. A large market for agricultural commodities develops due to increased population and income in the nonagricultural sector,
3. Proportion of agricultural population is low, and
4. Industrial base is to be expanded.

These are important preconditions for agriculture to develop and lose its subsistence characteristics.

While export markets should be investigated and exploited to the fullest extent possible, they cannot be expected to absorb all the increased production from agriculture and also provide the incentive for further increase in productivity. World trade in agricultural products is becoming more and more restricted and regionalized.

The most certain method for absorbing the increased production and providing the necessary incentive for further productivity increase is the expansion of domestic demand. The two most important means for expanding demand are increased per capita income and increased market-dependent population. If a market-dependent population increases without an income increase, the effect may be minimal. This is where agriculture and industry complement each other. Agriculture and industry should develop simultaneously to avoid undue hardship on the people. As agriculture becomes commercialized and specialized, more people will be displaced from the agricultural sector. These people must be absorbed by the services and manufacturing sector. The income received will be spent on food products, expanding the market for agricultural goods. In return, agriculture absorbs some of the outputs of industry. This interdependence between agriculture and industry continues to create a dynamic and growing society.

Distribution of Income

The marginal expenditure on food items (particulary cereals) by high-income people is generally lower than low-income people. That is, high income people spend less of any additional income on food consumption, while low-income people spend a large proportion of any extra income on food. Thus, from the point of view of expansion of demand for food, income distribution in favor of low-income people is desirable. A relatively smooth shift from a primarily subsistence agriculture to a commercial agriculture would occur if economic activities were spread more than at present.

Social Change

The creation of a dynamic and progressive agriculture requires a certain degree of discipline and organization. Lack of discipline and organization could be a hindrance to desirable changes. In Ethiopia, several attempts to improve conditions in agriculture fell far short of expectations. Several factors account for the slow progress, but the most important and often missing in economic studies, is the human element. For example, when a certain project is contemplated, a thorough inventory of soil, rainfall, material requirements, and labor (head count) is made. But rarely is an attempt ever made to analyze the attitudes of the people, their habitual ways of doing things, and the core values of the society. It is usually assumed that people will immediately respond to economic incentives. In all societies there are certain social organizations and integral codes of behavior which are essential for the existence of the society. These codes may be incompatible with some forms of modernization. For example, such things as the extended family system--families grouped by kinship and tribe to form a community, time and resources allocated to observing large numbers of holidays and attending ceremonies, the use of scarce resources for ceremonial activities, and indifference or resistance to change are characteristic of traditional societies. Some of these traditions and organizations serve useful purposes to the society, while others not serve any useful purpose. While some of the traditional ways can and will give way to the new way of life, others may have to be retained. Any proposal or program of change needs to recognize the nature of the society it wants to change. A program that does not take cognizance of these elements is likely to be frustrated.

Mobility--social, geographical, financial and educational--is important in breaking away from a stagnant situation. The absence of such mobility is a hindrance to the establishment of new settlements and overall agricultural development. It is essential to understand why a society is stable, how it resists attempts to change stable patterns, and how it learns about, evaluates, and adopts change.

Project Selection

The general areas where improvement are needed to facilitate the implementation of the results obtained in Chapter VI have been discussed. While it is desirable to carry out all the suggested measures, it should be realized that this is financially impossible. Several factors constrain activities. In less developed countries bottlenecks result from the lack of capital, skilled labourers and managers, foreign exchange, and even public administration. The severe scarcity of resources forces concentration of effort upon a limited number of activities, both geographically and by type of investment. The problem is how to identify the areas of priority.

In theory, at least, project selection is based on the profitability or net social benefit of the enterprise under consideration. Usually the activity which promises the highest return to the limited resource is selected. The difficulty is how to organize benefits and costs so as to make a meaningful comparison between alternative investments. The problem is further compounded by the fact that some benefits and costs are not quantifiable (e.g., education and health). Any decision concerning these things must be based on criteria other than quantifiable rate of return calculations.

Although benefit-cost evaluation has its own problems, it is now being used widely to evaluate investment projects. The determination of prices, costs, interest rates, and period of analysis are separate problems by themselves. Otto Eckstein discusses three possibilities for project evaluation:

1. Compare differences between net benefits,

2. Compare the rates of return, and
3. Compare ratio of benefits to costs.[1]

Since comparing differences of net benefits favors large investment projects, its use is not recommended. Which of the latter two criteria to employ will depend on the nature of the project. It was pointed out by Eckstein that the two methods yield the same result only under special conditions:

1. Where the current costs of the projects are in the same ratio as investment costs,
2. Where benefit-cost ratio is equal to 1.0, and
3. Where there are no current costs.[2]

The use of the benefit-cost ratio criterion is suitable for projects that have the following characteristics:

1. The economic nature of the costs are reasonably uniform,
2. No extreme variations of capital intensity,
3. Benefits are uniform and roughly equal in degree of uncertainty, and
4. Life span of the projects among which choices are made are the same.[3]

If the nature of the projects to be compared departs significantly from the above conditions, rankings that employ benefit-cost ratios are not very useful.

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[1] Otto Eckstein, Water Resource Development: The Economics of Project Evaluation (Cambridge, Massachusetts: Harvard University Press, 1958, p. 53.

[2] Ibid., p. 58.

[3] Ibid., p. 55.

Theoretically, if resources are unlimited and can be obtained at an increasing cost, all projects with rate of return greater than the market interest rate will be undertaken. In terms of benefit-cost analysis, all projects with benefit-cost ratio greater than 1.0 should be undertaken. On the other hand, if only a given resource is scarce, the optimum resource allocation will occur when projects with the highest return to the limited resource are undertaken. In a benefit-cost setting, selecting the project with the highest ratio implicitly assumes that returns are maximized for a "bundle cost."[1] The bundle of costs consists of diverse resources and materials, such as labor, machinery, fertilizers, chemicals, and equipment.

Most less developed countries suffer from severe shortages of one or more resources. In Ethiopia, the only resource that is not scarce is unskilled labor. Everything else--land, capital, skilled labor and foreign exchange--is extremely scarce. Optimum allocation calls for maximizing returns to these resources.

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[1] *Ibid.*, p. 61.

CHAPTER VIII

SUMMARY AND IMPLICATIONS

This study employed a programming technique to analyze the spatial distribution of the five major cereal crops raised in Ethiopia (namely, wheat, barley, teff, corn and sorghum). The main concern of the investigation was to examine the regional pattern of cereal production and the interregional flows which minimize national cost of production and transportation for the cereals in question but are consistent with the given levels of demand.

More than 80 percent of the people of Ethiopia are directly involved in agriculture. Agriculture also provides Ethiopia's entire foreign exchange earnings, which are dearly needed to finance the growing need for materials and resources to build an industrial base.

Agriculture is so important that it is also the cause of the country's backwardness and economic stagnation. An attempt to modernize the country can hardly succeed if agriculture is unaffected. However, because of the large number of people involved in agriculture, its modernization is a formidable task.

Ethiopian agriculture is primarily subsistence oriented. The farmers consume more than 80 percent of their produce. Purchases by them are limited to a few essential industrial items. By and large, the rural sector is non-monetized.

Farm tools and equipment are simple and inexpensive. Total investment on tools and equipment per farm was found to be less than Eth. $50.00. Property ownership is concentrated in the hands of very few and inequity of distribution of income is very high.

Spatial Distribution

For purposes of this study, the country was divided into twenty-eight production districts and nineteen consuming regions, the latter represented by a central place serving as the point from which transportation costs to other regions are measured. Producing districts were delineated so as to make them as homogenous as possible with respect to production conditions. Statistics were separately available for awrajas (sub-provinces). Therefore, boundaries had to coincide with the awraja boundaries. One or more awrajas were assigned to each producing district, and one or more producing districts were assigned to consuming regions, which, for the most part, coincided with Ethiopia's provinces. The provinces of Shoa and Eritrea were divided into two consuming regions, and the province of Harargie, into four consuming regions. Districts with minor crop producing potential were not separately identified; their production was netted out from the total regional demands for cereals.

The use of the programming method in an interregional competition study requires information on:

1. Estimates of input-output coefficient for each activity by producing region.
2. Estimates of per hectare costs per activity by producing region.
3. Estimates of demand for each commodity by demand (consuming) region.

4. Estimates of transportation costs between demand regions.
5. Estimates of resource and institutional constraints.

The constraints programmed were crop land and foreign exchange. The crop land constraints were determined at the actual 1966 land use level while the level of foreign exchange allowed for the importation of fertilizer was arbitrarily determined.

Using 1966 data, the following alternatives were programmed:

1. Regional specialization with conventional farming practices,
2. Conventional and fertilizer activities, and specialization with constrained fertilizer use (Eth. $100 million was allowed for importing fertilizer), and
3. Conventional and fertilizer activities, and specialization with unconstrained fertilizer use.

The same alternatives were programmed using 1980 data. A feasible solution was obtained only for the last alternative where fertilizer use was not constrained. The policy implications of the infeasible solutions for alternatives (1) and (2) were that unless substantial improvements in farming practices are made or crop land is increased, the country could find it difficult to satisfy the demand for cereals by the 1980's.

The questions to be answered were: Had Ethiopian cereal production been organized in accordance with regional comparative advantage in 1966, would it have been possible to satisfy the 1966 demand for the various commodities under investigation with fewer resources and effort? Also, how should cereal production be distributed in 1980? The year 1966 was selected for the base analysis because it was the year for which the necessary information was available.

The results of the analyses indicated that regional specialization and fertilizer use would be beneficial to the nation. The minimum cost solutions showed that approximately up to 2.6 million hectares of cropland could be wirthdrawn from the production of cereals if productions were specialized and chemical fertilizers were applied. The least-cost solutions of the models programmed indicated that the desirable regional distribution of cereal crops would be as follows:

Crops	Producing Districts
Wheat	2, 8, 21 and 22
Barley	5, 6, 7, 12, 13, 16, 17 and 24
Teff	2, 7, 14, 15, 17, and 20
Corn	6, 8, 9, 11, 13, 17, 18, 21, 23, and 25
Sorghum	1, 2, 9, 12, 17, 18, 21, and 25.

The solutions also indicated that high transportation costs have been a hindrance to regional specialization. The detrimental effect of the high cost of moving goods is evidenced by the absence of long hauls in the programming solutions. Efficiency in marketing and transportation is a prerequisite if a nation is to take advantage of differences in the productivity of producing districts.

Limitations of the Study

Three important problems are encountered when this type of analysis is made using the programming technique. The problems are data limitation, aggregation, and the assumption of linearity.

Activity analysis models are simple, but very powerful, techniques. Several studies of interregional competition have been made in the United

States and elsewhere using this technique and have shown promising results. However, one should not lose sight of the enormous amount of data required to conduct even a modest investigation of this sort. The most serious criticism of using the programming model hinges on this very problem. The criticism is even more valid for a country where data sources are relatively scarce.

Aggregation is a major problem to be faced in an interregional competition model which uses broad geographical regions as producing units. When such regions are used as producing units some key agricultural characteristics like soil, climate, crop mix, or cultural practice are assumed homogenous. The ideal thing would have been to segment the agricultural regions into small units and to define production and constraints for each unit separately. Since this is impractical for financial and other reasons, one is compelled to assume that every farm in the region is the same in at least some of the important agricultural characteristics. Usually in the delimitation of producing districts and consuming regions, data availability is an important consideration. Certain economic features and uniformity have to be sacrificed in order to make regional boundaries coincide with the unit for which data is available.

Another serious handicap with this type of model is the assumption of linearity. Linear programming analysis assumes constant returns to scale over all land in the region. Most production functions in agriculture are nonlinear. However, problems that involve nonlinearity in interregional competition have not been handled. Takayama and Judge have shown that it is possible to obtain solutions for nonlinear models if appropriate linear dependencies between regional supply and demand and prices are well-behaved continuous linear functions.[1] It has been suggested, therefore, that countries or research workers just beginning the study of interregional competition should use linear models. Greater detail (that is, more regions, more restraints) can be handled in a linear model.

Implications of the Study

Ethiopian farmers are nonmarket oriented. Their major objective is to produce enough of every commodity to satisfy their families' needs. Although it may be to their advantage as well as to the nation's advantage to concentrate on the production of fewer commodities as dictated by the comparative advantage of each region, it is unlikely that the farmer will accept this idea. Family security most often ranks highest in their list of priorities.

The primitive modes of transportation and inefficient marketing institutions discourage regional specialization. In addition, land ownership and tenancy relationships do not create incentives for improvement.

The attitudes of producers and the problems discussed above may handicap any effort towards specialization. However, in the future, as farm productivity improves and commercialization emerges, the move will undoubtedly be in the direction of regional specialization.

In the years to come, Ethiopia's agricultural development will be intimately connected with the country's Five-Year Development Plan.

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[1] T. Katayama and G.G. Judge, "Spatial Equilibrium and Quadratic Programming," JFE, Vol. 46 (1964), p. 67

The plan recognizes regional differences in quality and quantity of resources and has expressed the need for regional emphasis:

> During the third plan, a start will be made by assisting the people in a limited number of regions to initiate and carry forward the process of economic growth. Those who have the highest level of initiative, who are willing to contribute to integrated development plans, and who are able to organize for development, will be offered technical consultants to assist them in formulation and implementation of economic development projects. Government policy will encourage the identification and planning of major regional development projects for completion by various operating agencies.[1]

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[1] IEG, Third Five-Year Development Plan, 1968-1973, p. 365.

BIBLIOGRAPHY

ADAMS, Philip L. and Andrews, Benjamin V. Improvement of Ethiopian Ports. Report No. 4. Menlo Park, California: Stanford Research Institute, September, 1968.

BAKER, Randolph. "Estimation of Regional Supply." Interregional Competition Research Methods. Edited by R.A. King. Raleigh: North Carolina: University of N.C. Press, 1963.

BENEDICT, H.M. Potential Agricultural Chemical Demand in Ethiopia. Report No. 3. Menlo Park, California: Stanford Research Institute, September, 1968.

_____, and Cogswell, S.A. Potential Fertilizer Demand in Ethiopia. Report No. 1. Menlo Park, California: Stanford Research Institute, April, 1968.

BORTON, Raymond E., et al. Development of Castor Seed Production and Processing in Ethiopia. Report No. 12. Menlo Park, California: Stanford Research Institute, February, 1969.

_____, et al. A Development Program for the Ada District: Based on a Socio-Economic Survey. Report No. 14. Menlo Park, California: Stanford Research Institute, March, 1969.

CAVES, R.E. Trade and Economic Structures. Cambridge: Harvard University Press, 1960.

CHENERY, Hallis B. "Comparative Advantage and Development Policy." Surveys of Economic Theory. Vol. II. New York: St. Martin's Press, 1966.

CIRIACY-WANTRUP, S.V. Resource Conservation: Economics and Policies. Berkeley, California: Division of Agricultural Sciences, University of California, 1963.

CHEUNG, Steven N.S. The Theory of Share Tenancy with Special Application to Asian Agriculture and the First Phase of Taiwan Land Reform. Chicago: University of Chicago Press, 1969.

DAMON, E.G. The Cultivated Sorghums of Ethiopia. Exp. Stn. Bulletin No. 6. Dire Dawa: Imperial Ethiopian College of Agriculture and Mechanical Arts, April, 1962.

DAVIS, K.C. and Mohamed, Ahmed. Farm Organization of Terre and Galmo Villages (Harar Province, Ethiopia). Exp. Stn. Bulletin No. 42. Dire Dawa: IECAMA, October, 1965.

DEGEFU, Dawit. "The Chemistry of Potassium and Non-Crystalline Colloids in Ethiopian Soils." Unpublished Doctoral Thesis, Oklahoma State University, July, 1966.

DENNIS, Carleton C. "Processing Cost Estimation in Studies of Interregional Competition." Interregional Competition Research Methods. Raleigh: N.C. State University Press, 1963.

DERAFOLS, Winfiedo, et al. Development of the Ethiopian Oilseeds Industry. Report No. 8. Menlo Park, California: Stanford Research Institute, January, 1969.

DRAPER, N.R. and H. Smith. Applied Regression Analysis. New York: John Wiley and Sons, 1966.

DORFMAN, R.; Samuelson, P.A.; and Solow, R. Linear Programming and Economic Analysis. New York: McGraw-Hill Book Co., Inc., 1958.

EBBA, Fedadu. A Case Study of Six Peasant Farms in Ada District, Shoa Province. Addis Ababa: Ministry of Agriculture, Department of Agricultural Economics and Statistics, March,1970.

EBBA, Taddese. T'EF (Eragrostics Tef): The Cultivation, Usage and Some of the Known Diseases and Insect Pests. Part I. Exp. Stn. Bulletin No. 60. Dire Dawa: HSIU, College of Agriculture, March, 1969.

ECKSTEIN, Otto. Water Resource Development: The Economics of Project Evaluation. Cambridge, Mass.: Harvard University Press, 1968.

EGBERT, Alvin C. and Heady, Earl O. Regional Adjustments in Grain Production: A Linear Programming Analysis. Technical Bulletin No. 1241 and Supplement. Washington: USDA, 1961.

_____. Regional Analysis of Production Adjustments in Major Field Crops: Historical Prospective--An Application of Spatial Linear Programming. Technical Bulletin No. 1294. Washington: USDA, 1961.

_____, et al. Regional Changes in Grain Production: An Application of Spatial Linear Programming. Exp. Stn. Bulletin No. 521. Ames: University of Iowa, 1964.

EICHBERGER, W.G. "Food Production and Consumption in Ethiopia," Addis Ababa, USAID, n.d. (Mimeograph.)

FELEKE, Asrat. A Progress Report on Cereal and Oilseed Research, 1955-1963. Exp. Stn. Bulletin No. 39. Debre Zeit: HSIU, College of Agriculture, July, 1965.

FEROM, Kifle-Mariam. The Resources and Economy of Ethiopia. Report No. 13. Menlo Park, California: Stanford Research Institute, February, 1969.

FAO. Agricultural Commodity Projections, 1970-1980. Vol. II. Rome: FAO, 1971.

_____. Monthly Bulletin of Agricultural Economics and Statistics. No. 12, Vol. 18, December, 1969.

_____. General Report. Vol. I: Survey of the Awash River Basin. Rome: FAO, 1965.

_____. Soils and Agronomy. Vol. II: Survey of the Awash River Basin. Rome: FAO, 1965.

_____. Climatology and Hydrology. Vol. III: Survey of the Awash River Basin. Rome: FAO, 1965.

_____. Water Storage and Power Development. Vol. IV: Survey of the Awash River Basin. Rome: FAO, 1965.

_____. Irrigation and Water Planning. Vol. V: Survey of the Awash River Basin. Rome: FAO, 1965.

GALE, D. The Theory of Linear Economic Models. New York: McGraw-Hill, Inc., 1966.

GASS, Saul T. Linear Programming Methods and Application. Second edition. New York: McGraw-Hill, Inc., 1964.

GENTRY, Ruff L. Wheat Research: Debre Feit and Alaemaya 1955-1962. Exp. Stn. Bulletin No. 28. Dire Dawa: HSIU, College of Agriculture, June, 1963.

GOOT, P.F. Cander. "Analysis of the Returns on Government Investment in a Settlement for Cotton, Maize, and Ground Nuts." Addis Ababa, March 6, 1967. (Unpublished report.)

HABERLER, G. "An Assessment of the Current Relevance of the Theory of Comparative Advantage to Agricultural Production and Trade." Proceedings of the International Conference of Agricultural Economists, 1964. London: Oxford University Press, 1966.

HALL, Harry N. and Heady, Earl O. Models for the Analysis of Inter-regional Competition Product Allocation, Land Use, and Spatial Equilibrium, Economic Models and Quantitative Methods for Decisions and Planning in Agriculture. Edited by Earl O. Heady. Ames, Iowa: Iowa State University Press, 1971.

HEADY, Earl O. "Aggregation and Related Problems in Models for Analysis of Interregional Competition." Interregional Competition Research Methods. Edited by R.A. King. Raleigh: N.C. State University Press, 1963, pp. 129-146.

_____. Agricultural Supply Functions: Estimating Techniques and Interpretations. Ames, Iowa: Iowa State University Press, 1961.

_____ and Candler, Wilfred. Linear Programming Methods. Ames, Iowa: Iowa State University Press, 1958.

_____; Randhawa, N.S.; and Skold, M.D. "Programming Lodels of Interregional Efficiency and Land Use in Agriculture." Activity Analysis in the Theory of Growth and Planning. Edited by Malinvand and Bacharach. New York: St. Martin's Press, 1967, pp. 245-268.

_____ and Skold, Melvin. Projection of U.S. Agricultural Capacity and Interregional Adjustments in Production and Land Use with Spatial Programming Models. Agricultural Exp. Stn. Bulletin 539. Ames, Iowa: Iowa State University, 1965.

_____ and Whittlesey, Norman K. A Programming Analysis of Interregional Competition and Surplus Capacity of American Agriculture. Agricultural Exp. Stn. Bulletin 538, 1965.

HUFFNAGEL, H.P. Agriculture in Ethiopia. Rome: FAO, 1961.

JUDGE, George G. "Interregional Price Allocation Models of the Agricultural Sector," Interregional Competition Research Methods. Raleigh: N.C. State University Press, 1963.

IMPERIAL ETHIOPIAN GOVERNMENT. Ethiopia Nutrition Survey: Interdepartmental Committee on Nutrition for National Defence. Washington, D.C.: IEG, September, 1959.

_____, Central Statistics Office. Ethiopia: Statistical Abstract of 1967 and 1968. Addis Ababa: IEG, 1968.

_____. Report on Crop-Cutting Experiments and Some Observations on Farming in Setit Humera. Addis Ababa: IEG, October, 1967.

_____. Report on a Survey of Shoa Province. Addis Ababa: IEG, May, 1966.

_____. Report on a Survey of Tigre Province. Addis Ababa: IEG, May, 1967.

_____. Report on a Survey of Welleja Province. Addis Ababa: IEG, 1967.

_____. Report on a Survey of Wollo Province. Addis Ababa: IEG, May, 1967.

IMPERIAL ETHIOPIAN GOVERNMENT, and Ministry of Agriculture. Report on a Sample Survey in Yerer and Kereyu Awraja. Addis Ababa: IEG, 1964.

_____, IAR. Report for thePeriod April 1969 to March 1970. Addis Ababa: IEG, 1970.

_____ (Bako Research Station). Progress Report for the Period April 1970 to March 1971. Addis Ababa: IEG, April, 1971.

_____ (Holeta Guenet Research Station). Progress Report for the Period April 1969 to March 1970. Addis Ababa: IEG, May, 1970.

_____, Ministry of Agriculture Extension Service, and FAO. "Freedom From Hunger Campaign: Fertilizer Demonstration Program 1967/68." Addis Ababa, April, 1968. (Unpublished report.)

_____. "Freedom From Hunger Campaign: Fertilizer Demonstration Program 1968/69." Addis Ababa, n.d. (Unpublished report.)

_____. "Freedom From Hunger Campaign: Fertilizer Demonstration Program 1969/70." Addis Ababa, n.d. (Unpublished report.)

_____. "A Report on the S.I.A. Estate at Tessenei." Submitted to the Ministry of Planning and Development, January 19, 1967.

_____. Technical Agency: Live Sheep Export Study. Addis Ababa: IEG, May, 1971.

_____. Vegetable Production and Dehydration: A Preliminary Study. Addis Ababa: IEG, August, 1970.

_____, Ministry of Land Reform and Administration. Report on Land Tenure Survey of Arussi Province. Addis Ababa: IEG, August, 1967.

_____. Report on Land Tenure Survey of Bale Province. Addis Ababa: IEG, December, 1969.

_____. Report on Land Tenure Survey of Begemdir and Semien Province. Addis Ababa: IEG, January, 1970.

_____. Report on Land Tenure Survey of Eritrea Province. Addis Ababa: IEG, September, 1969.

_____. Report on Land Tenure Survey of Gemmu Gofa Province. Addis Ababa: IEG, February, 1968.

_____. Report on Land Tenure Survey of Illubabor Province. Addis Ababa: June, 1969.

_____. Report on Land Tenure Survey of Keffa Province. Addis Ababa: January, 1969.

IMPERIAL ETHIOPIAN GOVERNMENT, Ministry of Land Reform and Administration. Report on Land Tenure Survey of Shoa Province. Addis Ababa: 1967.

_____. Report on Land Tenure Survey of Sidomo Province. Addis Ababa: September, 1969.

_____. Report on Land Tenure Survey of Wollega Province. Addis Ababa: August, 1967.

_____. A Study of Agricultural Land Dispute in Kuni Wereda and Chercher Awaraja Courts (Haru Province). Addis Ababa: IEG, April, 1969.

_____, Ministry of Planning. Regional Aspects of National Planning in Ethiopia. Parts I and II. Addis Ababa: IEG, August, 1967.

_____. Third Five-Year Development Plan, 1968-1973. Addis Ababa: Berhanena Salam H.S.I. Printing Press, 1967.

IMPERIAL HIGHWAY AUTHORITY. Agriculture Development Project of Wollamo: Engineering Cost of Estimate of Feeder and Farm Roads. Addis Ababa: IEG, June 15, 1967.

_____. "Progress in Highway Transport." Paper presented at the XIII World Road Congress, Tokyo, Japan, November 3-11, 1967.

LADD, G.W. "Estimation of Regional Demand Functions." Interregional Competition Research Methods. Raleigh: N.C. State University Press, 1963.

LALWICH, Dushan. Agricultural Development Possibilities of the Awash River Valley. Addis Ababa: IEG, Planning Board, April, 1958.

LITTLE, Ian M.D. and Murlees, James A. Manual of Industrial Project Analysis in Developing Countries: Social Cost-Benefit Analysis. Paris: Development Centre of the Organization for Economic Cooperation and Development, 1968.

LOVE, Harold C., et al. Analysis of the Operation of a Commercial Feedlot in Southern Ethiopia. Report No. 18. Menlo Park, California: Stanford Research Institute, August, 1969.

MAKONNEN, Telahun. "Case Study of Ten Ethiopian Farms in the Chercher Highlands." Alemaya, 1969. (Unpublished paper.)

_____ and Tecle-Medhin, Getachew. "Case Study of Ten Ethiopian Farmers in the Central Highlands (Debre Zeit Vicinity)." Debre Zeit, 1969. (Unpublished paper.)

MAROUSEK, Gerald E. and Martin, Charles A. Economic Feasibility of Dry-Salting Treatment of Cattle Hides from Malque Wendo Abattoir and Local Slaughter. Report No. 5. Menlo Park, California: Stanford Research Institute, January, 1969.

MELLOR, John W. The Economics of Agricultural Development. Ithaca: Cornell University Press, 1966.

MIGHELL, Roland L. and Black, John D. Interregional Competition in Agriculture. Cambridge, Mass.: Harvard University Press, 1951.

MILLER, Carl F., et al. Systems Analysis Methods for Ethiopian Agriculture. Vol. I. Menlo Park, California: Stanford Research Institute, April, 1968.

MILLER, Clarence J., et al. Development of Agriculture and Agro-Industry in Ethiopia: A Proposed Program of Research and Planning Studies. Report No. 1. Menlo Park, California: Stanford Research Institute, October, 1967.

_____, et al. Development of Agriculture and Agro-Industry in Ethiopia: Strategy and Programs. SRI Report. Menlo Park, California: Stanford Research Institute, December, 1969.

_____, et al. Production of Grains and Pulses in Ethiopia. Report No. 10. Menlo Park, California: Stanford Research Institute, January, 1969.

MILLER, L.F. and Makonnen, Telahun. Organization and Operation of Three Ethiopian Case Farmers. Exp. Stn. Bulletin No. 35. Dire Dawa: IECAMA, March, 1965.

MITCHELL COTTS COMPANY, ETHIOPIA, LTD. Soil Analysis from Tendaho Plantation and Comments on Analytical Data. Addis Ababa: Mitchell Cotts Co., n.d.

MURPHY, H.F. A Report on the Fertility Status and Other Data on Some Soils of Ethiopia. Exp. Stn. Bulletin No. 44. Dire Dawa: College of Agriculture, Haile Selassie I University, 1968.

_____. Soils of Ethiopia: Analytical Data and Notes 1956-58. Vols. I and II. Dire Dawa: IECAMA, n.d.

_____. Soils of Ethiopia. Exp. Stn. Bulletin No. 4. Dire Dawa: IECAMA, February, 1963.

_____. Soils of Ethiopia: A Report on the Fertility Status of Some Soils of Ethiopia. Exp. Stn. Bulletin No. 1. Dire Dawa: IECAMA, November, 1959.

NATIONAL BANK OF ETHIOPIA. Local Prices in 1966 and Some Series of Local Prices in the Period 1957-1966. Addis Ababa: Economic Research Dept., National Bank of Ethiopia, June, 1967.

NEVIN, Robert L., et al. Supplemental Irrigation Projects on the Desset River. Report No. 15. Menlo Park, California: Stanford Research Institute, March, 1969.

NEVIN, Robert L., et al. A Supplemental Irrigation Project in the Borkenna Valley. Report No. 17. Menlo Park, California: Stanford Research Institute, April, 1969.

QUENEMOEN, M.E. Potential Returns from Commercial Farming Systems in Three Areas of Ethiopia. Exp. Stn. Bulletin No. 56. Dire Dawa: HSIU, College of Agriculture, June, 1968.

REINELT, E.R. "On the Role of Orography in the Precipitation Regime of Alberta." The Alberta Geographer, Vol. 6, 1969-1970, p. 45.

RICARDO, David. On the Principles of Political Economy and Taxation. Edited by Piero Sraffa and M.H. Dobb. London: Cambridge University Press, 1951.

ROBINSON, J.H. and Banta, Ato Mammo. An Agricultural Credit Program for Ethiopia. Report No. 9. Menlo Park, California: Stanford Research Institute, January, 1969.

SCHULTZ, Theodore W. Transforming Traditional Agriculture. New Haven and London: Yale University Press, 1964.

SCHWARZ, William L.K. Ethiopia's Export Trade in Major Agricultural Commodities. Report No. 6. Menlo Park, California: Stanford Research Institute, January, 1969.

SHANTZ, H.L. and Marbut, C.F. The Vegetation and Soils of Africa. New York: American Geographical Society, 1923.

SMITH, Adam. The Wealth of Nations. Vol. 1, Second edition. London: Methuen and Co., Ltd., 1920.

SOUTHWORTH, Herman M. and Johnston, Bruce F. Agricultural Development and Economic Growth. Ithaca, N.Y.: Cornell University Press, 1969.

SZEZEPANIK, E.F. "The Size and Efficiency of Agricultural Investment in Selected Countries." Monthly Bulletin of Agricultural Economics and Statistics, Vol. 18 (December, 1969), p. 2.

TADELE, Tastaye. "Capital Requirement to Establish a Small Size Commercial Farm in Awash Valley." College of Agriculture, Alemaya, Ethiopia, June, 1967. (Unpublished paper.)

TAKAYAMA, T. and Judge, G.G. "Spatial Equilibrium and Quadratic Programming." Journal of Farm Economics, Vol. 46 (1964), p. 67.

TATU, Kebede. "Rainfall in Ethiopia." Ethiopian Geographic Journal, Vol. 11, No. 2 (December, 1964), p. 31.

TECLE-MEDHIN, Getachew. "Economic Appraisal of Fertilizer Use in Ethiopia." Unpublished Masters thesis, University of Alberta, Edmonton, 1972.

TECLE-MEDHIN, Getachew. "An Evaluation of Commercial Farming Opportunities in the Teff Producing Areas East of Addis Ababa (From Dukem to Modjo)." Dire Dawa, College of Agriculture, August, 1967. (Unpublished paper.)

TESEMA, Tesfaye. Field Crops Experimental Results. Debre Zeit: Agricultural Experiment Station, College of Agriculture, HSIU, 1964 and 1965.

THODEY, Alan R. Marketing of Grains and Pulses in Ethiopia. Report No. 16. Menlo Park, California: Stanford Research Institute, April, 1969.

UNITED NATIONS COMMISSION FOR AFRICA. "African Population Conference Country Statement: Ethiopia." Proceedings of a conference held in Accra, Ghana, December 9-18, 1971.

USDA, Foreign Agricultural Service. Ethiopia: Livestock. Washington: USDA, June 10, 1963.

_____. Ethiopia: Cotton Report. Washington: USDA, March 29, 1963.

_____. Ethiopia: Dairy Report. Washington: USDA, August 27, 1963.

U.S., DEPARTMENT OF INTERIOR, Bureau of Reclamation. "Appendix VI: Agriculture and Economics." Land and Water Resources of the Blue Nile Basin of Ethiopia. Washington: USDI, 1964.

WOLDE MARIAM, Mesfin. Farm Data Summary, Blue Nile Basin, 1961 - Present Situation. Addis Ababa: Ethiopian-United States Cooperative Program for the Study of Water Resources. January, 1962.

_____. An Atlas of Ethiopia. Revised edition. Asmara, Ethiopia: Il Poligrafico, Private Ltd. Co., 1970.

APPENDICES

APPENDIX A

TABLE A-1

AWRAJAS INCLUDED IN EACH PRODUCING DISTRICT, ETHIOPIA

Prod. Dist.	Awraja	Prod. Dist.	Awraja
1	Jijiga	15	Yeju
	Gursum		Ambasel
2	Harar and Surrounding	16	Gayint
	Wobera		Lasta
	Chercher		Wadla Delanta
	Garamuleta	17	Gojam without Metekel
3	Wabe	18	Gimbi
4	Genale		Horo and Guduru
	Delo		Leka
	Fasil		Arjo
5	Arba Gugu	19	Gore
	Ticho		Buno
6	Chilalo		Mocha
7	Yerer and Kereyu	20	Asosa
8	Hykotch and Butajera		Kelem
	Chebo and Gurage	21	Wegera
	Kembata		Gonder
9	Wolamo		Chilga
	Sidama	22	Libo
	Derasa		Debre Tabor
	Jemjem	23	Wag
10	Gardula		Raya and Kobo
	Gemu	24	Raya and Azebo
	Gofa		Inderta
11	Gimira	25	Semen
	Jimma		Shire
	Kefa		Axsum
	Kulo Konta		Temben
	Limu	26	Adwa
12	Jibat and Mecha		Agame
	Menagesha	27	Hamasen
13	Menze and Gishe		Seraye
	Merhabete	28	Mitsewa
	Yifat and Timuga		Akale Guzaye
	Tegulet		
	Selale		
14	Desse		
	Werehimeno		
	Borena		
	Werellu		
	Kalu		

APPENDIX B

TABLE B-1

REGION 1: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Addis Ababa (1948-1957) (09° 02' N. 38° 45' E.) (Altitude 2408 m.)	Ambo (1953-1957) (08° 58' N. 37° 50' E.) (Altitude 2190 m.)	Debre Markos (1954-1957) (10° 10' N. 37° 49' E.) (Altitude 2313 m.)	Combolcha (1952-1957) (11° 08' N. 39° 38' E.) (Altitude 1903 m.)
		(mm.)		
January	21.4	18.9	21.5	27.9
February	26.3	18.2	7.6	39.8
March	76.0	86.1	78.9	84.6
April	111.7	78.0	82.8	117.9
May	70.0	61.0	59.5	27.7
June	125.2	144.7	174.2	22.7
July	278.2	216.6	299.1	320.3
August	287.9	269.2	290.3	310.7
September	184.8	152.8	224.3	176.3
October	41.0	56.3	65.8	18.9
November	4.5	1.6	5.5	9.2
December	10.5	5.0	13.3	18.0

Source: Huffnagel, Agriculture in Ethiopia, pp. 67-68.

TABLE B-2

REGION 2: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Bako (1954-1957) (05° 48' N. 36° 38' E.) (Altitude 1303 m.)	Gore (1953-1957) (08° 10' N. 35° 33' E.) (Altitude 2005 m.)	Jimma (1952-1957) (07° 39' N. 36° 50' E.) (Altitude 1750 m.)
		(mm.)	
January	29.7	16.9	33.4
February	15.0	38.2	31.3
March	116.3	147.0	79.5
April	182.9	139.0	188.5
May	122.6	256.0	139.0
June	122.0	334.9	224.2
July	194.7	296.1	209.1
August	226.2	313.4	212.6
September	120.6	312.2	179.5
October	82.4	173.0	65.7
November	31.6	87.9	10.8
December	33.8	64.7	27.6

Source: Huffnagel, Agriculture in Ethiopia, p. 76.

TABLE B-3

REGION 3: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Agordat (1949-1957) (15° 33' N. 37° 53' E.) (Altitude 633 m.)
	(mm.)
January	-
February	-
March	0.4
April	9.8
May	6.6
June	25.5
July	109.6
August	138.5
September	32.2
October	3.9
November	2.0
December	-

Source: Huffnagel, Agriculture in Ethiopia, p. 76.

TABLE B-4

REGION 4: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Wonji (1953-1957) (08° 21' N. 39" 15' E.) (Altitude 1580 m.)
	(mm.)
January	4.2
February	14.0
March	60.0
April	83.0
May	26.0
June	72.8
July	182.1
August	174.4
September	79.6
October	41.0
November	1.0
December	9.6

Source: Huffnagel, Agriculture in Ethiopia, p. 66.

TABLE B-5

REGION 5: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Neghelli (1952-1957) (05° 19' N. 39° 40' E.) (Altitude 1430 m.)	Gambela (1947-1957) (08° 05' N. 34° 55' E.) (Altitude 450 m.)
	(mm.)	
January	0.2	3.9
February	3.5	15.3
March	18.5	28.3
April	167.9	75.2
May	109.1	16[illegible].4
June	5.6	182.1
July	2.2	237.4
August	7.5	311.2
September	17.5	216.4
October	117.0	108.6
November	28.8	44.3
December	13.5	16.0

Source: Huffnagel, Agriculture in Ethiopia, p. 64, 69.

TABLE B-6

REGION 6: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Massawa (1949-1957) (15° 36' N. 39° 28' E.) (Altitude 5 m.)
	(mm.)
January	2.12
February	22.1
March	14.9
April	9.8
May	2.3
June	-
July	20.1
August	11.7
September	2.8
October	30.8
November	22.5
December	57.9

Source: Huffnagel, Agriculture in Ethiopia, p. 75.

TABLE B-7

REGION 7: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Galamso (1953-1957)[a] (08° 44' N. 40° 50' E.) (Altitude 1950 m.)	Dire Dawa (1962-1957)[b] (09° 37' N. 41° 52' E.) (Altitude 1402 m.)	Goba (1953-1957) (07° 19' N. 40° 00' E.) (Altitude 2727 m.)
		(mm.)	
January	0.6	26.5	1.4
February	43.1	20.7	22.5
March	56.1	34.5	48.4
April	160.8	108.6	105.6
May	137.2	16.4	80.2
June	124.6	401.	52.2
July	205.8	85.0	101.8
August	151.8	186.7	89.2
September	101.0	75.1	83.2
October	63.3	15.6	63.5
November	28.6	5.7	13.9
December	3.8	17.1	2.5

[a] Mean annual rainfall considered to be rather high for this region.

[b] Mean annual rainfall considered to be below average for this region.

Source: Huffnagel, Agriculture in Ethiopia, p. 65.

TABLE B-8

REGION 8: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Assab (1949-1957) (13° 01' N. 42° 43' E.) (Altitude 11 m.)
	(mm.)
January	5.9
February	1.5
March	2.3
April	0.5
May	0.2
June	-
July	16.8
August	8.1
September	5.7
October	-
November	0.8
December	24.6

Source: Huffnagel, Agriculture in Ethiopia, p. 37.

TABLE B-9

REGION 9: TYPICAL MEAN MONTHLY RAINFALL, ETHIOPIA

Month	Gondar (1953-1957) (12° 36' N. 37° 29' E.) (Altitude 2121 m.)	Maichew (1953-1957) (12° 44' N. 39° 16' E.) (Altitude 2300 m.)	Makalle (1954-1957) (13° 30' N. 39° 28' E.) (Altitude 2170 m.)	Asmara (1949-1957) (14° 17' N. 38° 55' E.) (Altitude 2325 m.)
		(mm.)		
January	2.3	6.6	1.3	0.1
February	27.9	15.2	0.0	1.0
March	61.0	84.5	60.0	12.9
April	68.4	94.1	24.7	27.5
May	48.6	42.1	13.3	47.0
June	159.3	9.8	58.8	47.7
July	339.6	175.7	251.3	196.4
August	364.5	268.1	227.5	144.1
September	157.0	96.0	33.5	30.1
October	24.2	27.5	0.0	9.0
November	27.6	4.0	0.0	13.3
December	11.6	9.0	0.0	6.9

Source: Huffnagel, Agriculture in Ethiopia, p. 70-74.

APPENDIX C

TABLE C-1

NUMBER OF CULTURAL OPERATIONS--BLUE NILE BASIN AREA, ETHIOPIA, 1961

	Grain						Pulses						Oilseeds		Spices & Vegetables
Areas	Barley	Corn	Millet (Dagussa)	Sorghum	Teff	Wheat	Chick Peas	Field Beans	Field Peas	Guaya	Horse Beans	Lentils	Flax	Noog	Peppers
Ambo-Guder															
Number of fields	16	18	-	8	43	47	13	6	3	14	10	-	7	28	-
Number of operations															
Most frequent occurrence	10	6	-	8	11	10	8	9	-	7-8	7	-	8	9	-
Average number	9.9	8.5	-	9.5	11.0	10.1	7.7	8.5	7.0	7.8	8.3	-	8.3	7.3	-
Sululta-Chancho															
Number of fields	51	-	-	-	-	10	-	-	8	-	9	1	-	-	-
Number of operations															
Most frequent occurrence	11	-	-	-	-	11	-	-	8	-	8	8	-	-	-
Average number	10.2	-	-	-	-	12.5	-	-	7.9	-	8.9	8.0	-	-	-
Lekkemt-Sire															
Number of fields	-	1	-	-	-	4	-	-	-	-	-	-	-	3	-
Number of operations															
Most frequent occurrence	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average number	-	8.0	-	-	11.7	-	-	-	-	-	-	-	-	7.6	-
Buré-Jiga															
Number of fields	45	86	56	-	76	1	3	-	5	-	5	-	-	27	44
Number of operations															
Most frequent occurrence	12	12	14	-	13	11	11	-	8	-	8	-	-	7	14
Average number	12.4	11.9	13.6	-	13.1	11.0	11.0	-	9.4	-	9.4	-	-	9.9	14.6

Source: USDI, Bureau of Reclamation, "Appendix VI: Agriculture and Economics."

TABLE C-2

AVERAGE SEEDING RATE ON PEASANT FARM IN ETHIOPIA

Grain	Amount/Ha.
Teff	50 kg.
Wheat	100 kg.
Barley	120 kg.
Maize	50 kg.
Sorghum	60 kg.

Source: Unpublished data from The Stanford Research Institute files.

TABLE C-3

DEPRECIABLE ASSETS OF A TYPICAL PEASANT GRAIN FARM IN ETHIOPIA

Type of Asset	No.	Original Cost	Approximate Life	Salvage Value	Annual Depreciation
		(Eth. $)	(Years)	(Eth. $)	(Eth. $)
Oxen	3	375	8	150	28.45
Donkey	1	40	10	0	4.00
Farm Bldg.	1	200	20	0	10.00
Grain Bin	3	30	10	0	3.00
Farm Tools & Equipment					
Plough	1	10	5	0	2.00
Yoke	1	8	5	0	1.60
Bull Whip	1	2.5	3	0	0.25
Leather Bag	3	15	5	0	3.00
Ax	2	5	5	0	1.00
Hoe	3	6	5	0	1.20
Basket	3	6	5	0	1.20
Mechagna	1	3	5	0	0.60
Sickle	3	6	3	0	2.00
Laida	1	2	5	0	0.40
Minsh	1	1	5	0	0.20
Maragebia	1	10	5	0	22.00
TOTAL		719.00			59.60

Source: The table is constructed from information found: Miller and Makonnen, Organization and Operation of Three Ethiopian Case Farms; M.E. Quenemoen, Potential Returns From Commercial Farming Systems in Three Areas of Ethiopia, Exp. St. Bull. No. 56 (Dire Dawa: HSIU, June, 1968); Davis and Mohamed, Farm Organization of Terre and Galmo Villages; Taddesse Ebba, T'EF: The Cultivation, Usage, and Some of the Known Diseases and Insect Pests, Part I, Exp. St. Bull. No. 60 (Dire Dawa: HSIU, March 1, 1969); E. Ebba, A Case Study of Six Peasant Farms in Ada District, Shoa Province; USDI, Bureau of Reclamation, "Appendix VI: Agriculture and Economics"; Telahun Makonnen, "Case Study of Ten Ethiopian Farms in The Chercher Highland," Alemaya, 1969. (Unpublished paper.); Telahun Makonnen and Getachew Tecle-Medhin, "Case Study of Ten Ethiopian Farmers in the Central Highlands (Debre Zeit Vicinity)," Debre Zeit, 1969. (Unpublished paper.)

TABLE C-4

FARM ACTIVITIES OF A TYPICAL PEASANT GRAIN FARMER IN ETHIOPIA

Type of Activities	Number of Times Operation is Carried				
	Teff	Wheat	Barley	Corn	Sorghum
Breaking sod land	3	3	3	3	3
Plowing (seed bed preparation)	5	3	3	2	2
Seeding:					
Compacting seed bed	1	-	-	-	-
Broadcasting seed	1	1	1	1	1
Covering seed (plowing)		1	1	1	1
Weeding	2	2	2	2	2
Harvesting:					
Cutting	1	1	1	1	1
Threshing	1	1	1	1	1
Storing (bagging & transporting)	1	1	1	1	1

Source: C.F. Miller, et al., Systems Analysis Methods for Ethiopian Agriculture; USDI, Bureau of Reclamation, "Appendix VI: Agriculture and Economics"; Makonnen and Tecle-Medhin, "Case Study of Ten Ethiopian Farms in The Central Highland (Debre Zeit Vicinity)"; F. Ebba, A Case Study of Six Peasant Farms in Ada District, Shoa Province.

TABLE C-5

PERFORMANCE COEFFICIENTS FOR SOME COMMON FARM TASKS ON A PEASANT FARM IN ETHIOPIA

Type of Activity					Labor Requirement Per Hectare
1. Oxen plowing					0.25 ha/day
2. Broadcasting and plowing seed under					0.50 ha/day
3. Weeding/cultivation					
	Teff	Wheat	Barley	Corn	Sorghum
1st	24 man days/ha	15 man days/ha	15 man days/ha	18 man days/ha	18 man days/ha
2nd	20 "	10 "	10 "	12 "	12 "
4. Cutting & stalking					
	16 "	8 "	8 "	10 "	10 "
5. Threshing & cleaning					
	6 "	4 "	4 "	4 "	4 "
6. Bagging, transporting and storing					
	2 "	2 "	2 "	2 "	2 "

Source: L.F. Miller and Makonnen, Organization and Operation of Three Ethiopian Case Farmers; Quenemoen, Potential Returns From Commercial Farming Systems in Three Areas of Ethiopia; C.F. Miller, et al.; Systems Analysis Methods For Ethiopian Agriculture.

TABLE C-6

PERCENT OF TOTAL AREA "NEEDED" BY LIVESTOCK NUMBER AND AREA OF CROPS, ETHIOPIA

Sub-Province	Index of Grazing (Percent)	Sub-Province	Index of Grazing (Percent)
Kembata	136	Menz-Yift	36
Dessie Zuria	131	Kalu	35
Haikock-Butajira	96	Yeju	32
Wolamo	90	Ticho	31
Adwa	93	Damot	31
Raya-Azebo	85	Borena (Wollo)	31
Yerer-Kereyu	83	Leka	30
Harar Zuria	76	Agewmider	30
Chilalo	70	Debre Marcos	28
Axsum	65	Batie Wereda	27
Bahir Dar	62	Inderta	26
Bechena	61	Arba Gugu	24
Menagesha	60	Shire	24
Lasta	59	Gemu	21
Jibat-Mecha	57	Wag	19
Hule Awlailo	53	Kelem	17
Were Illu	52	Arjo	17
Werehimenu	50	Horo Induru	17
Merhabete	49	Chimba	17
Mota	48	Raya-Kobo	17
Ambasel	47	Jarra	14
Chebo-Guragie	45	Gardula	10
Selale	45	Gofa	7
Wadla Delanta	38		
Agagame	38		
Tegulet-Bulga	37		

Source: IEG, Ministry of Planning and Development, Regional Aspects of National Planning in Ethiopia, Part I, p. 42.

TABLE C-7

YEARLY AVERAGE FARM GATE PRICES BY DISTRICT FOR THE MAJOR CEREAL CROPS IN ETHIOPIA, 1966[a]

Region	Crops				
	Teff	Wheat	Barley	Corn	Sorghum
	(Eth. $ Per Quintal)				
1	29.70	22.85	16.40	18.00	20.75
2	28.80	21.00	14.40	17.10	19.50
3	30.00	15.00	10.00	20.00	22.00
4	30.00	15.00	10.00	20.00	22.00
5	23.40	15.00	10.75	14.40	19.03
6	25.20	16.00	11.25	15.30	23.25
7	26.73	17.50	11.90	16.20	12.60
8	26.30	18.00	11.00	13.50	16.91
9	29.34	18.40	18.00	18.00	21.25
10	29.34	18.40	18.00	18.00	21.25
11	29.25	25.35	15.58	18.36	20.00
12	31.60	18.40	13.30	16.20	17.00
13	29.70	17.40	12.10	16.20	16.50
14	24.93	18.50	14.00	14.50	17.75
15	24.30	18.00	13.50	14.40	17.20
16	24.00	17.00	12.50	14.40	16.75
17	18.90	14.85	9.70	14.40	18.55
18	22.50	18.00	20.00	15.66	12.50
19	44.00	30.00	24.00	13.50	20.00
20	22.50	19.00	20.00	13.50	12.50
21	21.60	18.30	14.10	14.40	14.25
22	18.80	17.80	13.60	13.00	13.75
23	24.30	17.90	15.20	14.40	16.50
24	27.90	17.50	15.60	14.40	16.10
25	27.90	17.95	15.10	14.40	14.70
26	27.00	18.60	17.00	18.40	16.50
27	29.50	22.20	17.00	18.90	16.10
28	29.00	21.70	16.50	18.45	15.60

[a] The farm gate prices were obtained from wholesale prices with appropriate downward adjustments for transportation, middle man's margin and other marketing costs.

Source: National Bank of Ethiopia, Economic Research Department, Local Prices in 1966 and Some Series of Local Prices in the Period 1957-66 (Addis Ababa: Economic Research Dept., June, 1967).

APPENDIX D

TABLE D-1

LAND AREA WHERE FERTILIZER SHOULD BE APPLIED, BY PRODUCING DISTRICTS, MODEL II, ETHIOPIA

Prod. Dist.	Wheat	Barley	Teff	Corn	Sorghum
			(Thousand Hectares)		
1	20.8		0.58		33.6
2	84.1		134.5		33.2
3				4.5	5.7
4					
5		53.2			31.6
6				55.5	
7			160.4		
8					28.0
9				24.8	54.5
10		7.0			
11			33.0		22.5
12					122.2
13			25.5		
14					
15			108.5		
16		124.6			
17		150.7	137.2		
18					
19	8.6		28.1		
20			6.1		
21					
22					
23					42.1
24					
25					67.8
26		17.1			
27					
28					7.4

TABLE D-2

LAND AREA WHERE FERTILIZER SHOULD BE APPLIED, BY PRODUCING DISTRICTS, MODEL III, ETHIOPIA

Prod. Dist.	Wheat	Barley	Teff	Corn	Sorghum
	(Thousand Hectares)				
1	20.8		0.6		33.6
2	104.5		134.5		33.3
3				4.5	5.7
4					
5		53.2			31.6
6		52.1	81.4		
7			160.4		
8					26.0
9	9.0			32.6	54.5
10	6.6	7.0			
11			33.0		24.4
12					122.2
13		173.2			
14					
15			81.5		
16		22.9		22.6	79.1
17		177.0	137.2		
18					
19			28.1		
20			56.0		
21					
22					
23					
24		107.4			
25					67.8
26		17.3			
27					
28					7.4

TABLE D-3

LAND AREA WHERE FERTILIZER SHOULD BE APPLIED,
BY PRODUCING DISTRICTS, MODEL IV, ETHIOPIA

Prod. Dist.	Wheat	Barley	Teff	Corn	Sorghum
	(Thousand Hectares)				
1	24.0				67.8
2	239.2		227.58		57.6
3				6.9	
4		2.6			24.9
5		93.0			48.5
6		86.6		135.9	
7			160.4		
8				194.9	69.5
9				54.6	86.0
10	2.7	10.8		29.3	
11		8.7	154.4	19.4	8.0
12				90.8	164.1
13		163.4	102.8		
14					
15			127.4		
16		98.6		26.0	
17		104.7	235.8	122.7	116.0
18	72.8		30.0	60.7	63.9
19	14.4		47.2	28.0	
20	173.6				
21		17.5			
22					
23					
24		179.0			
25					260.9
26		52.7			
27					
28					69.5

APPENDIX E

TABLE E-1

HARVESTED WHEAT LAND BY PRODUCING DISTRICTS IN ETHIOPIA, ACTUAL 1966 AND PROGRAMMED 1966 AND 1980

Producing District	1966 Actual	Programmed 1966 Model I	Programmed 1966 Model II	Programmed 1966 Model III	Programmed 1980 Model IV
	(Thousand Hectares)				
1	2.9		20.81	20.81	24.01
2	40.6	86.02	84.13	104.50	239.22
3	14.0	27.50	3.70	3.70	7.41
4	14.0	27.50	16.40	16.40	
5	43.0	99.65			
6	52.4				
7	46.5				
8	102.5				
9	11.1			9.03	
10	5.6		20.84	20.84	2.73
11	7.0				
12	37.1				
13	31.9				
14	56.0				
15	1.2				
16	24.0				
17	59.6				
18		62.56	85.29	85.29	72.76
19	7.4	14.96	8.57	14.96	14.37
20					
21	19.6	209.51	104.99	0.99	89.39
22	6.9	52.07	91.95	137.60	154.44
23	4.7				
24	34.8				
25	30.7				
26	6.2				
27	16.3	45.78	45.78	45.78	45.78
28	3.6				
TOTAL	679.6	579.77	482.46	459.90	650.11

TABLE E-2

HARVESTED BARLEY LAND BY PRODUCING DISTRICTS IN ETHIOPIA, ACTUAL 1966 AND PROGRAMMED 1966 AND 1980

Producing District	1966 Actual	Programmed 1966			Programmed 1980
		Model I	Model II	Model III	Model IV
		(Thousand Hectares)			
1	2.2				
2	66.0		25.75		
3	7.0		2.52	2.52	
4	7.0				
5	46.6		53.20	53.20	92.99
6	153.4	222.50	167.01	52.06	86.59
7	19.2	110.70	160.40		
8	29.3			22.66	24.63
9	20.4				
10	44.3		7.02	7.02	10.75
11	14.4				8.66
12	116.8	209.75	12.97	30.94	
13	82.6		71.66	173.22	163.37
14	68.2				
15	4.5				
16	120.40	124.58	124.58	22.94	98.55
17	250.3	24.37	156.07	176.96	104.71
18	35.2	17.52	17.52	17.52	26.91
19	42.0	8.08	8.08	8.07	12.44
20	9.7				
21	64.3				17.48
22	65.4	123.72	34.74	16.84	
23	18.2				
24	40.2	179.00	107.40	107.40	179.00
25	53.2				
26	29.7	52.68	17.13	17.13	52.68
27	28.1				
28	14.1	32.34	34.29	34.29	
TOTAL	1452.7	1105.24	100.34	742.77	878.76

TABLE E-3

HARVESTED TEFF LAND BY PRODUCING DISTRICTS IN ETHIOPIA, ACTUAL 1966 AND PROGRAMMED 1966 AND 1980

Producing District	1966 Actual	Programmed 1966			Programmed 1980
		Model I	Model II	Model III	Model IV
	(Thousand Hectares)				
1	7.0		0.58	0.58	
2	61.0		134.48	134.48	227.58
3	4.5				
4	4.5				
5	24.0				
6	3.7				
7	48.2		160.40	160.40	160.40
8	83.8	50.61			
9	38.1	122.33	96.24	96.24	51.71
10	33.5	92.69	64.83	64.83	90.91
11	17.3		33.00	33.00	154.41
12	70.7				
13	87.5	190.15	25.51		102.83
14	117.9	263.60	125.91	158.16	263.60
15	52.3	127.40	108.49	81.52	127.40
16	86.8				
17	464.9	268.91	137.21	137.21	235.79
18	182.0				29.98
19	31.5	60.23	28.12	28.12	47.16
20	27.6	173.60	104.16	104.16	173.60
21	128.2				
22	166.6				
23	63.0	90.21	26.95	21.21	69.05
24	43.1				
25	89.6	108.80			
26	28.2				
27	15.5				
28	4.2				
TOTAL	1985.2	1548.53	1045.88	1019.91	1734.42

TABLE E-4

HARVESTED SORGHUM LAND BY PRODUCING DISTRICTS IN ETHIOPIA, ACTUAL 1966 AND PROGRAMMED 1966 AND 1980

Producing District	1966 Actual	Model I	Model II	Model III	Model IV
	(Thousand Hectares)				
1	59.0	62.92		33.61	67.83
2	259.0	438.38	33.25	33.25	57.59
3	1.0		5.72	5.72	13.24
4	1.0				24.91
5	12.1	41.85	31.60	31.60	48.51
6	1.5				
7	16.5				
8	15.3		27.95	25.98	69.54
9	73.8		54.46	54.46	86.01
10	55.8				
11	36.5		22.47	24.44	8.00
12	12.7		122.21	122.21	164.10
13	48.2				
14	15.5		32.25		
15	67.4				
16	15.1	22.60	22.60	101.68	22.60
17	154.9	90.23	93.67	161.42	116.00
18	71.3	273.68	81.51	81.51	63.86
19	70.9	37.57	37.57	51.82	57.87
20	63.4				
21	119.1	73.95	69.03		91.85
22	18.5	27.75	27.75		
23	33.5		42.10		
24	45.4				
25	92.4	161.76	67.83	67.83	260.89
26	3.6				
27	13.4				
28	35.7	37.16	7.41	7.40	69.50
TOTAL	1412.5	1267.85	779.38	802.93	1222.30

TABLE E-5

HARVESTED CORN LAND BY PRODUCING DISTRICTS IN ETHIOPIA, ACTUAL 1966 AND PROGRAMMED 1966 AND 1980

Producing District	1966 Actual	Programmed 1966 Model I	Programmed 1966 Model II	Programmed 1966 Model III	Programmed 1980 Model IV
		(Thousand Hectares)			
1	20.6				
2	97.8				
3	1.0		4.46	4.46	6.85
4	1.0				
5	15.8				
6	11.5		55.49	81.44	135.91
7	30.0				
8	72.2	131.25	131.25	131.25	194.87
9	157.6	70.03	41.65	32.63	54.64
10	83.6	40.99	40.99	40.99	29.28
11	115.3	190.50	56.82	58.85	19.43
12	17.4	45.15			90.79
13	2.5	76.05	76.05		
14	7.0				
15	2.0				
16				22.57	26.03
17	35.7	195.67	192.23	103.59	122.68
18	145.1	69.85	69.85	69.85	60.65
19	73.5	32.20	32.20	32.20	28.04
20	72.9				
21		47.75	24.70	197.73	
22					
23		29.39	50.55	50.55	60.55
24	15.5				
25	17.0	2.34	95.91	95.91	12.01
26	20.1		35.55	35.55	
27	3.0				
28	11.9				
TOTAL	1030.0	931.17	907.70	957.57	841.73

APPENDIX F

TABLE F-1

INTERREGIONAL FLOW OF CEREALS, MODEL I, ETHIOPIA, 1966

To Region	Wheat Amount	Wheat From	Barley Amount	Barley From	Teff Amount	Teff From	Corn Amount	Corn From	Sorghum Amount	Sorghum From
				(Quantity in thousands of quintals)						
1	200.61	5	111.03	4	478.15	5	510.85	11	752.97	6
2			26.98	4	116.20	3	147.70	9	182.98	5
3	464.32	2	249.02	4					172.81	5
4					202.61	15	994.04	11	455.97	5
					176.51	3				
					428.71	10				
5			202.13	4	2185.30	15	304.73	11		
							793.32	9		
6	341.17	5	157.72	4	757.93	5	863.17	11		
7	80.24	16	44.00	4	191.27	15	234.88	11	301.19	5
8	162.87	4	2192.61	4	614.01	13	1114.19	9	1598.03	5
	402.72	13			426.94	15			2229.93	13
	713.43	16								
9	221.48	4	122.58	8					831.30	13
10	91.93	2	141.92	4					962.49	5
	164.50	4								
11	208.39	4	115.34	4	194.74	15			782.20	13
					301.99	9				
12										
13										
14	480.86	16								
15	951.79	16								
16					211.04	15	2059.49	14	2353.47	5
					711.96	14	535.78	14		
17	608.79	16			1922.91	15	1911.67	11	194.38	19
18	7.94	16	4.54	15	18.55	15	22.87	11	29.08	5
19	92.48	16	1319.96	16	1115.55	17	1344.91	14		
			3258.09	17						
			496.94	8						
			714.48	15						

TABLE F-2

INTERREGIONAL FLOW OF CEREALS, MODEL II, ETHIOPIA, 1966

To Region	Wheat		Barley		Teff		Corn		Sorghum	
	Amount	From	Amount	From	Amount	From	Amount	From	Amount	From
	(Quantity in thousands of quintals)									
1	200.6	6	111.0	6	478.2	6	390.3	4	753.0	6
2					116.2	10				
3	121.6	2	249.0	4						
	342.7	5								
4	338.9	5			807.8	8				
5							225.1	8		
							1073.0	11		
6			200.0	4	1226.7	5	863.2	4		
			68.0	5						
7	80.2	5	44.4	15	191.3	15	234.9	4	301.2	5
8	485.10	13	3247.0	4			2027.3	9		
9	221.5	13			52.8	11	952.5	8		
10	50.8	2								
11	208.4	5	115.3	9						
12									63.1	9
13										
14	480.9	16								
15	951.8	16								
16							1538.7	14		
17	608.9	16			923.0	14	962.5	14	68.8	14
					1631.9	15	104.1	16		
18	7.9	5	4.5	15	18.6	15	22.9	9	29.1	15
19	92.5	15	1169.0	14	1115.6	15	1344.9	14		
			2251.2	15						
			221.1	16						
			1827.8	17						

TABLE F-3

INTERREGIONAL FLOW OF CEREALS, MODEL III, ETHIOPIA, 1966

(Quantity in thousands of quintals)

To Region	Wheat Amount	Wheat From	Barley Amount	Barley From	Teff Amount	Teff From	Corn Amount	Corn From	Sorghum Amount	Sorghum From
1	200.61	6	111.0	6	478.17	5	452.19	4	752.97	6
2					116.2	10	58.66	9		
3	172.35	2	249.02	4						
	132.98	5								
4	338.91	5			807.84	8				
5			145.60	4			1098.05	4		
6			268.75		748.54	5	863.17	4		
7	80.2	5	44.40	15	191.27	15	234.9	4	301.19	5
8	590.15	5	1741.71	4	372.44	13	1968.68	9		
	706.87	13	20.71	9			1016.55	11		
			1134.17	14						
9	221.48	5			52.79	11				
10									952.49	8
11	208.39	5	115.3	9						
12										
13										
14	480.86	16								
15	739.93	15					78.71	14		
	211.86	16					1459.96	16		
16					923.0	14			1423.76	14
17	608.79	16			1630.98	15	104.10	16		
18	7.94	5	4.54	15	18.55	15	22.87	9	29.08	15
19	92.48	16	3041.34	14	1115.55	15	1344.9	14		
			2727.85							

TABLE F-4

INTERREGIONAL FLOW OF CEREALS, MODEL IV, ETHIOPIA, 1980

To Region	Wheat Amount	Wheat From	Barley Amount	Barley From	Teff Amount	Teff From	Corn Amount	Corn From	Sorghum Amount	Sorghum From
(Quantity in thousands of quintals)										
1	272.71	5	170.56	4	799.73	5	902.22	6	1156.47	6
2					194.32	11				
3	798.59	5	405.91	4	660.90	11				
					662.17	13				
4	566.73	5			1350.70	8				
5			341.96	4			1808.94	4		
6			272.80	4	1279.13	5	2345.28	4		
7	134.75	5	68.49	15	321.14	15	362.30	4	464.40	17
8	1796.69	5	2943.59	4	1061.38	13	4027.21	9		
	254.02	13	1521.35	14						
9	371.36	13	188.76	14	885.06	11				
10	379.87	5							535.34	8
									939.72	2
11	348.55	13							945.27	9
12										
13										
14	803.91	16								
15	1591.86	5					3036.10	9	4889.4	17
16					1639.68	14	1849.82	14	360.71	19
17	1180.52	16	1589.42	15	2806.48	15	2998.0	8	724.48	14
18	13.0	5	6.60	15	30.98	15	34.95	4	44.80	17
19	419.29	16	509.51	14			2104.30	14		
			6463.29	17						

APPENDIX G

TABLE OF CONVERSIONS

1 m.m. = 0.0394 inches

1 meter = 39.37 inches = 3.281 feet

1 kilometer = 0.6214 miles

1 square kilometer = 0.3861 sq. miles

1 hectare = 2.471 acres

1 kilogram = 2.2046 pounds

1 quintal = 100 kilograms = 220.46 pounds

Centigrade: C = 5/9 (F° - 32)

Fahrenheit: F = 9/5 (C° + 32)

Eth. $2.50 - US $1.00 before the 1972 devaluation of US $.

APPENDIX H

[illegible] OF ABREVIATIONS

IEG - Impe[illegible]th[illegible] Government

HSIU - Haile [illegible] University

TFYP - Third [illegible] Plan

CSO - Central [illegible]stics Office

SRI - Stanford [illegible]earch Institute

ARI - Agricult[illegible] Research Institute

IECAMA - Imperia[illegible]iopian College of Agriculture and Mechanical Arts