TRANSPORTATION AND AGRICULTURAL DEVELOPMENT IN WESTERN KENYA: AN APPROACH TO THE PROBLEM OF INVESTMENT PRIORITIES

Thesis for the Degree of Ph.D.

MICHIGAN STATE UNIVERSITY

Stephen S. Birdsall

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presented by

Stephen S. Birdsall

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of the requirements for

Ph.D. degree in Geography

Major professor

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ABSTRACT

TRANSPORTATION AND AGRICULTURAL DEVELOPMENT
IN WESTERN KENYA: AN APPROACH TO THE
PROBLEM OF INVESTMENT PRIORITIES

by Stephen S. Birdsall

The efficient expenditure of limited investment funds is of vital concern to development planners in low income countries. If the project chosen for investment from a set of alternatives is not the one which will yield the maximum return for that investment, then in a normative sense, some portion of these funds has been wasted. This problem is approached as it applies to agricultural road investments. A methodology is offered illustrating by example the procedure for determining the most remunerative road improvement that could be made in a section of western Kenya.

Agriculture and transportation are important elements in a country's total development effort. The majority of the population in each newly independent African state are engaged in agriculture. Agriculture is also an indispensible source of revenue for most of these countries. The agricultural production process can be made more efficient by encouraging regional specialization. Improved movement facilities do provide such encouragement. Clearly, decisions concerning rural roads in underdeveloped countries should be based upon an empirically determined

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list of investment priorities. It is argued that such a list must be obtained through analysis founded upon the geographic perspective.

The procedure for determining the priorities for investment in agricultural roads is described in detail during its application in Nyanza Region and Kericho District, Kenya. The method used calculates the improvement which can reasonably be made in the profitability of agricultural production. The costs and advantages of improving one road rather than another are then compared with the agricultural potential located along both roads. The result indicates which roads will assist the greatest agricultural change for the least investment in facilities. Crucial to the method is treatment of each economic element as a spatially variable function.

The pattern of existing profitability for each of eight crops was calculated by subtracting the pattern of production costs from the pattern of crop value per acre. Using environmental characteristics in combination as ecological regions, and projected crop prices and yields, patterns of potential crop profitability were derived. The difference between existing and potential profitability is the improvement of which the land is capable. After modification for the variable pressure of population on land resources, a map is derived illustrating the place-to-place variation in the increased returns from the land which are possi

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The justification for investment in one road rather than another must be based in part upon the direct costs and returns expected from these investments. Road construction costs, the cost of future road maintenance, and the reduction in vehicle operating costs following road improvement are seen as the primary elements in the transport sector to be considered in the priority determination. The ratio between these incremental costs and returns from road investment is, in turn, related to the adjusted pattern of agricultural profitability improvement. The result is a variable index of relative priorities for road upgrading for each unit distance of road in the study region. The method is judged flexible, inclusive, and well suited to dynamic application.

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By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

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Department of Geography

1968

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ACKNOWLEDGEMENTS

As this volume is completed, I am indebted to many people and wish to thank them here for their assistance. Dr. Harm J. de Blij has provided intellectual stimulation and encouragement throughout my graduate studies and typically incisive comments and suggestions on the substance of this book. Dr. Milton H. Steinmueller has also offered constructive criticism on this work as well as previous research upon which part of the present volume is based. I also want to thank Dr. Lawrence M. Sommers for his help as Chairman of the Department of Geography. I especially want to thank Dr. Charles C. Hughes, Director of the African Studies Center, for the financial assistance without which this study would have been seriously weakened.

Many individuals contributed to the completion of this work by their assistance in Africa and earlier in London. Professor R. J. Harrison Church provided numerous introductions in London. Dr. E. D. Tingle, Head of Tropical Section, Road Research Laboratory, supplied me with many relevant unpublished reports.

In Africa, Mr. S. Kealey and Mr. K. Shabani of the East African Railways and Harbours, and Mr. J. D. G. F. Howe of the

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Road Research Laboratory, Kenya Branch, were of immeasurable assistance. A great many Kenyans, in addition to those interviewed, were more helpful than they realized, I am sure, because of their friendliness and their consistent good humor in the face of my questions and requests.

I want to thank Mrs. Beverly Nadele for her frequent assistance (and her patience) throughout five long years of graduate study.

Special thanks must also be given to Mrs. Lawrence H. Snyder for typing the complete final draft of this manuscript. Mr. In Kim and Mr. Dennis Enberg provided some cartographic assistance.

I am also indebted to Mr. S. M. Sepeku in many ways. As a friend, a fellow graduate student of geography, and as a teacher, he was a constant source of wisdom and insight into the importance of being African.

Above all, my wife Sally has been an inspiration as well as directly helpful. In addition to shouldering much of my responsibility as a parent to our two young children, she undertook, with no previous experience, a good deal of the cartographic work during the final weeks of work and did an excellent job.

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INTRODUCTION

This study deals with the justification for decisions concerning economic development investments. It outlines in detail the explicit grounds on which an objective decision based on empirical data may be made. It does not approach the problem of whether or not to invest, but rather, where might the most remunerative investment be made. The scope of the study is limited to investment in transport route improvement, and more specifically, to those roads which are used to market agricultural produce. The procedure presented here allows the determination of a set of investment priorities for road improvements within an agricultural region.

Before proceeding to the main body of this work, it should be understood by all readers that no attempt has been made here to provide a source for policy decisions. Whether an academician or a politician, an economic theorist or an agricultural economist, an overworked civil servant or a student of economic development problems, it should be accepted by all that the purpose for writing this volume is threefold.

First and foremost, it is an attempt to formulate a general method for determining a system of economic development investment priorities in regions of incompletely utilized agricultural p

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agricultural potential and inadequately developed transport facilities. The primary emphasis, again, is on development of an objective method of determining these priorities for the transport sector. The small portion of the earth's surface chosen to provide an example of this method is not unique in its suitability for such study, and the procedure developed here should be of use elsewhere.

Second, the method formulated has sufficient latitude to enable development planners, given adequate data, to gain insight into non-transport limitations on a region's development. The scope is not unlimited, for the basis for maximum economic improvement estimates pivots on the calculated agricultural potential in the area. The method only incidentally allows manufacturing development potential to be seen more sharply. Such aspects of the economic picture as lack of public services and overly populated areas may be made more apparent under this method, however, insofar as they are related to agricultural development and potential.

Third, by the very nature of the data used in this application of the method, specific requirements for future research are clearly outlined. This is as it should be. Whenever a new approach to a problem is first proposed, it is bound to raise more problems than it solves. Data are rarely available in the form desired, especially in newly independent and low per capita income countries such

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countries such as Kenya. Trained personnel are at a premium; too many immediate tasks are to be accomplished for grand new theories to be conceived; and researchers from abroad are too often either unaware of the dearth of relevant data and attempt to force misplaced information into involved models, or they are not interested in undertaking the extremely difficult job of gathering such data. Throughout this study, problems of this kind are outlined; hopefully some of the findings will be of use in later undertakings.

The region of concern in this volume was shown for several reasons. First, it is an area of high agricultural potential. Perhaps the chief element of the environment which limits agricultural production in Kenya is precipitation. When high rainfall sections of the country are further subdivided on the basis of roughness of relief and elevation, the region chosen for study becomes increasingly exclusive. Large areas even marginally suitable for cultivation are limited to a narrow band along the Indian Ocean coast, the central highlands--much of which was restrictively scheduled for European settlement--and a fairly large area of land to the east and north of Lake Victoria. This last is the area under scrutiny here.

Second, the focus of this work (the problems of investment in agricultural feeder roads) diminishes the suitability of some areas of high agricultural potential and makes other such areas more attr

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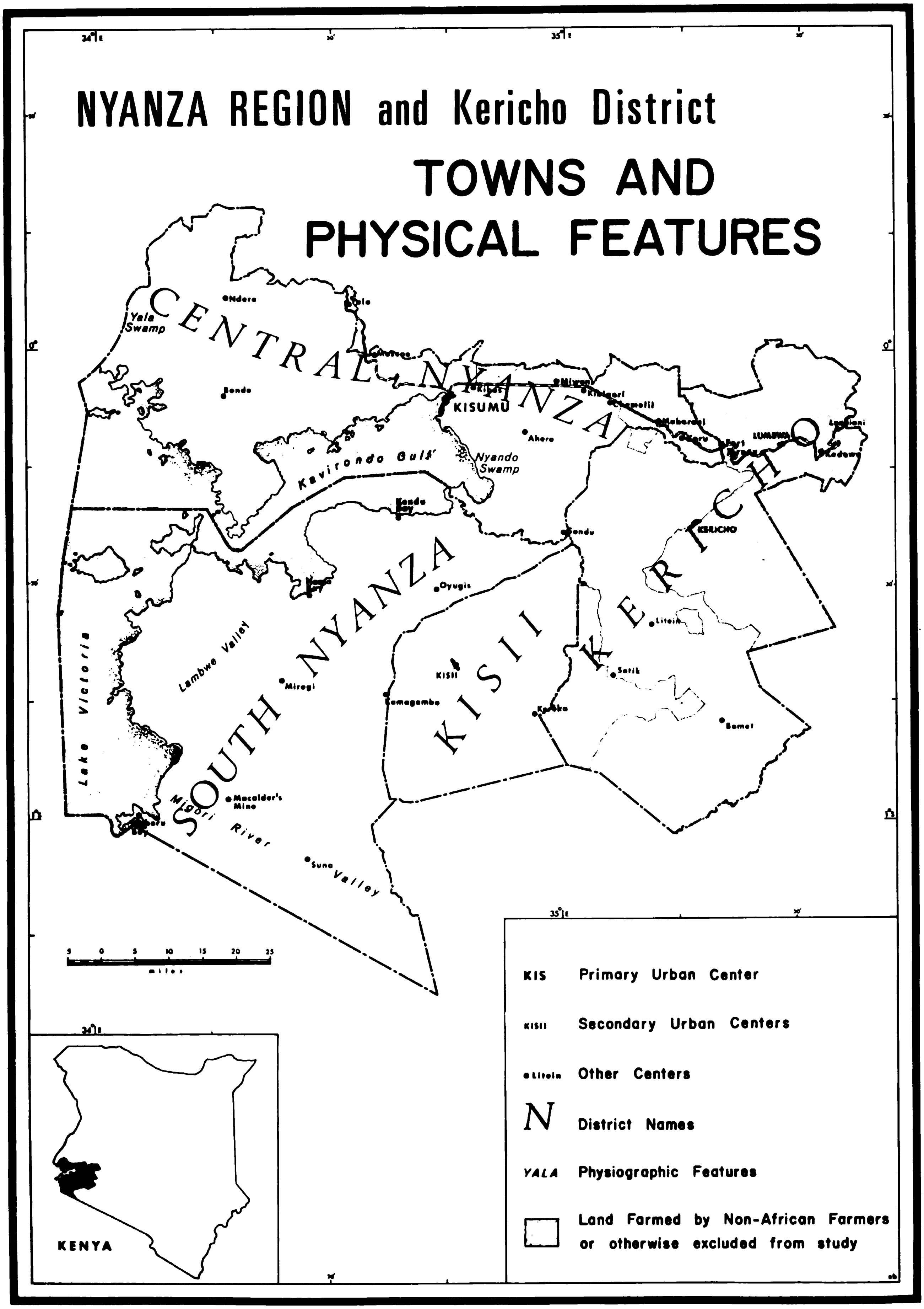
areas more attractive. The coast was considered a poor choice for a study of this nature because (1) movements within that area would be dominantly linear and thus rather restrictive in the general applicability of any conclusions reached, and (2) the variety of environmental characteristics is not great, thus yielding the same conclusion as that above with regard to applicability elsewhere. The central highland area was also decided against as a region in which to carry out this research because (1) the attention given this area by the British resulted in a relatively well-developed road network, too well-developed for the purposes of this study, and (2) the presence of urban centers in the area, not only in peripheral locations but throughout the region, results in a marketing pattern which is much too complex for what is meant to be an introductory research effort.

The region finally chosen for study comprises part of the high precipitation area in Kenya adjacent to Lake Victoria. (See Figure I-1.) The study region is the combined area of Central Nyanza, South Nyanza, and Kisii Districts in Nyanza Region, and Kericho District, which has been part of the Rift Valley Region since 1962. Although it would have been more rational to examine the entire high rainfall area (after all, production potential does not vary along administrative boundaries), such an undertaking would have been prohibitively expensive at this stage of research development, in terms of both money and time. With the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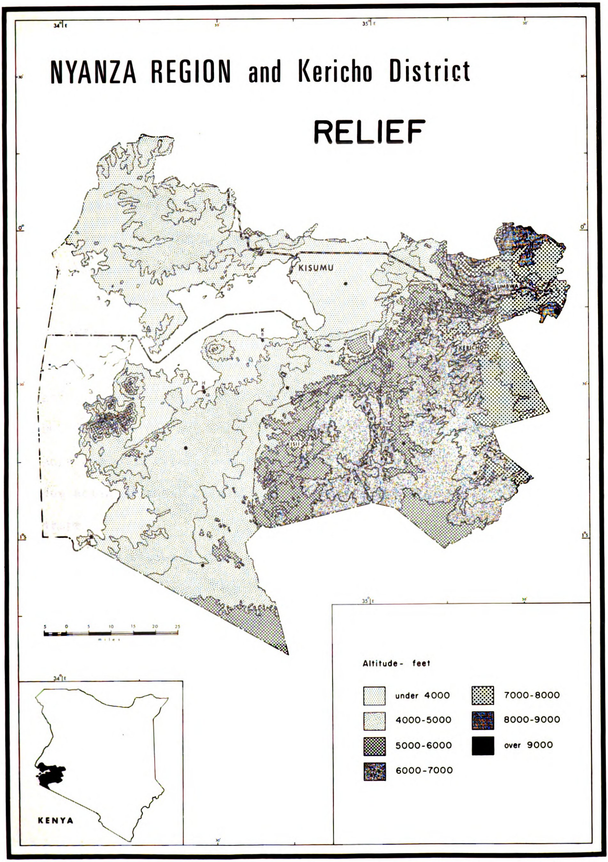
exception of that portion of Central Nyanza to the west of Maseno and Yala in which there is no sharp change in physical characteristics as one travels north into Busia District, the study region is rather well bounded by a distinct change in agricultural potential. (See Figure I-2.) The Nyando Escarpment provides a sharp boundary along much of the remainder of the northern edge of the study region. The Mau Forest occupies the largely uninhabited eastern edges of Kericho District. The southern boundary is indicated by the Tanzanian border in the west, and a gradual drop in altitude and precipitation toward the southeast away from the study region. The western boundary is, of course, clearly indicated by the coast of Lake Victoria.

The focus of the present work is on agricultural roads which facilitate movement for the African smallhold farmer. Because of this, a portion of Kericho District and a smaller area in Central Nyanza District are excluded from examination. These excluded areas contain land owned or operated by non-African farmers during the period for which data were available. It was believed that the economics of cash crop farming are sufficiently different in non-African areas from the present conditions of African farm operation that the resulting patterns would be distorted and less applicable to regions where long established European or Asian farmers are absent.

Before proceeding to the study itself, several final re-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marks are appropriate. Because this volume is not meant to be a general thesis on economic development, some of the discussion of problems of development (Chapter I) may appear rather superficial to those well-versed in development theory. As might be implied by the fact that such discussion takes place in the first chapter, it is provided primarily as background for readers less familiar with the basic arguments in this field.

The discussions in this volume are not meant to denigrate the efforts and achievements of the civil servants in Kenya or elsewhere. Many of those with whom the author had personal contact, whether expatriate or African, were obviously doing more work for less pay and under less-than-favorable conditions than those academic critics who so often sit in judgement on the inadequacies of their results. I do not count myself among the latter.

The research upon which the study is based was conducted in East Africa during 1966. Very few data for 1966 have been included because of their fragmentary nature when the author was in the field. The conclusions, therefore, are relevant to the data of 1965 and earlier. Monetary equivalents, of course, are also as of 1965. One shilling consists of 100 cents (East African) and is equivalent to \$.14 (U.S.). Thus, one pound sterling = Shs. 20/- = \$2.80 (U.S.) throughout the volume. It is hoped that rather the use of p

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neither the use of pounds-shillings-cents nor the retention of British English terminology (and occasionally spelling) will prove a hindrance to American English readers.

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CHAPTER I

DEVELOPMENT, AGRICULTURE, AND THE NEED FOR MOVEMENT

Rarely has a concept evoked such varied reactions as has economic development. Academicians have toyed with abstractions about its processes and stimuli for many years, challenged by the complexities and the elusiveness of the object of their attention. To politicians in low-income countries, economic development is a serious and immediate task. And as so often occurs with new ideas, those with whom the concept of development most closely deals, i.e., the small farmer living in relative isolation, are least likely to have any awareness of the process that occupies their political leaders' attentions.

As varied as the reactions to economic development are, the definitions of this process are often very much alike. The customary discussion concerning economic development first stresses the difficulties associated with any attempt at definition of the subject, then may make some reference to possible indices of development, and finally arrive at something such as: that process which results in a significant increase in average annual per capita income well-distributed among the country's population.[1]

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population,[1] or which results in a more efficient use of resources.[2]

The problem of settling for such definitions should be obvious. There are numerous other measures of development which might be used equally well, e.g., a production per capita index based on one or more sectors of the national economy, relative levels of consumption, or relative returns to investment. Similarly, to say that development encourages or results in greater efficiency simply says development results in a developed condition. The basic difficulty with these "definitions," as with rising per capita income, is that they merely describe and do not define, constituting one measure of the process but not its essence, indicating one of the goals of development but no aspect of the means of arriving there. In other words, such indices describe economic growth or the economic results of development but do not really define economic development.

In spite of these definitional problems, little confusion results from the use of "underdeveloped," "less devel-

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[1]For an example of this common introductory definition, see, John R. P. Friedmann, The Spatial Structure of Economic Development in the Tennessee Valley (Department of Geography Research Paper No. 39; Chicago: University of Chicago Press, 1955).

[2]John W. Mellor, The Economics of Agricultural Development (Ithaca, N. Y.: Cornell University Press, 1966), p. 3; and, Santikumar Ghosh, The Financing of Economic Development (Calcutta: The World Press Private Ltd., 1962), p. 1.

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oped," "developing," and "low income" with reference to national well-being. Kenya, Guatemala and Burma are underdeveloped and Great Britain, New Zealand, and Sweden are not, regardless of the degree to which each country's resources are utilized. Elaborate techniques are used to classify countries in terms of their level of development, and description remains dominant as countries "develop" in the degree to which they are seen to change.

It is argued here, however, that historical perspective is useful only when it is used to provide insights into possible future occurrences. Thus, a description of processes that have already occurred is meaningful to the extent that it may be used to indicate trends. A useful definition, therefore, should distinguish between growth and development, the results of development and its primary characteristics. To this end, economic development will be considered here to mean the evolution of production outlook from that of local subsistence to one of specialization for the sake of commercial gain, whether individual or national. The revolution in attitudes and values necessary to bring about a change of personal emphasis from production for direct support of oneself and one's family to production for sale is the most distinguishing characteristic of what is commonly called economic development. It is almost pointless to speak of per capita income when an individual provides for his own needs and has litt

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needs and has little excess. On the other hand, without perceiving utility in the selling of produce, incomes will not rise, based as they are on improvements in quantity or quality of a regular surplus.[3] It could be argued that the values of the producer may change but without knowledge of the means of commercial production, it is unlikely that a significant surplus will result. While it will not be so easily assumed here that small-farm producers in low-income countries are unable to produce a surplus with traditional methods if they see the value in it,[4] it will be conceded that investments must be made in social overhead capital and infrastructure which will assist the producer to pursue his gradually changing values. That is, there is the need for investment capital, for funds with which the necessary facilities for encouraging this revolution in outlook may be best pursued.

Problems of Financing Development

The problem of finding adequate funds for development has two major facets. The first of these relates to the ability,

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[3]It is ironic that a study explicitly discussing the necessity of changing values in the manner described should use in its title the term "growth" rather than development. See, W. W. Rostow, The Stages of Economic Growth (Cambridge: The University Press, 1961), especially Chapters 1 and 3.

[4]See, for example, the discussion in William Allan, The African Husbandman (London: Oliver and Boyd, 1965).

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or the inability, of the low-income countries to generate the needed capital internally. The other aspect of this problem arises from the trade structure of these countries and the manner in which this structure and the foreign exchange earned are affected by world market conditions.

On a purely economic basis, the paucity of internal capital generation in countries is a function of their low income. With a low level of per capita income, a relatively poor capacity to build up any significant amount of savings exists. The closer is income to subsistence expenditures, the less will remain for saving--even assuming a strong desire to save. Similarly, the lower the level of savings, the lower will be the ability to invest in improvements, whether individual or national. Without investment, it may be difficult to maintain levels of productivity, let alone increase them. And finally, since income is an immediate function of productivity (excluding taxation), low output per unit of input will result in a maintenance of low levels of personal income. This sequence of arguments is commonly called "the vicious circle of poverty." The importance of this basic concept here is the self-reinforcing nature of the argument. A low-income country does not have the financial-institutional resources available to generate its own economic development, and thus rarely enough for growth.

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As Nurkse has pointed out,[5] this argument has its demand counterpart. Even assuming, for example, an amount of capital available for investment, there will be little incentive to invest private capital if the market is small. The size of market, of course, is limited by the low income - low productivity relationship which is, as has been shown, self-reinforcing. The most obvious path out of this two-sided dilemma, and that taken by most low-income countries, has been to set aside dependence on private capital and make "public" investments in industries which might ordinarily be more efficiently operated in private hands, given the incentive of a potentially large market.

With the acceptance of investment responsibility residing in governmental rather than individual hands, attention is focussed on obtaining a source, or sources of capital with which to invest. Bilateral international aid, whether grants or loans, is attractive financially in the short-term view but usually has long-run political or economic liabilities. Taxation of the productive portion of the economy, on the other hand, may result in depressed incentives to invest because of the relatively small marginal increase in returns. Nurkse has pointed out that with care and under somewhat unusual circumstances, this

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[5]Ragnar Nurkse, Problems of Capital Formation in Underdeveloped Countries (New York: Oxford University Press, 1962), p. 5.

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Taxation

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[7]*Ibid.*,

repressive effect need not occur.[6] For example, in an unsuccessful attempt at indirect taxation of exports in Argentina, primary products were marketed through a government monopoly. Prices on the world market for the export goods were much higher than the prices paid by the government to its internal suppliers. It was hoped to finance the country's industrialization in this manner. The result, however, was a drying up of export supplies. In other words, Argentine producers were not willing to maintain production levels at a depressed price merely for an impersonal, national goal of future industrialization. In Japan, on the other hand, the government did not tax exports but the land. "In this way it left intact the incentive to produce silk for export at a time of favorable export markets, while yet, in effect, intercepting the foreign exchange proceeds of these exports for use in industrial development."[7] This comparison should be sufficient to illustrate that taxation of production is a risky proposition, even when there appears no alternative. This is made even more difficult by the fact that the primary source of export produce lies in the hands of a majority of the population, i.e., the farmers.

Taxation of exports will have a less deliterious effect

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[6]Ragnar Nurkse, "Trade Fluctuations and Buffer Policies of Low-Income Countries," Kyklos, XI (1958), 152-53.

[7]Ibid., p. 153.

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on production when such production is increasing and the tax is a smaller proportion of the total return. Given steady or rising world prices for the export product, and a desire on the producers' parts for the benefits of increased income, production will increase and allow taxation to drain off a portion of the gain for investment projects. Export products from low-income countries are essentially primary products, however, and the world market for primary products is subject to considerable price fluctuation. It is to this point that we must turn next.

It is an unfortunate characteristic of primary product markets that they are an unstable source of foreign exchange, for it is the primary producing countries that most need stability in earnings. Although there is some dispute over the validity of figures illustrating this instability in the long run, there is little argument over the existence of short-run fluctuations in prices. A recent study by the United Nations measured the deviation of export proceeds from a three-year moving average, 1953-1960, for a large number of countries and found fluctuations to be four times as high for countries exporting primary products as for the industrial countries.[8]

Another unfortunate aspect of this situation is that this instability in market prices is largely inherent in the

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[8] United Nations Conference on Trade and Development, Stabilization of International Commodity Markets, (E/CONF.46/8) (New York, 1964), p. 14.

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process of production. Where the products are agricultural, supply is irregular; attempts to regulate it are clumsy and achieve moderate success only where there is considerable capital available to counter the unpredictable forces of nature. Where the products are more directly extractive, as in lumbering and mining, supply requires considerable investment, and reliability of supply depends upon the accuracy of estimates concerning the size and quality of reserves. Contrary to industrial production, primary production in low-income countries is liable to be controlled by a very large number of individual producers, especially in agriculture. The stubborn independence of these producers adds to the problems of organizing the production process. The unpredictable character of natural occurrences is amplified by the necessity that investment and planting decisions be made well in advance of the harvest. If these complications are added to the fluctuations in demand which occur in the purchasing countries, the foundations of short-term instability in primary product prices may be seen.

The severity with which these price variations affect the producing country is further modified by the problem of adjusting the supply to the demand. The production process is such that an input-to-output time lag limits any such effective action. A crop planted in April in light of existing market prices may be harvested to a very different price situation in

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September. Attempts to control the supply in the producing countries by holding excess supply during years of low prices for later release during low production-high price years has failed for several reasons. Either the price trend is downward over the long-run and the government after a decade finds itself holding large stocks of unwanted or very low price commodities, or the individual producers, realizing that prices are not going to drop below a certain level regardless of production volume, merely increase production to gain higher returns. Both situations have the same result, namely the government eventually finds itself holding large quantities of low value goods. Under these circumstances, there is little benefit in encouraging production with the aim of gaining capital for investment through taxation.

Buffer stocks and marketing boards can hold prices approximately stable, then, only when there is no change in the long-run trend of consumption and price fluctuations are essentially random. If demand increases, stocks will eventually become depleted, but if demand declines, the program will become very costly, requiring the disposal of large quantities of produce without allowing it to reach the world market where prices would only be further depressed.

What is equally important, fluctuations in demand are often brought about by production variations in the industrial countries and

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countries and are not under the direct influence of the exporting country. There is no assurance that a high production year in the exporting country will be coincidental with a low production-high demand year in the purchasing country, for many primary products exported from low income countries compete in part with similar products originating in the higher income countries. Fluctuations in price, then, may result in an even slower accommodating response from the producer than initially considered.

The impact of such a situation on the primary producing countries is serious. Most underdeveloped nations are also primary producers with a majority of their export (foreign exchange) earnings based on two or three commodities. In many instances, these commodities are agricultural and can expect a slower increase in demand than manufactured goods as incomes rise. Throughout the less developed world, rapid and general economic improvement through development has become a dominant concern. If development investments were planned from year to year, variation in foreign exchange earnings would mean annual variation in the degree of achievement for these development plans. Furthermore, investment plans are not made merely from year to year, but usually in increments of from three to seven years. An unforeseen drop in world prices for the major commodities of a primary producer, and a corresponding drop in export earnings, would be an even more serious blow to such investment p

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Not only are low income countries limited in their sources of investment funds, then, but they are also subject to wide fluctuations in the earnings based on their most substantial source of funds. It becomes crucial under such circumstances that expenditures be made only on those aspects of the national economy which will result in the greatest benefits relative to the amount invested. This is only economic self-interest in any case, but when there are few funds available for development, it heightens the urgency of a "waste not, want not" policy. It is in this context that we now turn our attention to the first of two investment sectors important to economic development.

The Agricultural Sector

Agriculture is no longer viewed by most development economists as an unpromising sector for investment. During much of the 1950's, agriculture was viewed as a sector which provided manpower for industrialization but was a decidedly secondary element in development stimulation. This attitude was largely based on the assumption of the zero marginal productivity of labor in agriculture in most underdeveloped countries.[9] That is,

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[9]For one of the earlier arguments for such an assumption, see, W. Arthur Lewis, "Economic Development with Unlimited Supplies of Labour," Manchester School of Economic and Social Studies (May, 1954), pp. 139-92.

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the productivity of agricultural labor was such that a relatively large fraction of the rural population could be removed from productive effort in agriculture without causing a drop in total output. The validity of this assumption has been opposed recently by Schultz[10] and others, and while this argument has not yet been settled to the satisfaction of all its participants, there is less justification in ignoring agriculture's possible role in the development process.[11]

The most widely supported position among development economists argues that neither industrialization nor agriculture alone is sufficient to provide the impetus for national economic development. This "balanced" approach states that both agriculture and industrial production are necessary in some proportion, for without adequate support for production in one sector, the other will be stalled by a "bottleneck" of low demand, low source of investment capital, lack of adequate supplies, and so forth.[12]

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[10]Theodore W. Schultz, Transforming Traditional Agriculture (New Haven, Conn.: Yale University Press, 1964).

[11]For a review article of the methodological developments on this topic, see, Charles H. C. Kao, Kurt R. Anschel, and Carl K. Eicher, "Disguised Unemployment in Agriculture: A Survey," Agriculture in Economic Development, Carl Eicher and Lawrence Witt, eds. (New York: McGraw-Hill Book Company, 1964), pp. 129-44.

[12]For a review and discussion of the major theoretical arguments current among economists concerning the "balanced" approach to development, see, Lawrence W. Witt, "Role of Agriculture in Economic Development -- A Review," Journal of Farm Economics, XLVII (February, 1965), 120-31.

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Without reviewing the argument in more detail, it will suffice here to point out that the importance of agriculture to underdeveloped economies is apparent from the proportion of the population so engaged and the degree to which many such countries' export earnings are based on crop production. The precise importance of agriculture is difficult to determine, and in fact is so intertwined with other factors within the various national economies that it may never be possible, or worthwhile, to abstract its importance in detail. It may be useful at this point, however, to describe the manner in which agriculture can contribute to development, and some of the problems that may be seen associated with these contributions.

One of the most basic contributions of agriculture lies in the increased food available for home consumption. As national population grows, there will naturally be an increased requirement of food. Secondly, if there is a rise in per capita income brought about by development, there will be additional need for greater food supplies. The level of supplies needed will be described by the income (rather than price) elasticity of demand for food; in low-income countries this tends to be higher than in high-income countries. Thus, demand for food will rise relatively sharply during the early stages of rising incomes in those countries which are less able to invest in agriculture to meet this rising demand. Finally, because of the rural-urban migration, relatively more food will be consumed in u

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consumed in urban areas; more food will have to be moved to the cities. The importance of movement facilities in this is often overlooked. If there is a considerable population shift, the entire marketing system will require transformation.

In addition to providing more food to meet increasing domestic use, there are several other contributions which agriculture can make to the development process. As indicated earlier, increased foreign exchange can be earned through greater crop export if prices on the world market do not drop too sharply. Increased productivity (per man-hour) in agriculture will theoretically release manpower for expanded use in non-farm sectors of the economy. An expanding agricultural sector may also be a growing market for industrial goods. These goods may be useful inputs for agriculture, e.g., fertilizer, or they may be consumer goods, more appealing to those with some surplus income. And as also indicated earlier, agriculture may be considered a source of capital funds to be invested in industry or social overhead. Whether these funds are withdrawn from agriculture as taxes on land, on agricultural inputs, or through controls on prices of agricultural products is subject to individual variability.[13]

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[13]For discussions on these topics, see, Bruce F. Johnston and John W. Mellor, "The Nature of Agriculture's Contributions to Economic Development," Food Research Institute Studies, Stanford University, I (November, 1960), 335-56; also by Johnston

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The Transport Sector

Closely associated with development in the more apparently productive aspects of the economy is development of the structural and institutional framework within which the productive sectors operate and upon which they depend. In low income countries, such elements of social overhead capital as education and health facilities, and portions of national infrastructure such as electrical power grids, large-scale irrigation works, and transport and communication networks all compete with each other and the agricultural and industrial sectors for scarce investment funds. The intuition that these "non-productive" elements of a modern economy are vital to the growth and development of the economy is widely held.

The extreme difficulty in determining the degree of their contribution, precise or relative, has led to investment procedures which do not do justice to the scarcity of the funds available. As Adler has remonstrated, for example, "it is frequently assumed that all transport improvements stimulate economic development. The sad truth is that some do, some do not, and that even some of those that do may not be economically

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and Mellor, "The Role of Agriculture in Economic Development," American Economic Review, LI (September, 1961), 566-93; and Mellor, op. cit., pp. 3-129. For another approach to the same general problem, see, Simon Kuznets, "Economic Growth and the Contribution of Agriculture: Notes on Measurements," International Journal of Agrarian Affairs, III (April, 1961), 59-75.

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justified in the sense that there may be better investment opportunities."[14] As Hirschman has pointed out, this may be one reason for the high interest in the transport sector by development planners. The obscurity of the data before investment insures acceptance of the plan, and the similarly vague data which issue after the investment insure that no specific portion of the plan may be blamed if it fails.[15] Although this is a trifle unfair, for transportation is essentially a means in development, not an end in itself, planners do seem to forget this when particularly enamored with the concept of transportation's contribution to development.

When attending to the necessity and potential of transportation for economic development, it is not difficult to lose perspective for the possible contributions of transport improvement are many and varied. On a very elementary level, an improvement in transport means that goods may be moved more cheaply, more safely, and more dependably through space. In another dimension, better transport also means faster movement

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[14]Hans A. Adler, "Economic Evaluation of Transport Projects," _Transport Investment and Economic Development_, Gary Fromm, ed. (Washington: The Brookings Institution, 1965), p. 189; also see, George W. Wilson, _et al_., _The Impact of Highway Investment on Development_ (Washington: The Brookings Institution, 1966), p. 174.

[15]Albert O Hirschman, _The Strategy of Economic Development_ (New Haven, Conn.: Yale University Press, 1958), p. 84.

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of goods.[16] To some economists, expensive transportation means low revenue to those areas distant from markets, and therefore an underuse of resources.[17] Hawkins, on the other hand, has laid emphasis on rate of movement, in addition to that of substitution for less efficiently used resources.

> The saving of capital brought about by the increased speed of transport enables more and different types of investment to be carried out with the same quantity of savings. In under-developed economies this is important, since capital tends to be the scarcest factor. It is also a fertilising factor because its wider use will provide employment opportunities for the use of surplus land and labour. There are many grounds for thinking that this is the major connection between economic development and transport improvements. Economic growth depends upon the growth of capital employed per capita; transport improvements release working capital which can then be used more productively as fixed capital elsewhere in the economy.[18]

One of the more immediate results of increased transport efficiency appears to be a rise in agricultural production in the area through which the route passes. Although such cause-effect relationships are impossible to determine with certainty, i.e., it is not possible to distinguish between rises in production *caused* by the better transport and those which are only coincidental to road improvements but would have occurred even without

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[16]For a short discussion of these, see Wilson, *et al.*, *op. cit.*, p. 7.

[17]Mellor, *op. cit.*, p. 340.

[18]E. K. Hawkins, *Roads and Road Transport in an Under-developed Country: A Case Study of Uganda* (Colonial Research Studies No. 32; London: H. M. Stationery Office, 1962), p. 25.

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the better means of movement, empirical encouragement for theoretical considerations has come from several studies. In Uganda, the research of Smith[19] and Hawkins[20] has reached conclusions similar to those illustrated by March[21] and outlined by Wilson.[22] Hunter also had observed this phenomenon in an area of Ghana.[23] In this area, a zone of coastal scrub with no transport facilities, a sparse population maintained an isolated existence; the nearest road was too far to headload produce. After the Ghanaian Government constructed a road into this area, there was a fairly rapid influx of food crop farmers, apparently because of the new access to markets. In any case, real benefits are gained by investments to improve transport facilities, as shown by the rise

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[19] N. D. S. Smith, "A Pilot Study in Uganda of the Effects upon Economic Development of the Construction of Feeder Roads," _Research Note_ No. RN/3408, Department of Scientific and Industrial Research, British Road Research Laboratory, February, 1959 (unpublished).

[20] Hawkins, _op. cit._

[21] Jose J. March, "Impacto Economico y Social de los Caminos Vecinales," _Mas Caminos_, Mexico D. F., (November, 1956), as referred to in: Organization of American States, General Secretariat, Department of Economic Affairs of the Pan American Union, _Farm to Market Roads in Latin America; their administration and financing_ (Washington: Pan American Union, 1964), pp. 8-9.

[22] Wilson, _et al._, _op. cit._, pp. 127-61 _passim_.

[23] Communication from Professor John M. Hunter, Michigan State University, July 25, 1967.

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in traffic which new highways, especially, seem to generate.[24]

On a more detailed level, the absence of suitable storage facilities and cash reserves has had an impact on the efficiency with which local transportation is used for marketing goods. Largely as a result of these two factors, the small-scale agricultural producer must market his harvest quickly, in small units and at fairly short intervals. "This postulates a large number of intermediaries, who, because of the high cost of capital, employ methods of transportation using relatively little capital and much labor."[25] The obvious result, at least in part, is the loss to the farmer of a sizable portion of his available income, and this in turn maintains the marginal subsistence nature of his farming.

Transportation is also an important factor assisting the revolution in outlook necessary for widespread and successful development within a country. The extreme importance of the proper marketing facilities when dealing with "traditionally

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[24]See the conclusions on this in Wilson, et al., op. cit., pp. 177-78.

[25]P. T. Bauer and B. S. Yamey, "Economic Progress and Occupational Distribution," The Economic Journal, LXI (December, 1951), 744. For another approach to this problem, see, United Nations Economic and Social Council, Economic Commission for Africa, East African Transport Problems in Relation to the Promotion of Economic Development (Progress Report), (E/CN. 14/148) (January 24, 1962).

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minded producers" is pointed out by Walker.[26] The easier movement of ideas as well as the people who transmit them should not be underestimated as a stimulus for change. As illustrated by the rise in land values coincidental with better accessibility, Brunner argues, "people are willing to pay for the convenience of moving easily far more than the difference in the actual cost of movement."[27] Although such a statement would have to be carefully tested, it does have a cynical ring of truth. More plainly, the extension of good transport facilities into previously isolated districts tends to weaken local loyalties and allow national feeling to become stronger. New movement facilities offer a broad range of opportunities directly and to a greater proportion of the population; road transport has greater potential in this than any other mode of movement.[28] Internal political and economic cohesion is a vital element in generating this development, for

> . . . the dominating characteristic of the new African national economies is their disjointedness, their lack of internal links and connections. The first step to increase the production of agriculture and to bring the

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[26]David Walker, "Problems of Economic Development of East Africa," Economic Development for Africa South of the Sahara, E. A. G. Robinson, ed. (London: Macmillan, 1965), p. 110.

[27]C. T. Brunner, "Developing Countries: Roads Economic Justification," British Road Federation, Bulletin, no. 310 (December, 1962), 239.

[28]See the discussion in Wilson, et al., op. cit., pp. 198-202.

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> subsistence sector more fully into the exchange economy should be expansion of the internal transportation system, followed by improvement of the marketing system generally.[29]

While it may be accepted that, in general, there is crucial need for improved transportation in the new African states, it will do no harm to re-emphasize the misgivings of Hirschman and Adler.[30] Furthermore, transport investment ~~to~~ satisfy present demand often creates excess capacity for future needs. Present facilities will affect future costs. If future demand for transport is underestimated, the higher costs of that future time may waste resources greater than those which would have been required to upgrade the original investment. Abandoned railways, such as the one built to support the abortive Tanganyika Groundnut Scheme in southern Tanganyika, are extreme examples of the waste possible from overestimation of demand for transportation. It is well to be committed to worthwhile goals, but if in practice, decisions based on this commitment are made without empirically testing the assumptions upon which the commitment, in turn, is based, serious waste of investment resources can result.

Agriculture itself differs from other economic sectors with respect to the form in which information is useful for

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[29] William O. Jones, "Increasing Agricultural Productivity in Tropical Africa," Economic Development in Africa, E. F. Jackson, ed. (Oxford: Basil Blackwell, 1965), p. 47.

[30] See footnotes 14 and 15.

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estimating transport requirements. This has been pointed out by Fromm:

> Long-range agricultural planning has usually been limited to indicating production goals by food stuff types and means of increasing production through seed, fertilizer, mechanization, water, and credit programs. These programs are not readily translated, even in the short-run and especially in the longer run, into transport needs.[31]

The implications of such an observation should have great importance to non-geographer development planners. Fromm's immediate implication is that the temporal perspective gained through indication of goals in essentially static terms is not meaningful in the context of transport planning which must be dynamic. What may be more important, or is at least more often ignored, is the intrinsically spatial aspect of transportation, in sharp contrast to the spatially indeterminate character of the most common measures used to increase agricultural production.

Agriculture, then, may be referred to as an important sector in almost all underdeveloped economies. It may not be the sole foundation for a country's economic development, and in a few cases it may not even be necessary. That it must be considered important, however, is borne out by the many contributions to a state's economy that it can make, and the high proportion of low-income countries' population which remains employed

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[31] Gary Fromm, "Design of the Transport Sector," Transport Investment and Economic Development, Gary Fromm, ed., op. cit., p. 96.

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in, or associated with agricultural production. Transportation is definitely a necessary element in any national economy, although there is some doubt that it is a factor sufficient by itself to generate development.

Both the role of agriculture and that of transportation in the development process are, therefore, in need of more careful empirical analysis. That these analyses should be integrated at least in part has been indicated by the authors of a United Nations report on transportation and development in West Africa.

> Improved transport must, for its full effect be combined with a corresponding expansion of production and trade. The latter must have reached a certain level before expenditure on infrastructure is contemplated; and to judge when that minimum has been attained is one of the most difficult problems in framing development policies.[32]

That is to say, rationally planned expansion in either agricultural production or the transport facilities which will move these products presupposes a certain degree of expansion in the other. Before an increased output can be efficiently marketed (assuming capacity use of movement facilities previous to the increase), there must be some improvement in the means of transporting the larger production from the farms to the market. Conversely, and more difficultly, it may be wasteful to use scarce resources improving transport facilities unless there are sufficient increases in productive traffic prepared to use these

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[32]United Nations, Transport Problems in Relation to Economic Development in West Africa, (E/CN.14/63) (1962), p. 64.

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CHAPTER II

GEOGRAPHY AND ECONOMIC DEVELOPMENT

The Necessity of a Geographic Perspective

The present volume has been written by a geographer. Because of this, it will be seen to treat economic development in a manner different from what is "customary" in development studies. Although the impact of a geographer's approach on some of the problems of economic development should become more apparent as this study proceeds, it is thought relevant here to examine more specifically, if only briefly, this approach and contrast it with the way in which other disciplines, and most other geographers, have treated the subject. Economic development is, after all, a difficult topic to force into one or two academic disciplines.

Research which deals with economic development must be, in the end, interdisciplinary. Whether the study in question deals with only one aspect of the development process or attempts to treat reality to some degree, the study must extend beyond traditional discipline boundaries. In the latter case, it should be obvious that reality is not bound by academic tradition; in economic development, administration, agriculture, economics (business and "pure"), geology, politics, psychology (group and individual), soil science, zoology, and many other "separate"

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realms of academic study are tightly interwoven within an historical and geographic framework. Even when there is an attempt to artificially separate a portion of reality for more detailed study along academic lines, the study is valueless, in a pragmatic sense, to the extent that it succeeds in eliminating the "complicating" factors of other disciplines. The degree to which <u>ceteris paribus</u> is maintained at the conclusion of the study, explicitly or by assumption only, the less real that study is likely to be, regardless of any theoretical value such a study may have.

Almost all human activity takes place in space, i.e., involves transmission of something between two locations. That which is transmitted may not be visible on the landscape (information, knowledge of decisions or innovations, etc.) except when it has been utilized at the goal of its movement. Goods transport, population migration, and military troop movements are all examples of man's activities which are obvious aspects of the visible landscape. All too often, studies of these manifestations of human activity unrealistically treat these phenomena in an abstract manner, totally <u>outside</u> their spatial framework.

Economic development should, by definition, include as much of reality as possible without losing sight of the value of generalization. Both "economic" and, as defined here, "development" are concepts with anthropomorphic associations. As such, studies in either should include within their framework of assumptions the sp

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tions the spatial nature of human activity. The reluctance of most "pure" economists toward this idea has been amply demonstrated by the necessity of some of their more reality-conscious brethren to set themselves aside as "regional scientists."

Given the importance of space in any study of human activity, it appears strange that almost every published study concerning economic development and containing some recognition of the heterogeneity of spatial phenomena is either descriptive of existing or past patterns, or when dealing in the abstract, treats space as something homogeneous in relatively large blocks or as a simple cost function within a larger economic model. Thus, Myrdal and Hirschman treat rich and poor regions to be compared as wholes.[1] Among many others, on the other hand, Isard and Vining include "transfer" or distance costs in discussing economic areas and economic systems.[2] With so few exceptions that they are made prominent by their scarcity, approaches to problems in economic development generally do not

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[1]Gunnar Myrdal, Economic Theory and Underdeveloped Regions (London: Duckworth, 1957); Albert O. Hirschman, The Strategy of Economic Development (New Haven: Yale University Press, 1958).

[2]Walter Isard, Location and Space Economy (New York: John Wiley & Sons, Inc., 1956), and also Isard's "Distance Inputs and the Space Economy," The Quarterly Journal of Economics, LXV (1951), 181-98 and 373-99; Rutledge Vining, "Delimitations of Economic Areas: Statistical Conceptions of the Spatial Structure of an Economic System," Journal of the American Statistical Association, XLVIII (March, 1953), 44-64.

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In any absolute sense, this is not an easy task. Even disregarding the vertical dimension of movement, i.e., the fact that airplanes fly over, not on, the earth's surface, earth space is three-dimensional. The well-discussed problem of representing any sizable portion of the earth's spheroidal surface on a flat map, to say nothing of relief variations, are several of the difficulties of working with reality. There is no reason, however, why the spatial distribution of phenomena, the agents acting on them, and their effects cannot be accepted rather than be ignored because they are difficult to fit into a model, or cause mental strain when there is an attempt to conceptualize the problem in this manner. Granted, the diversity and spatial heterogeneity of reality is difficult to manipulate mentally; this is a basic value of cartographic representation. It is through the imaginative use of maps and all they represent that geographers can contribute greatly to the solution of problems of economic development.

Geographers should have the most suitable training for dealing with real problems such as those in economic development. Geography is necessarily interdisciplinary. Like history, it is distinguished from other disciplines by its approach rather than the subje

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the subject matter it studies.[3] Geography also deals with reality in that it is primarily concerned with spatial patterns and relationships as they exist, existed, or are expected to exist, on the earth's surface. Basically, it is this concern that has led many geographers to intensive regional descriptions of places, areas, regions, portions of the earth's surface, other geographers to abstract that which deals with the spatial characteristics of a real problem or phenomenon and present it as geographic analysis, and still other geographers to formulate models (one factor of which is a distance function) in an attempt to make the analytical process more rigorous, i.e., less liable to subjective qualification and human error. In each of these ways, geographers have made numerous contributions to the professional literature.

As the reader may have realized, however, in none of the categories listed is there necessarily an attack made on real-world problems in the manner described at the beginning of this chapter. Geographic studies of aspects of economic development fall into two major groups. Geographers approach economic development either at the extreme macro-level or as essentially unique "case studies" of portions of the earth's surface. Furthermore, geographers using "areal differentiation" and "spatial interaction" when giving

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[3]For a discussion of this concept, one which has had considerable methodological impact on the field, see, Richard Hartshorne, Perspective on the Nature of Geography (Chicago: Rand McNally & Company, 1959), esp. pp. 12-21.

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attention to the economic development concept, use these approaches in a descriptive rather than a prescriptive manner. Examples may be appreciated at this point.

The Case Study

There are innumerable possible examples of the case study type. This has resulted in part from the methodological emphasis within geography on regional studies, until recently taken to mean in-depth study of some part of the world that had not been studied before, this tendency being reinforced in turn by the pressure for "original" research--and what could be more original than study of an area no one else knows anything about? The great number of case studies has also resulted in part from the fact that although it is difficult to do case study research in the field, for data must be collected on virtually every aspect of the region, it is much more difficult both before and after the research to think of a general principle to be tested in the study area or to analyze the results to provide new insights into areal characteristics of which the study area provides one example. This is not to say that such case studies are not useful, for they do provide information about many parts of the world for which there are no ready data. One can argue, however, that such studies' usefulness might be enhanced by a hypothesis or method explicitly tested in the "case" context and conclusions drawn concerning its utility.

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A good example may be made on this point by reference to one of the studies in the University of Chicago Geography series.[4] The interesting thing about this thorough case study is that while it is unlikely that a non-geographer would have undertaken the research necessary for this study, or written in the same way, there is almost nothing in the approach which calls attention to the author's presumed training in geography. As legitimate research, there is nothing against a geographer "doing" economics or history, or economists and historians "doing" geography, as long as the studies are well done. But a geographer who does not bring something of the unique approach to reality that is part of his discipline to bear upon the research problem under study sacrifices a greal deal of his potential contribution to the problem's solution.

As pointed out earlier, however, this non-spatial type of contribution from geographers has broad foundations in the rather recent evolution of the discipline. In 1953, at a meeting of geographers explicitly concerned with economic development, one of the participants argued "that the geographer's contribution lies in his ability to evaluate the interrelationships of various projects in over-all balanced development and that administrators with

[4]Darrell Randall, Factors of Economic Development and the Okovango Delta (Department of Geography Research Paper No. 47; Chicago: University of Chicago Press, 1957).

a technical background often posses [sic] a limited perspective of the broader problems with which they must deal."[5] Four years later, another geographer wrote that a geographer contributes to national development by pointing out the regional importance of conservation and by functioning as a resource person to banks and commercial firms, providing information on regions of the world as "background to investment and trading policies."[6] In other words, geographers are to assist development indirectly and in part, passively, by fulfilling the role of walking, talking encyclopedias and reference manuals.[7]

More useful are case studies designed to examine in detail an assumption, hypothesis, or methodological approach to an economic development problem. The study by Larimore and several by Hunter provide excellent examples of case studies of this nature.[8]

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[5]Attributed to Frank Keller at "Program Presented at the 49th Annual Meeting by the AAG Committee on Economic Development," Lloyd D. Black, Chairman, Professional Geographer, V (July, 1953), 16-17.

[6]B. J. Garnier, "Geography and National Development," The Nigerian Geographical Journal, I (April, 1957), 4-5.

[7]For a well-done example of this approach, see, William A. Hance, African Economic Development (New York: Harper & Brothers, 1958).

[8]Ann Larimore, "A Measure of Economic Change: Sequent Development of Occupance in Busoga District, Uganda," Essays on Geography and Economic Development, Norton Ginsburg, ed. (Department of Geography Research Paper No. 62; Chicago: The University of Chicago, 1960), pp. 111-23; John M. Hunter, "Cocoa Migration

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The study by Hunter on migration of cocoa farmers, for example, provides not only an extraordinary amount of information about the small areas concerned, most of it gathered "fresh" in the field rather from published and unpublished documents, but it also gives an example of centrifugal and centripetal ("separatist" and "unifying") factors bearing upon the new community made up of these migrants. It is meaningful, then, to those concerned with development in other parts of Africa in its indication of precisely where non-European cultural traits may affect national unity. Because of its completeness, the study also provides specific data concerning the manner in which these separating and unifying forces have arisen for their particular study area.

One unfortunate aspect of such studies, however, and one which is understood by those aware of the dangers of induction, results from unwarranted extension by those not aware of these dangers. The implication may be taken that what has or has not worked in area "A" will probably have the same results in area "B." Researchers making this induction may not then carry out a similar study in area "B," as should be done, but use this assump-

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and Patterns of Land Ownership in the Densu Valley near Suhum, Ghana," Transactions and Papers, The Institute of British Geographers, no. 33 (December, 1963), 61-87; John M. Hunter, "Population Pressure in a Part of the West African Savanna: A Study of Nangodi, Northeast Ghana," Annals of the Association of American Geographers, LVII (March, 1967), 101-14.

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tion, base conclusions on its veracity, and eventually, political and economic decisions may be made on this basis. The failure here is, of course, not on the part of the original researcher but on those who make unfounded extensions of the initial work. This is not a call for fewer such useful case studies, therefore, but for more of equal quality aimed at similar problems in other parts of Africa.

That variety of case study in which geographers use their disciplinary training directly in developing a methodological approach of use to development planners in many countries is especially valuable. Although as early as 1953, Vinge had called for a more intelligent use of maps, beyond their role as "mere illustrations,"[9] the studies by Gosling[10] and Moss[11] are unfortunately rare examples of this kind of presentation. Gosling attempted to determine indices (e.g., rice production per agricultural worker, stored rice reserves per capita, and others) by which areas relatively less suitable for development investment

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[9]Clarence L. Vinge, "The Language of Geography," Professional Geographer, V (May, 1953), 8-9.

[10]L. A. Peter Gosling, "The Location of 'Problem' Areas in Rural Malaya," Essays on Geography . . . , op. cit., pp. 124-42.

[11]R. P. Moss, "Soils, Slopes and Land Use in a Part of South-Western Nigeria: Some Implications for the Planning of Agricultural Development in Inter-Tropical Africa," Transactions and Papers, The Institute of British Geographers, no. 32 (June, 1963), 143-68.

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than other areas might be determined. This study, however, appears to assume administrative districts suitably uniform with respect to these indices, for data are presented in this manner. This is undoubtedly caused in part by the way in which the data were gathered, but it is an unfortunate expediency. Furthermore, in the case of this article, an unstated assumption could limit its usefulness in more sparsely populated areas. That is, that existing utilization of agricultural resources reflects the absolute potential of these areas is an assumption that can be made only with a serious danger of superficial assessment in non-densely populated areas. In spite of this, the article is a useful attempt at determining the areal variability of development potential.

The article by Moss could be of even greater methodological utility. By combining the mapped distributions of soil, soil parent material, slope, and existing land use, Moss was able to form conclusions regarding a basis for regional comparison of reaction to changing agricultural techniques. Not only is the study useful for the detailed data presented and the substantive conclusions made concerning the local ecosystem and planning for agricultural development, but it is also important in demonstrating the utility, even the necessity of dealing with the spatial variability of reality. Thus,

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> In order adequately to plan agricultural development some assessment of the impact of new crops and techniques upon the ecosystem must be made, an end which may be achieved by study of the relations of the ecosystems at present existing, and by detailed investigation of mechanisms within them. In either case detailed knowledge of the distributions of these systems is an indispensable preliminary, and valid application of the results also depends upon informative mapping.[12]

It is this use of "informative mapping" that most closely identifies Moss's article with the approach to be used in the present volume.

Models of the Macro-Region

Before proceeding to the main body of this work, a few comments should be made concerning the other major category of geographic study of economic development, i.e., those at the macro-level. By the term "macro-level," reference is not being made to the in-depth case studies of large regions, but to discussions of the variability of characteristics *between* relatively large regions. As with discussion of the case study type of research, there is much that is commendable in macro-level geographic research on aspects of economic development. The *Atlas of Economic Development* by Ginsburg, for example, provides a tremendous amount of information, containing the country-by-country variation of no less than forty-eight indices of development.[13] Furthermore, the

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[12] *Ibid*., p. 165.

[13] Norton Ginsburg, *Atlas of Economic Development* (Department of Geography Research Paper No. 68; Chicago: University of Chicago Press, 1961).

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statistical analysis of these differences provides insights to the patterns not easily apparent.[14] In sum, however, these patterns and the analyses of them are descriptions of average differences and can be of only marginal use for decision-makers in the underdeveloped world. They may be encouraged, for example, to discover that ". . . equatorial location apparently has little to do with stage of economic development . . ."[15] and enlightened that ". . . political colonialism, seems not to explain poverty but even in some instances to have countered it . . . ,"[16] but it will not help planners decide where and how to use scarce investment resources.[17] Academically of interest, these studies survey economic development problems with much too broad a brush to contribute more than marginally to the increased well-being of

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[14]Brian J. L. Berry, "Basic Patterns of Economic Development," *Ibid.*, pp. 110-19.

[15]*Ibid.*, p. 119.

[16]*Ibid.*

[17]For further examples of descriptively interesting studies on the macro-level, see: Brian J. L. Berry, "City Size Distributions and Economic Development," *Economic Development and Cultural Change*, IX (July, 1961), 573-88; the articles by Wagner, Guyol, and Berry in *Essays on Geography* . . . , *op. cit.*, pp. 49-62, pp. 65-77, pp. 78-107, respectively; and in a somewhat different manner, Norton Ginsburg, "Natural Resources and Economic Development," *Annals of the Association of American Geographers*, XLVII (September, 1957), 197-212.

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any less developed country's population.[18]

Studies which use statistical and mathematical techniques of analysis for model building often have the generally descriptive character of macro-level studies whether examining large areas or small.[19, 20] For example, in an article written specifically toward the problem of decision criteria for development planners,[21] Reiner becomes "hoist with his own petard" when he attempts to regionalize variable phenomena and ends up restricting their variability. Thus, he complains that "traditional texts and studies of economic development give scant heed to subnational analysis, decisions, and aspirations."[22]

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[18]An exception to this generalization is the study by Gould of one aspect of an entire country's development. Perhaps by maintaining this focus throughout, Gould's work has taken on some characteristics of a case study while remaining committed to the analysis of the changing pattern of spatial interaction and the impact of some of these changes on the development of the country as a whole. See, Peter R. Gould, The Development of the Transportation Pattern in Ghana (Studies in Geography No. 5; Evanston, Ill.: Northwestern University, 1960).

[19]I have the suspicion that topological models would be an exception, although I must confess ignorance of the principles involved in topology.

[20]Gould's study is again a partial exception; Gould, op. cit , pp. 96-114, passim.

[21]Thomas A. Reiner, "Sub-national and National Planning: Decision Criteria," Papers, Regional Science Association, XIV (1965), 107-36.

[22]Ibid., footnote, p. 109.

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Before long, however, he indicates his assumption of, or predilection for, space that is made up of a number of relatively homogeneous areas; the implication is made that space must be so construed in order to be usefully included in development planning and analysis. He writes:

> Finally, limits to the acceptable range of homogeneity or heterogeneity within a given region must be set. Thus, it might be argued, interregional equality is relatively meaningless where, within regions there remains (or possibly there is built up) greater disparity. Such internal inequality may be expressed spatially, in which case a finer regionalization might resolve the problem.[23]

And so, because of a commitment to model-building, spatial variety is "homogenized" and therefore made unreal.[24]

In sum, studies of economic development problems conducted by geographers have varied from descriptive typologies of development characteristics to detailed examinations of individual aspects of less-developed countries, a few with utility for development planners but most without. Although geographers profess to be concerned with "areal differentiation," or the variability of phenomena from place to place, there are only a few geographers interested in economic development, such as Hunter, Gould, and Moss, who perceive this variability in a useful, analytical

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[23] _Ibid._, pp. 115-16.

[24] An indication that this need not hold when quantitative techniques are applied with care and in circumstances where data are available in suitable detail is provided by Julian Wolpert in his, "The Decision Process in Spatial Context," _Annals of the Association of American Geographers_, LIV (December, 1964), 537-58.

manner. Even Hartshorne, the single most important geographer in spreading the acceptance of the concept of areal differentiation among members of the profession, sees generalized description of development as "a primary task for the geographer." More explicitly, "a primary task for the geographer . . . is to find ways and means of providing a more realistic description of the current, and changing situation in economic development over the world than that provided by statistical tables which list countries as though all of one kind."[25] There can be no doubt that Hartshorne is aware of the variability of reality. His emphasis here, however, remains on description of the development process and its effects rather than on use of geography's approach in the solution of problems associated with this process.

There are several implications which arise from geographers' abdication of their discipline's full utility in testing problems of economic development. The least important is that there has been a gradual deterioration of the discipline's academic "reputation," as other social scientists have often come to identify geography with the trivial case study form of research. This is important, not because of any diminution of the validity of the geographic perspective, but in a reduction of expectations and a tendency to ignore the contributions which are

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[25]Richard Hartshorne, "Geography and Economic Growth," Essays on Geography . . . , op. cit., p. 21.

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More crucial is the continuing disregard of the necessity of approaching reality in both a temporal and spatial framework. As discussed earlier, this minimizes the total applicability of many research contributions to economic development problems; the heterogeneous character of the real world makes less secure the extension of isolated research suggestions for solution of the immediate problems of decision-makers in underdeveloped countries. After all, it is only by indicating where abstract solutions overlap with related problems, of a different nature but occurring in the same location, whether dealing with institutions, population characteristics, agricultural economics, or whatever, that these solutions may be easily utilized.

The present volume attempts to face each of these objections, at least by example. Although dealing with a relatively small portion of the earth's surface it is not a case study of the superficial variety. A methodology is offered which is applicable in detail throughout much of the underdeveloped world. This methodology is presented with clear recognition of points at which further research is required and where more specialized, aspatial research may be necessary to provide preliminary answers to problems raised. Most importantly, the study treats space not merely as something to be described but as a part of reality that must be accepted in all its variety when dealing with real problems.

PART II

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CHAPTER III

A REGIONAL APPROACH TO RECONCILING INVESTMENT PRIORITIES IN AGRICULTURE AND TRANSPORTATION

As has already been discussed, there is a vital need in economically underdeveloped countries to minimize "wasteful" investment, or at least to maximize investment in those areas of the nation's economic life which will be the most certain to yield a return. This need is pressing not only because of the political considerations but also because given the accepted goal of development, there is a severe shortage of funds to invest. In those countries where population growth, rapid urbanization and the rising tide of personal aspirations are combined with a low average level of personal income (characteristics true of most of Asia, Africa, and Latin America) a governmental policy which wastes funds by poor investment decisions is begging for political disruption, if not disintegration.

The importance of both agriculture and adequate transport facilities for a general improvement in individual welfare has also been pointed out. The argument among economists over the "correct" or the best path to national economic development, whether by industrialization or concentration on the agricultural sector, is unimportant here. It is sufficient to point out that

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agriculture is the major occupation of the great majority of the population in these countries. If improvements in income are to come in the foreseeable future to more than a handful of people in such countries, they may be most easily and profitably achieved in agriculture; agricultural products, methods, attitudes, and marketing conditions are all improvable aspects of the means of increasing average incomes. It is primarily with this last aspect of agriculture that this study is concerned.

In the present attempt at developing a procedure to minimize investment decision errors, attention is focussed on the relative costs of farming and possible income which could be obtained from better use of resources and better facilities for marketing farm produce. Estimates of profit are obtained from a comparison of costs and returns. This is not to imply that this study uses the methods of cost-benefit analysis, often described in these terms, nor is a sophisticated input-output model attempted. The general language may be similar because the larger concepts are the same; it is to a great extent definitional. That is, the concept of "profit" is defined as the difference between costs and total returns. As presently constituted, however, the methods of cost-benefit analysis and input-output analysis are incomplete at best, and grossly misleading at worst, for application in less developed economies although attempts at greater refin

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greater refinement of such methods continue to be made.[1] Data collected for use in such models are often inadequate, or even incorrect because of errors in the collection procedure. Even where the numbers are correct, there is no guarantee that categories into which the data are placed do not mask or distort what is important and uniquely "non-Western" about the economy. It has been attempted here, therefore, to maintain simplicity in theory and approach real problems as they exist rather than as they have been supposed to exist by some economic theory.

Costs and Income

In the development of a useful method of determining agricultural and transportation investment priorities, it is important to begin with a thorough understanding of the economics of the existing situation This means that existing levels of costs and returns must be established preliminary to a determination of existing levels of profit, or net income.

Direct costs to the farmer may be viewed in two parts: the costs of production and the costs of marketing the produce. Costs of production will vary in many ways. The type of crop grown, the suitability of the land for production of each crop,

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[1]For example, see the dissertation, Henry Malcolm Steiner, *Criteria for Planning Rural Roads in a Developing Country: The Case of Mexico* (Project on Engineering - Economic Planning, Report EEP-17; Stanford: Stanford University Institute in Engineering - Economic Systems, 1965).

variations in taxation, crop labor requirements and many aspects of the individual farmer's make-up, e.g., commitment to farming, receptivity to new methods (which often involve more capital cost but do not necessarily result in a proportional increase in output), etc., are all aspects of production costs. As such, it is important that their variation from place to place be determined.

Production costs are admittedly one of the most crucial elements in a program of improved farming. Without knowledge of such costs, there can be no clear understanding of the motivation of a farmer to grow one crop rather than another, or indeed, not to grow any crops at all. It is apparently only a recent revelation to Western economists that perhaps the subsistence farmer is not acting "irrationally" in refusing to grow certain crops or in maintaining subsistence food production along with minor investments in cash crop production. And yet, in spite of the importance of knowledge on production costs, very little research has been conducted to gather such information. Although blame for such a lack may be accepted because of the difficulty of gathering correct data--a generally illiterate, often suspicious farm population do not make data collection easy even assuming adequately educated and motivated data collectors--surely the present situation has been made worse by the biases of researchers who avoid collecting precise data on costs because "it is too difficult to gather and it is probably rather like costing in . . .

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(Yorkshire, Illinois, the Rhone Valley, etc.) anyway." The fact that most African farming is obviously not similar to European or American agriculture has not persuaded more than a few researchers to undertake studies to determine the elements of costing in small-farm African agriculture.[2]

In comparison to costs of production, costs of marketing are deceptively more easy to determine. Essentially, they are comprised of the cost of moving the produce from the fields to the market, and any costs which may arise from charges levied by a middle-man or marketing board. Since movement costs are costs per unit distance, it is theoretically possible to determine actual movement costs on the basis of the mode of transport used, the type of goods shipped, and the distance to the market. This, however, provides another example of the difficulties which may arise if theoretical considerations are not examined in the light of circumstances prevalent in the region with which the researcher is concerned.

In order to be of practical value, a theoretical approach to a problem must at least imply the exceptions or variations which will be encountered in the problem's specific examination. That is to say, theories should not be so generally stated that

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[2]For a recent condemnation of the results of ethnocentricity in economic development research, see, Polly Hill, "A Plea for Indigenous Economics: the West African Example," Economic Development and Cultural Change, XV (October, 1966), 10-20.

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they lose all meaning when attempts are made to test them empirically. In the present example, unless it is known whether farmers carry their goods to market on their backs, by bicycle, or by wagon, a real estimate of transport costs cannot be made. Perhaps more importantly, more difficult to determine, and therefore less likely to be measured, the inclination of the farmers to use a more highly mechanized form of transport to market should be known. If private trucks are not used to pick up produce close to the field in which it was grown, it is very important to know whether this is because of high deterioration costs on trucks resulting from the low quality of roads in the area, greedy middlemen who demand high rates for movement of the goods, the farmer's perception of the value of their own time, the distances involved, or incidental benefits derived at the market place, e.g., social contacts or relief from relative isolation. Unless such attitudes and behavior patterns are well understood, decisions should not be made concerning improvement of transport facilities, primarily roads, which may have no effect on relative costs to the farmer, thus limiting the expected response of greater production.

The average farmer's gross income may be more easily determined. For present purposes, agricultural output not consumed on the farm is considered to have cash value, regardless of its cultural context. The price and the quantity of produce sold provide the relative level of gross farm income. Such minor or basically non-farm sources of income as sale of mulch or occasional pieces of timber, share of bridewealth, and so forth, can usually be excluded from any calculation of total farm income; they are too irregular and most often a very small proportion of the total.

With costs and total farm income determined, it is obviously possible to calculate the spatial variability of net farm income, or profit. On a regional as on an individual basis, the profitability of farming varies inversely with total costs; in areas of high total cost, whether caused by production or marketing, profits will be lower, *ceteris paribus*. The difficulty is that rarely are "other things equal." Better prices may be obtained by farmers frequenting some markets rather than others on the basis of quality, reputation, or favoritism. Without adequate supervision, farmers in one area may be given less than the standard market price by an unscrupulous trader, a practice made worse by the lack of accurate information on such matters available to the farmer. Nevertheless, a map of total cost of production, given all the variability of the elements of cost, subtracted from a map showing total value of existing production (i.e., volume multiplied by price) will result in a map illustrating the variability of farm profits, or spatial differences in "profitability of farming" at the present time.

Potential

The next element in the method of determining transport investment priorities is that of total production potential. This pattern may be best derived and mapped by the use of ecological regions and the suitability of each such region for agricultural production.

Although there are numerous definitions of the concept of ecology, the basis of almost all involves the interrelationships between, even the interdependence among the various aspects of the environment. This general juxtaposition is dominated by the study of the interdependence of living things with respect to each other and also to the impersonal forces or actions of nature. Thus, the way in which man affects the "natural balance" and conversely, the way in which man is affected by nature are both seen as legitimate fields of research open to the ecologist For the present purposes, the manner in which plants of use to man are limited by environmental characteristics is of primary concern.

At a given level of technology, the upper limits placed on the productivity of a given crop are set by the suitability of environmental characteristics in the area in which it is being grown. Other elements of agricultural production act upon these limits so that they are rarely, if ever, achieved. But as a determinant of the absolute yield, it is the environment which

is crucial. Thus, incomplete knowledge or a value system which does not contain maximizing output as a relevant issue will prevent the environmental bounds from being approached. Consistent with this argument is the position which holds that the limits which man places on the production of crops by his own behavior are not as immutable as those levied by nature.

The errors contained within this argument, however, pivot on the assumption of a given level of technology. As with Malthus, the fact that a change in agricultural technology, in effect, changes the environment cannot be ignored. Irrigation, fertilizers, and the steel-bladed plow are clear examples of technological innovations which brought about changes in the effective environment. They have permitted crops to be grown in areas which could not support production at the same level before the new tool or technique was developed.

It is important, however, to remember the use to which the concept of ecological regions is to be put. The concern here is with total agricultural production potential. Changes in environmental suitability for agriculture based on future technological developments are unpredictable, and therefore irrelevant for the present purposes. They are important in theory, but not pertinent in practice until they occur. Furthermore, if a study area is divided into a number of distinct ecological regions, i.e., "homogeneous" regions defined on the basis of soils-vegetation-relief-climatic association, a technological improvement affecting the agro-suitability of one or more of these regions will merely increase that region's production potential by some factor. In turn, this will affect the present attempt in substance but not in style or validity.

These, then, are the next steps in the procedure under consideration, the method by which a priority for regional investment in agriculture and transport facilities may be objectively determined. Ecological regions, which by their internal similarity of environmental characteristics indicate a basically similar support for plant growth, must be delimited. Each ecological association indicates a potential level of agricultural production per unit area. Once the estimates of these levels have been made, relative cropping capacities may be determined and total value of these production capacities may be areally indicated for the entire study region. By then subtracting the spatial distribution of existing cost of farming, as determined above, from this map illustrating total potential income from farming, a map of the total potential profitability of farming is obtained. By then subtracting the spatial distribution of the existing profitability of farming from this derived estimate of total potential profitability, a final map will result illustrating the variations in profit improvements possible in farming within the study area.

The general concept of the use of ecological regions to define agricultural potential is not new. Mr. L. H. Brown, agricultural economist, ecologist, natural historian, and ex-civil servant in Kenya, outlined in a number of unpublished reports the ecological regions of two of the major agricultural areas in Kenya.[3] In these reports, Brown describes the major ecological divisions within these areas and then offers combinations of farm production which would take best advantage of the environmental characteristics of each such sub-region. The immediate purpose of these reports was to indicate reasonable production goals for African farmers and guidelines for approaching these goals. The purpose of the present paper is to make a similar use of these ecological regions, and then extend the results to achieve much broader ends.

Movement Facilities

The final task preliminary to completing a methodology for determining investment priorities for agricultural transport facilities deals with the costs of goods movement. Assuming for the moment that no human variables are involved, the cost of moving goods is proportional to the type of good, the mode of

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[3]For a more available publication of the statistical sections of the report not used in the present study, although presented with no reference to Mr. Brown's authorship, see, Eric Clayton, Agrarian Development in Peasant Economies (New York: The Macmillan Company, 1964), pp. 35-39.

transport, the quality of the road surface, the rate of movement, and the distance traveled. Bulk goods are less expensive to transport than freight which requires special or individual handling. The smaller the volume moved and the shorter the distance it is to be carried, the more costly it is, per unit volume or per unit distance, to transport the freight by railway relative to road carrier. Maintenance costs and rate of vehicle deterioration rise sharply with a decline in quality of running surface. Unless the freight has high utility, and therefore high value, the increase in speed of carriage beyond a certain point becomes less economic, i.e., more costly in proportion to the returns gained by faster service. Finally, in absolute terms, it always costs more to move goods a greater rather than a lesser distance; more out-of-pocket funds, more time, more effort is involved. In a precise accounting of transport costs, all of these factors must be considered. The present task will treat each of these aspects of transport costs, but will do so to varying degrees of thoroughness.

As mentioned earlier, man and his idiosyncrasies cannot be so easily ignored when theory is applied to reality. In terms of transport costs in a facility-poor and an agricultural region, this can mean many things. To a farmer who pushes his produce to market piled high on the rear of his bicycle, the "effective" cost may be no greater on unimproved earth roads than on gravel roads.

If his farming is such that he has extended periods of non-working time, a greater distance to market may not be perceived as involving greater costs, whether in time, effort, or capital. An improvement of facilities, therefore, would not result in greater individual profits in such instances, because these aspects of transport costs were not seen to exist as costs.

Further such complications arise if a middle-man is involved in produce transport. As often occurs in parts of the world where small-scale cash cropping is beginning in isolated rural areas, an entrepeneur-trader may grasp the opportunity to gain profit from the wide separation between farmer and market, separate in physical distance and in knowledge of market prices. The "marketing agent" travels through the rural area in a truck, purchasing produce at a price enough below the market price to obtain a profit for himself after paying his own transport costs. If the farmers do not know the price their produce would obtain at the market, there may be little reduction in their total costs of production even after road improvements; the agent would simply receive a larger profit. On the other hand, if the farmer does know the market price, or becomes aware of it after improvements in road facilities have been made, there could be a dramatic shift in methods of marketing, perceived costs of marketing, and thereby a change in total output. It is important, then, before attempting to apply the method being developed here, to determine the farmers' degree of awareness of true market prices, their reaction to these prices in terms of the decisions made to gain full advantage of such prices, the importance, if any, of perceived transport costs to their production efforts, and if possible, the differences between the true cost of transport and the rates charged by goods carriers, whether contracted or itinerant.

As will be seen in the application of the present methodology, many of these complications of reality have not been taken into account. This is due to expediencies involving time and resources, for most such research, designed to make theoretical derivations more realistic for a specific region, requires considerable time and manpower. In the application, then, the following assumptions are made: costs of movement over land distances are those of road motor hauliers in all cases, unless specifically designated otherwise; a reduction in transport costs will result in a comparable reduction in the total average production costs of the farmers; a reduction of total average production costs will lead the farmers to attempt to approach more closely the maximum potential production of which their land is capable. With these costs determined and the assumptions understood, it is possible to outline the final phases of the investment priority determination technique being developed here.[4]

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[4]Some readers might ask: What of the assumption that a decrease in costs and a proportionate increase in profit will

At any given level of production costs, quality of road surface, and volume of goods produced, the priority for investment in transportation facilities in agricultural areas may be easily determined. By determining the changes in movement costs which would follow from an equivalent investment in each road in the study region, depending in part upon the amount of traffic to be carried and variable with the existing quality of the roads, a map of relative road investments may be constructed. This map may then be compared with that map derived earlier illustrating the variations from place to place in the potential improvement of farming profitability. Obviously, then, those areas with the greatest improvement potential which can be reached by the least investment in upgrading transport facilities should be the first areas to benefit from reduced movement costs. That is, those roads connecting areas of greatest potential profit improvement while themselves requiring the least relative investment should have the highest priority in an investment schedule for road facilities.

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necessarily result in a greater desire to produce? Can it legitimately be assumed that more money for the same effort will induce more work in order to gain even more money? It can be assumed, but it should be tested. The present study, however, is not concerned with this problem. The focus, again, is concentrated upon the reasons for making one decision rather than another, i.e., on investment decisions. The question is <u>not</u>: To invest, or not to invest? but whether objective justification may be made about a decision concerning investment in an A-type or a B-type project.

This procedure is one which may be made dynamic. That is, with suitable adjustments in several of the factors, a series of differing investment priority schedules may be determined. Changes in volume, and therefore total value of crops produced, in any of the agro-ecological regions will result in an alteration of the difference between total existing and total potential profitability. Thus, as regions are improved and more produce grown, they are less likely to justify further transport investments unless they have considerably more potential relative to the other parts of the study area. Furthermore, by gradually upgrading in the procedure the road quality of those roads which have been improved, the ratio between costs of investment in movement facilities and the level of profitability improvement possible in the areas to be connected with market outlets will also change. That is, as higher investment costs are required and existing profits are increased, the overall differences between improvement costs and improved profits will be diminished, and a change in investment priorities will result.

A final note should be added to this outline regarding non-economic considerations. Ideally, there should be no conflict between economic and non-economic pressures on decision-makers. In reality, however, an efficient economic decision may be a despotic decision. Political or religious expediencies often force economically sound undertakings to be set aside, modified, or in some way diminished in effectiveness. The present author has no quarrel with such considerations. They are made or not at the option of the national leadership, or the people as represented by this leadership. It is simply not within the scope of this volume, or indeed, the jurisdiction of its author to attempt to take such considerations into account. While it is hoped that a method for making objective decisions, such as the one presented here, could be implemented without undue personal dislocations, it is recognized that such a hope may be somewhat fatuous. It is recognized and it is admitted, but it is not excused.

PART III

APPLICATION

CHAPTER IV

THE COSTS OF MOVEMENT

A basic concern in determining total costs of production to small-hold farmers in rural areas of Africa is that portion of costs required to overcome location separation of the producer and the consumer or his agent. Transport charges may be a crucial element in the productivity of an area. Transport costs are "crucial" not necessarily in the sense of raising output per unit input or per unit area, but more in the distinction between limited, subsistence production with an occasional surplus and commercial production with considerable commitment by the farmer to production for sale. The distance between production and demand centers is obviously of little relevance to the producer if his primary goal is subsistence.

There are numerous components of transport costs which, in different combinations, result in varying levels of movement-vehicle operating cost. These costs may be classified as fixed or variable. For highway carriers, the former include such factors as vehicle purchase cost and licenses, terminal construction and maintenance, administrative wages, and the like. Fixed costs are those which must be borne regardless of the volume of traffic moved. Variable costs, then, include costs of fuel and oil, tires, vehicle maintenance, and in some proportion, vehicle depreciation and drivers' wages. In the following discussion, and in construction of the map of transport costs, it is the strictly variable costs of fuel, oil, tires, and maintenance which are used as a measure of these costs. In the present case, these variable, or "out-of-pocket" costs will be taken to approximate the transport cost to the small-scale agricultural producer. This may be justified not only on the basis of data availability, but also in the argument that since few such producers will own their transportation, there will be a tendency for trucking charges to fluctuate with the amount of freight carried. Freight charges, reflected by operating costs, will also fluctuate with several other factors. It is to these factors that the discussion would now be turned but for an objection that may have arisen in the mind of the reader.

It may be objected that there need be no relation between variations in cost, borne immediately by the transport operator, and the rates charged the farmer for shipment of his goods. The former figure, after all, does not include operator profit while the latter does. Since it is cost to the farmer which is of concern in this volume, considerable error is possible by substituting operating cost for transport charges. In reply to this argument, it must be remembered that entry into the trucking industry is relatively easy. Without restrictive licensing, there is some evidence that road transport is viewed by African entrepeneurs as an area fertile with development possibilities.[1] Under such conditions of competition, discriminatory pricing between commodity classes will be minimized and charges will be closely related to costs.

Data, unfortunately, are not available to substantiate an assumption of large volume entry into the trucking industry by numerous individual Kenyans. There is some question over the precision of road license statistics, but as Table 4-1 indicates, the trend in commercial vehicle licensing is unclear. It may be

TABLE 4-1

NEW MOTOR VEHICLE REGISTRATIONS, 1960-1965

	1960	1961	1962	1963	1964	1965
Motor cars	5,007	3,653	4,305	4,466	4,058	5,031
Utilities	2,914	2,118	2,422	2,542	2,974	3,402
Lorries	857	714	618	799	658	785
Buses	243	186	206	289	281	252
Motorcycles	1,151	634	536	602	650	729
Other	740	452	557	753	980	850
Total	10,912	7,757	8,644	9,451	9,601	11,049

Source: Kenya, Economic Survey, 1966, p. 56.

too early after true independence, however, for indications of

[1]See, E. K. Hawkins, Road Transport in Nigeria (London: Oxford University Press, 1958).

entrepeneurial activity of this nature to be reflected in ownership or registration statistics. It should also be pointed out that many African smallholders engaged in cash crop productions operate through co-operative marketing societies. Under such an arrangement, profits on transport of produce are negligible since most societies are large enough to operate their own "lorries," or trucks, and maintain administrative operations by more direct levy.

Factors of Transport Costs

Vehicle operating costs will vary under a number of different operating circumstances. For example, the quality of the road surface will affect out-of-pocket costs. As road quality declines, maintenance costs increase, as does tire wear. Average speed is reduced, resulting in fewer trips per week and possibly, higher fuel consumption. Similar influences on truck operating costs result from variations in road alignment, gradient, speed of operation, volume of traffic or congestion, and traffic "composition," or the types of vehicles operating in what proportion. Of all these factors of haulage costs, those relating to road conditions (surface, alignment, gradient) are likely to have the greatest effect on costs in Nyanza Region and Kericho District. Maximum vehicle speeds are limited in Kenya by weight class, traffic volume is rarely high enough to warrant a label of "congestion," and the factors making traffic composition important are a function of gradient and deterioration of road surface.

Of the three elements of route condition, the effects of alignment, or horizontal road curvature, are the most difficult to assess. This difficulty arises in the individualized nature of the source of a high proportion of cost variation based on this factor. As Winch has pointed out with regard to road alignment, ". . . the exact correction factors needed in a particular case will depend on observed driver behavior, and may well differ for different types of roads in different areas."[2] Therefore, while road alignment _may_ be a factor of significant weight, seriously affecting vehicle operating costs, there is no clear indication that it _is_ such a factor. For present purposes, effects of alignment will be considered proportional to the effects of the other factors of road quality, at least within the study region.

There is an inverse relationship between the quantitative factor of vehicle operating costs and the qualitative one of road surface condition. Costs increase as road surface quality declines. Unfortunately, it is rather problematic to determine this relationship with any precision. In an attempt to discover the manner in which these costs varied within three general categories

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[2] David M. Winch, _The Economics of Highway Planning_ (Toronto: University of Toronto Press, 1963), p. 70.

of road quality for five countries in East and Central Africa, Bonney and Stevens were forced to conclude:

> No direct comparison can be made on a cost basis between the various countries owing to local variations in unit costs but the results show a consistent pattern although data on improved routes are restricted. . . . These variations can result from local standards of road construction and road maintenance, terrain, vehicle age, traffic volumes and climate.[3]

In spite of these reservations, it is necessary to discover the approximate cost-proportions for the several qualities of road surface.

In addition to the research conducted by Bonney and Stevens, data on cost variability with road surfaces is provided by a study in Kenya by Klein[4] and one near Lake Victoria in Tanzania by Halcrow and Partners.[5] All three studies list average operating costs per mile for several vehicle sizes over a number of road surfaces. Although it would be difficult to defend

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[3] R. S. P. Bonney and N. F. Stevens, "Report on the Investigation into Vehicle Operating Costs in East and Central Africa, Part III. Kenya and Uganda," Laboratory Note No. LN/606/RSPB.NFS, Road Research Laboratory, June, 1964 (unpublished), p. 6.

[4] Martin S. Klein, Economic Feasibility of Improving Two International Highway Links in Kenya (Cambridge, Mass.: United Research Incorporated, 1965).

[5] Sir William Halcrow & Partners, Report on the Feasibility of Constructing Roads to Serve the Buyagu Cotton Zone and Preliminary Route Location for a Road from Busisi via Buyagu to Kharumwa and for a Link to Kasamwa (Ministry of Communications and Works, Government of Tanzania, August, 1966).

comparability of road surface criteria, it is useful to group the more numerous classes used by Halcrow and Partners, and by Klein, into the three general categories of paved, improved, and unimproved roads after Bonney and Stevens. These operating costs, and the grouped averages, are shown in Tables 4-2 and 4-3.

TABLE 4-2

VEHICLE OPERATING COSTS,* OPERATED IN THE GEITA PENINSULA, TANZANIA, 1966 (EAST AFRICAN CENTS PER MILE)

Road type	cars, pickups, vans		3-5 ton lorries		6-8 ton lorries	
		grouped		grouped		grouped
Bitumen	-/42	-/42	-/62	-/62	-/83	-/83
Gravel "spine"	-/53		-/77		1/03	
Graded earth:		-/59		-/83		1/16
"spur"	-/64		-/89		1/28	
existing	-/76		1/17		1/59	
Track,		-/86		1/27		1/77
cross-country	-/95		1/37		1/94	

*Cost components included are only those attributed to fuel, oil, tires, and maintenance and repair.

Source: Sir William Halcrow & Partners, Report on the Feasibility . . . , 1966.

Even quick calculation of the ratios represented by the three categories of road surface demonstrates a surprising similarity among these proportions regardless of the weight of the vehicle. These ratios, shown in Table 4-4, are also similar to that determined by

TABLE 4-3

VEHICLE OPERATING COSTS,* OPERATED IN KENYA, 1963 (?)
(EAST AFRICAN CENTS PER MILE)

Road type	Light vehicles		Heavy vehicles	
		grouped		grouped
Bitumen	-/70	-/70	1/40	1/40
Improved gravel	-/84		1/68	
slightly impr. gravel	-/98	-/98	1/96	1/96
improved track	1/11		2/23	
slightly impr. track	1/26	1/33	2/51	2/65
unimproved track	1/40		2/79	

*Cost components are those used by Klein and may not be directly comparable to the figures in Table 4-2.

Source: Martin S. Klein, Economic Feasibility . . . , 1965, p. II-15.

TABLE 4-4

RATIO OF VEHICLE OPERATING COSTS,
BY ROAD SURFACE QUALITY

Study	vehicle weights	paved	unpaved improved	unpaved unimproved
Halcrow	cars, pickups, vans	1.00	1.40	2.05
Halcrow	3-5 ton lorries	1.00	1.34	2.05
Halcrow	6-8 ton lorries	1.00	1.40	2.13
Klein	"light"	1.00	1.35	1.90
Klein	"heavy"	1.00	1.40	1.90
B and S		1.00	1.22	2.06

Bonney and Stevens for Zambia, the only country for which an "improved" category of road was available. The variation in costs on "unimproved" roads is not unexpected; it is this low-quality road category which would contain roads most susceptible to variations in relief, precipitation, maintenance frequency, and so forth. The single departure from a rather close grouping of operating costs on unpaved but "improved" roads may be attributable to a great many variables such as those described by Bonney and Stevens, above. Indeed, one of the most startling aspects of this comparison of cost ratios on the three categories of road surface is the general propinquity of the figures within each road class. On the basis of these figures, the ratio used in the present volume for vehicle operating costs over roads which are paved : improved : unimproved has been accepted as 1.0 : 1.4 : 2.0, respectively.

This ratio of out-of-pocket operating costs designates the manner in which transport costs vary with differences in road surface quality. Although there are numerous factors affecting operating cost other than that used to determine this ratio, for simplicity it is assumed that all but one of the additional cost factors vary directly and in the same fashion as costs due to variable road surface quality. In other words, the ratio 1.0 : 1.4 : 2.0 for paved, "improved" (gravel), and "unimproved" (earth) road surfaces, remains constant with the inclusion of the other cost variables. The factor which cannot justifiably be considered to vary in this manner is cost variability due to topographic relief, or road gradient.

The effects of gradient, primarily the rate of grade,[6] on transport operating costs are numerous. The vehicle's power unit will have to work harder per unit distance on sloped vis-a-vis flat conditions. There is an increase in fuel consumption and an increased time on the road when the route consists of steep slopes. Furthermore, by reducing the maximum load which can be carried, it becomes necessary to use additional carrying units, thus increasing average costs per ton-mile. "There are many factors governing the extent of these effects, the most important of which are: rate of grade, length of grade, combination of grades, over-all rise and fall, approach conditions, terminal conditions, power of vehicles, and the necessity to change gear or brake."[7]

A fairly large proportion of the region under examination in the present work contains considerable topographic variation. Virtually all of Kisii District and almost all of Kericho District are very hilly while much of South Nyanza District has rolling to moderately hilly relief. A truck operating exclusively within

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[6]In the United States, an _x_ percent grade is a vertical rise of _x_ feet per 100 feet horizontal distance.

[7]Winch, _The Economics_ . . . , _op. cit._, p. 69. For further discussion on most of these factors, see, William W. Hay, _An Introduction to Transportation Engineering_ (New York: John Wiley & Sons, Inc., 1961), pp. 217-22.

these regions would be continuously confronted with relatively high road grades with an associated increase in operating costs. At a four percent average grade, fuel consumption is approximately 15% above that on level roads; at 5 percent grade, fuel consumption increases to better than 40% beyond that for level roads; and with a 6 percent grade, fuel consumption is nearly double the amount averaged on 0-1 percent grade roads.[8]

The basic concern in the present volume, however, is with movement from production areas to market outlets, and return. It is on these costs, under the proper conditions of competition, that cost to the producer will be based. The two major outlets for the study region are Kisumu and Lumbwa, both of these stations being located at altitudes lower than the region which uses them as railheads. Most of the gain in fuel costs made by lorries (trucks) transporting goods to these markets--more downhill than uphill grade--will be lost on the return trip. Between the fact that grades on most main roads are less than four percent, and the fact that cost increases or decreases on inbound and outbound transport will tend to balance each other, the impact of gradient variation on a map of average transport costs will be small. In the present volume, therefore,

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[8] G. J. Roth, "The Economic Benefits to be Obtained by Road Improvements, with special reference to Vehicle Operating Costs," Research Note No. RN/3426/GJR, March 1959, Road Research Laboratory, Crowthorne, U.K. (unpublished), see Figure 4.

this element of cost variation will be excluded. If more detailed data justify, or are required for, more precise application of cost factors in some future instance, this judgment may be false. At the present scale, it is not.

Absolute Transport Costs

In order to construct a map of transport cost between any point in the study region and the major market outlets along the railway, some estimate must be made of absolute levels of cost rather than the relative costs described by the ratio 1.0 : 1.4 : 2.0. On the other hand, the problems associated with determining a single level of cost for each class of road are considerable, as has been discussed before. By referring to Tables 4-2 and 4-3, the reader can see that the impact of vehicle weight on operating cost is as great as the impact of differing road surface quality. Klein shows that a light weight vehicle, operating on unimproved track, costs no more to operate per mile than a heavy vehicle traveling on bitumen. Similar difficulties are raised because of the inclusion, or exclusion, of different cost components by different authors. Klein, again, does not designate the components of his figures of "average operating costs" per mile; they undoubtedly include such factors as driver's wages, depreciation, and possibly profit.

Hints toward the solution of these problems come from personal observations in Nyanza Region and Kericho District during 1966. Very rarely were vehicles above 6-ton tare weight observed in this region. Almost all were three to five ton lorries, or the smaller pick-ups and vans. The latter were operated chiefly by small merchants from towns such as Kericho, Kisii, Sotik, and the like, carrying non-agricultural goods. It should be acceptable to assume, then, that under present conditions of vehicle availability and operation, the dominant trucks transporting surplus agricultural produce are within the three to five ton category. The only direct data on lorries of this weight group is in the Halcrow report, the cost per mile on bitumen roads being -/62 cents. Confirmation of this general level of costs does come from the studies conducted by Bonney and Stevens. Also dealing with vehicles of a wide tonnage range, their figures are averages of costs for each vehicle and are therefore liable to be closer to the middle category of vehicle sizes than to either the very light or the very heavy trucks. By converting their figures[9] from "pence per gross ton mile" to "East African cents per ton mile," taking into account the relative distances traveled by each vehicle and the variation in gross weights of the trucks, the average operating costs for vehicles moving on

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[9]The detailed data for Zambia is given in the authors' "Report on the Investigation into Vehicle Operating Costs in East and Central Africa, Part I. Zämbia," Laboratory Note No. LN/344/RSPB.NFS (revised), Road Research Laboratory, February, 1965 (unpublished).

bituminous roads was calculated to be -/61 cents per ton mile.

With these figures, the foundation for accepting an absolute level of transport operating costs has been laid. Although the degree of similarity between the data for both the Bonney and Stevens report and the study made by Halcrow and Partners may prove coincidental, the fact that they are very close provides support for the use of a similar cost figure here. For purposes of simplicity in calculation, the cost of movement per mile over surfaces of paved, improved unpaved, and unimproved unpaved will be taken to equal Shs. -/60, -/84, and 1/20, respectively. These figures are, of course, based on the ratio of vehicle operating costs over the three road quality categories as determined earlier.

Further support for these cost levels is received from two agricultural officers dealing with movement to and from the study region. Although actual cost data were not available from trucking operators, ostensibly on the grounds of inadequate information, both men provided independent educated estimates which in their similarity lend credence to the cost estimates accepted for the present work. The District Agricultural Officer of Kericho District pointed out that maize grown in the district may be sold to the Produce Marketing Board. There is a seven cent (-/07) cess per 200 lb. bag per mile for transport of this maize from market stall in the rural areas to the Board store.[10] The cost to the farmer for movement of his corn surplus to the Board store therefore is -/70 per ton-mile. The present author was also informed by a staff member of the Pyrethrum Marketing Board in Nakuru that pyrethrum is carried from Kisii District to the Nakuru factory at about five shillings (5/-) per mile for a one-way load.[11] Since the lorry carries about 130 bags of pyrethrum flowers at 65 pounds per bag, or approximately 8450 lbs., this is a cost to the producer of about 1/20 per ton-mile, or -/60 per ton-mile each way on the predominantly bitumen road. With these additional indications of transport cost levels, the absolute costs are well established, albeit in an indirect manner.

Using estimated movement costs for each category of road surface, a map was drawn showing trip costs for three to five ton trucks from any location in the study region to either of the major produce outlets for the region, i.e., Kisumu or Lumbwa (Figure 4-1). All road distances were first measured regardless of road surface quality. Such measurements were made on virtually every road or track "suitable for wheeled vehicle" in the study region (see Figure 4-2). In converting these distances to cost-

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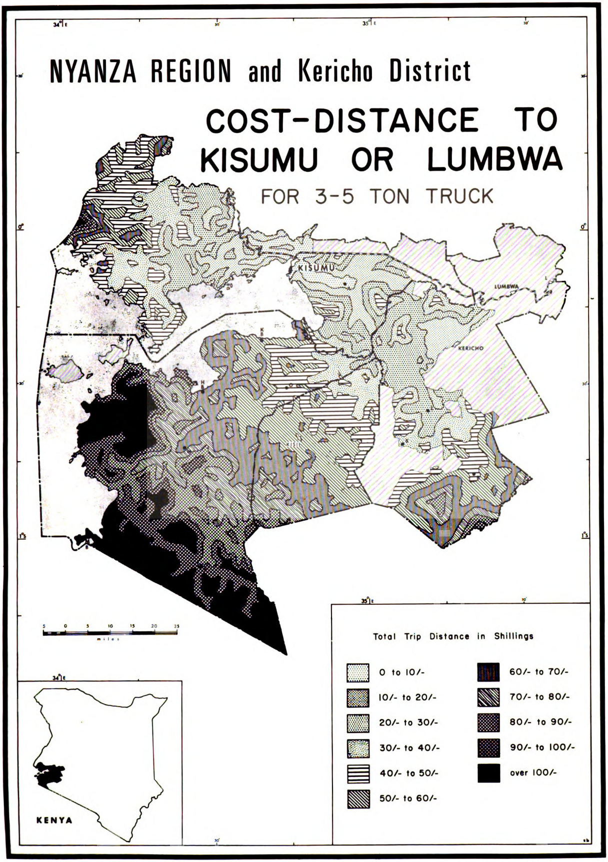
[10] Interview with Mr. J. Birir, D. A. O. Kericho District, November 12, 1966.

[11] Interview with Mr. R. J. Munro, November 11, 1966.



NYANZA REGION and Kericho District
COST-DISTANCE TO KISUMU OR LUMBWA
FOR 3-5 TON TRUCK
KISUMU
LUMBWA
KERICHO
Total Trip Distance in Shillings
0 to 10/-
10/- to 20/-
20/- to 30/-
30/- to 40/-
40/- to 50/-
50/- to 60/-
60/- to 70/-
70/- to 80/-
80/- to 90/-
90/- to 100/-
over 100/-
KENYA

FIGURE 4- 1

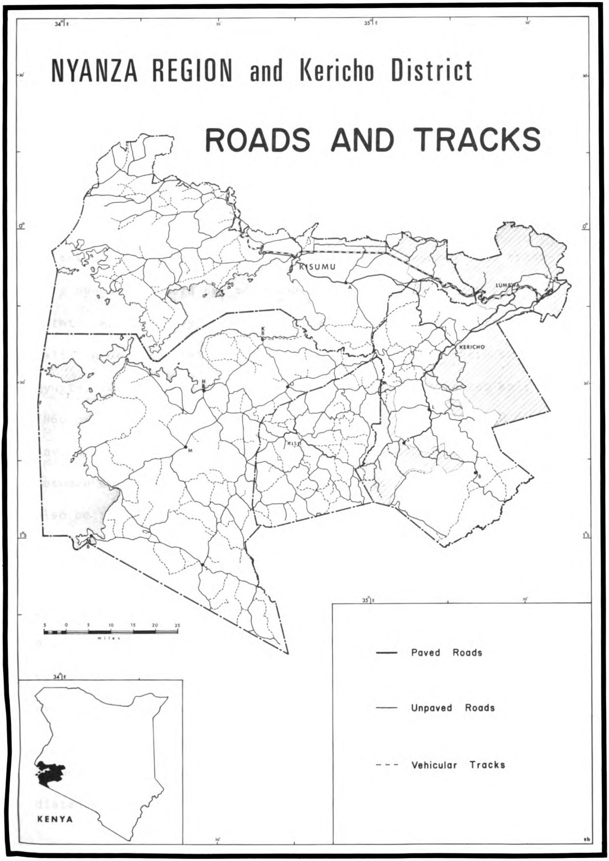

NYANZA REGION and Kericho District
ROADS AND TRACKS
KISUMU
KERICHO
LUMBWA
KISII
KENYA
Paved Roads
Unpaved Roads
Vehicular Tracks
miles

FIGURE 4- 2

distances--based on the various qualities of road surface--and constructing Figure 4-1, a series of assumptions were made. While these assumptions were necessary for clarity and do not undermine the theoretical development of the present illustration, they should be made explicit.

One of the most basic assumptions involved the consistency of road quality within each category. It was assumed that transport operating costs per mile would be the same over any road within each category. While necessary, this assumption is not valid in detail. The unpaved-improved road between Ahero and Oyugis, for example, was being upgraded during the latter half of 1966 preliminary to bitumenizing. Until funds are obtained to pave this road, it will continue to appear a more costly route between Kisii and Kisumu than it actually is. The question may also be raised whether all tracks rated "suitable for wheeled vehicles" are actually passable in any season other than the very driest. The so-called "all-weather" roads are also often found mis-named during the heavy rains. Without detailed data on all the roads in question, and their quality variation from season to season, each category of road surface has been considered of even quality and possible seasonal variations ignored.

The isopleths of transport operating cost, shown on Figure 4-1, have been drawn on the assumption that minimum cost-distance to Lumbwa or to Kisumu was the distance which would be traveled by a lorry from any given point in the region. Thus, a shorter cost-distance route via an unimproved track may be shown rather than a more costly route which may be preferred and actually covered by an individual driver because it is an improved road. Similarly, the railway rate differential between Kisumu-Nairobi shipments and Lumbwa-Nairobi shipments was not taken into account when Figure 4-1 was drawn. The fact that these railway charges vary with the product being shipped, and in any case are relatively low, argued for this exclusion. Finally, isopleths of movement cost-distance in areas containing no vehicular roads, only foot- and bicycle-tracks, were drawn on the basis of one to two miles per ten shillings movement cost. While these costs would undoubtedly be much larger if the labor involved were assigned even moderate wages, it would be unrealistic to do this at the present time.

Examination of Figure 4-1 shows nothing startling in its pattern of transport cost levels. The lower cost-distances from Lumbwa and Kisumu extend outward from these railheads along major roads toward each other and the interior of the study region. Total movement costs to these foci merge between twenty and thirty shillings, with the major trend of these costs increasing rather regularly beyond thirty shillings to the southwest through Kisii and South Nyanza Districts, and to the west in that portion of Central Nyanza. Major variations from this pattern are those areas containing no vehicular roads at all.

Two objections may be raised in regard to the cost-distance pattern of Figure 4-1. One of these is that the isopleths should be drawn with reference to the nearest railhead, not only to Kisumu or to Lumbwa. Examination of freight consignments in each of the stations between Kisumu and Lumbwa, however, showed that traffic moving through these railheads was almost entirely local in character, most of the outbound freight originating in the large commercial farms north of the railway. While more of the freight shipped from the stations north of Kisumu does originate within the study region, much is transported directly to Kisumu by road. For the sake of consistency, Kisumu was kept as the sole focus of produce movement in the western part of the study region.

The second possible objection to the pattern derived for Figure 4-1 is that since the several ports operated by the East African Railways and Harbours were not part of the cost-distance calculations, the map does not show actual movement costs to Kisumu. While this may have been a valid criticism a decade ago, there are indications that the cost difference between moving freight via the road-lake route and completely by land is rapidly disappearing. Improved roads, inadequate "go-down" or warehouse facilities at the ports, speed, flexibility, and an increasing demand for consumer goods in the interior portions of the study region have combined to encourage movement to Kisumu from Kisii District and much of South Nyanza solely over land routes. Most of the parchment coffee, for example, shipped by the Kisii Farmers Co-operative Union, now moves directly to Kisumu by lorry. There are cases where lake movement is likely, but for present purposes these are exceptions and have been specifically pointed out later in the volume.

With the spatial variation in transport costs determined it is necessary to turn to the somewhat more problematic determination of the spatial variability of agricultural production costs.

CHAPTER V

THE COSTS OF PRODUCTION

When the question of crop production costs is raised to agricultural economists, the responses will be widely varying; only rarely will they have ready replies. There have simply been too few studies made in detail to provide definite answers to this question even in the dollars-and-cents (or pounds-shillings-pence) framework of Western economics. That this cultural context may not be pertinent in Africa has been questioned before.[1] Whether because of the wide range of variables involved, the "irrational" or at least "unclear" motivation of the African smallholder from Western points of view, or colonial predilection for focus on total output rather than relative income, formal attempts at objective determination of farm production costs in Kenya--and other part of Africa--have been quite recent.

It is not difficult to accept the importance of crop production cost knowledge in newly independent Africa. A great majority of the population of Kenya are farmers. The well-being

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[1]See the discussion of this point in Chapter III.

of the nation as a whole cannot be improved solely by industrialization in the few large urban centers, although political pressures may be stronger and more immediate in the cities. The personal income of smallhold African farmers can be increased by improving the volume or quality of output, thereby increasing gross income, or income can be made larger by focussing attention on production costs in an attempt to reduce those costs which are unnecessarily large. To do this latter, of course, a clear picture of the various components of cost must be appreciated. On a practical level, production costs are an element to be included in the proper consideration of agricultural loan applications from individual farmers. In other words, once the objective of "improved personal well-being for every citizen, urban and rural" is accepted as a national goal, it becomes imperative to be capable of assessing input-output relationships with some detail both for purposes of planning resource allocation and for more immediate economic operations.

Problems of Cost Determination

The various expenses to be enumerated and analysed in a detailed accounting of crop production costs are numerous and difficult to determine. Many of those costs directly attributable to a particular crop or stock unit are of a type which varies with the productive unit. Coffee, for example, requires cost components of fertilizer, mulch, manure, sprays, and replacement seedlings in addition to labor costs associated with each of these plus labor for cultivation, planting, weeding, and harvesting. Such components for cotton, tea or sugar cane are at a completely different volume, if they are even part of the production process. Some crops have high seasonal labor demands while others may be grown and harvested without any need for hired labor. And on this last point, on what basis should "unpaid" family labor be evaluated--if it is to be included at all? How are joint capital costs (e.g., communal grazing land) to be subdivided among the several farmers? How can those elements of cost which apply to the general productivity of an enterprise without contributing directly to any specific process (e.g., materials for structural improvements, fuel for farm machinery in general use, and other "overheads") be included in a cost accounting of any of the individual crop accounts?[2] It should be evident that it is not an easy matter to correctly estimate the many directly accountable cost variations from crop to crop and the other cost variables more indirectly contributing to farm production.

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[2]For one attempt to allocate the various farm expenses, see, Government of Kenya, _The System of Recording and Analysis used in Production Cost Studies of Large Scale Farming in Western Kenya_ (Report No. 17; Nairobi: Farm Economics Survey Unit, Economics and Statistics Division, Ministry of Finance and Economic Planning, 1963).

In addition to the methodological difficulties posed by these complexities, there are a number of practical problems raised by the characteristics of African agriculture. Most of the population with whom cost researchers must deal are illiterate. Information concerning farm costs must either be obtained by frequent (and expensive) observation of farm operations by the research worker, or it must depend upon the memory of the farmer. If the farmer associates farm cost research with the taxes he must pay, or for some other reason doubts the motives of the questions being asked him, the accuracy of the data collected will be impaired. Many population censuses taken in Africa during the latter portion of the colonial period are of doubtful validity for this very reason. Fortunately, there are indications that data collected in this manner is available and fairly reliable, regardless of the degree of farmer literacy, if sufficient care has been taken preliminary to data gathering. A study of farm economics in western Tanzania specifically undertaken to answer such questions resulted in the general conclusion that "there is no question that the African farmer knows most of the details which we need to fully analyse his farm. His accumulated experience over a number of years must have left its impression on his mind, both quantitative and qualitative."[3] As the

[3]"Report on Bukumbi Survey, Completed February 1962," Western Region Research Centre, Ministry of Agriculture, Tanganyika (unpublished), p. 23.

report proceeds to point out, however, there are two basic barriers which must be overcome in gaining access to the farmers' information: the cultural and linguistic framework in which the questions and answers will be given, and the confidence and interest of the farmers which must be maintained throughout the research period. The accuracy of the results are largely a function of the efficiency with which these barriers are overcome.

Further problems of determining cost-of-production in agriculture are raised by variations in environmental conditions and in quality and quantity differences in yields. It is inexpensive to grow a given quantity of rice in well-watered, fertile, flat terrain which receives warmth all year long relative to the cost of growing the same amount of rice in a hilly, sub-arctic environment with a growing season of 80 days and effective precipitation under 15 inches annually. In the latter case, obviously, considerable capital in necessary to modify the environment so that the rice may be produced in yields even approaching the former environment's output, produced with only a relative modicum of labor or capital input. For most forms of agricultural produce, the relative suitability of the environment is a primary factor to be considered when studying the variability of production costs.

In reality, it is impossible to set, for a given product, an arbitrary quantity or quality level as a base for comparison of production costs between environments. The range of yield and produce quality is likely to be as wide within similar environments as between different ones. A poor or disinterested farmer will usually have low quality produce in spite of natural advantages. On a cost basis, this low level of output would ideally be represented by a low labor or investment input. However, such qualitative measures as the attention given by the farmer to weeds, pests, or market conditions, the desire of a farmer to provide for himself and his family more than a subsistence level of living, and the felt importance of extra-agricultural activities which may distract the farmer from his farm work are all extremely difficult to quantify.

From the foregoing discussion, it is not difficult to understand the less-than-positive reaction that an agricultural economist may be expected to make when faced with questions concerning average crop production costs. In spite of these problems, however, the importance of gaining a detailed understanding of the farm economics of small-farm African agriculture has been made clear. A number of studies of large-scale and small-scale farming in Kenya have been completed by the Farm Economics Survey Unit in response to the need for this knowledge. Although the cost figures obtained from these studies may be applied, strictly speaking, only to those areas in which the research was undertaken and for those years during which the data were gathered, they do provide guidelines for similar research needed in the area under consideration in this volume as well as tentative levels of average costs in environmental conditions similar to those in which the studies were made.

Reconciling Production Cost Variability

It is certainly possible to surmount the difficulties inherent in research of agricultural production costs, given sufficient time and money. Cost-of-production is first determined by crop and stock unit; these total costs are simply the sum of the costs of those operations directly contributing to each crop's output. Those over-all farm costs which cannot be attributed directly to individual crop output are totaled under a general category such as "overheads."[4] In several of the Kenya FESU studies, the difficulty of whether or not to include unpaid family labor is avoided by showing total costs for various crops both without any value attached to family labor and with family

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[4]There is no conceptual reason why several levels of such general farm costs could not be determined on the basis of grouped individual farm characteristics, say, by means of a modified form of factor analysis. This would provide others interested in farm production economics the means by which total farm costs could be estimated with a reduced number of factors describing the relative levels of these costs. To this author's knowledge, such factors have not been determined for large-scale or small-scale African agriculture.

labor costs included at the rates that would have been required if all work had been done by hired labor.[5] For a given farm, then, production cost estimates could be based on the quantities of each crop grown or stock unit carried and the amount of unpaid family labor available. The subjective element, dealing with farmer attitudes and the like, would still remain unmeasured.

Much more difficult is the resolution of the problem posed by variations in environmental suitability for a given farm enterprise and the accompanying variation in support for the optimum output of that enterprise per unit input. It is important to remember here that the specifics of optimizing crop yields continue to be rather elusive, even to agricultural research specialists. Environmental optima for any crop must be given as ranges rather than as singular criteria; it may never be otherwise, considering the interdependence of the many environmental characteristics even now recognized as crucial to crop growth. The effect on crop yields of one degree-day change in temperature may be countered by, say, a 0.3 rise in soil pH, or two inches greater precipitation during the week of highest

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[5]See, for example, Government of Kenya, "Some Aspects of Agricultural Development in Nyeri District, 1962," _Report No. 21_ (August, 1964), and ". . . 1963" _Report No. 24_ (August, 1966), Farm Economics Survey Unit, Economics and Statistics Division, Ministry of Finance and Economic Planning.

temperature, or slightly lower soil porosity, or lower average wind velocity, or . . . . When the variations in human commitment to obtaining the highest possible yield, and the continually changing possibilities for technological modifications of the environment are considered in all their variegated combinations, it is not difficult to understand the uncertainty of an "optimum" environment. That some environments will give a higher yield per unit cost--or will have a lower cost of operation per unit output--is certain; that the concept of an optimum environment has any reality is less clear.

The Precision of Cost Patterns

It may be helpful here to review the use to which crop production costs will be put in this work and the precision required by this application. The production costs for agricultural output within the study region are needed to complete the picture of total production costs which must be borne by the individual farmers in this region. It is the variation of current production costs from place to place, i.e., the spatial variation of these costs, which is of primary interest. The precision required in the present work is not such that detailed policy decisions may justifiably be made from its conclusions. This was explicitly stated earlier. When the present methodology is used preliminary to investment decision-making, detailed cost studies should be made on the basis of, perhaps, a one percent stratified sample, randomly chosen from the African farms located within each of the ecological regions comprising the study region. In this volume, however, the pattern of farm cost variation will be drawn on bases of less practical rigor but of equivalent conceptual soundness.

Assumptions

In order that a map may be drawn illustrating the spatial variation of the major cash crops in the study region, a number of simplifying assumptions have been made. Again, in a real application of the present method, these necessary assumptions may be much fewer in number, depending upon the financial resources available for research. At the scale of the present undertaking, the only crops included in the study are those which (1) have been marketed in large quantities during the first half of this decade, (2) show promise of continuing to be significant sources of cash income to the African smallholders in the study region, or (3) are cash crops which are not yet well established in the study region but could be grown there profitably if cultural-psychological factors do not prevent their success. By placing these limitations on the products to be included here, marginal crops with a very low year-to-year surplus for sale to external markets (e.g., finger millet or wimbi, sesame or <u>simsim</u>, grams and pulses, sorghum, castor, most vegetables, etc.) do not cloud the more individually remunerative cash crop pattern based on high value, often high output crops. In addition, possibly transitory crops (e.g., passion fruit[6]) and agricultural products originating almost entirely on non-African operated farms (e.g., wheat and wattle) are also excluded. In spite of these restrictions, the crops which remain are sufficient in variety and number to test fairly the proposed approach being presented.

It should also be pointed out that each crop comprising a portion of the pattern of crop production costs should be part of a system of crop rotation. This rotation may be three years pasture alternated with three years arable, as is common on the lower land in Kisii District,[7] or some other series. Some form

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[6]Passion fruit experienced a rapid rise in popularity among farmers in Kisii District as the following production figures indicate:

	Quantity marketed	Value recorded
1963	nil	nil
1964	316,498 lbs.	£2,374.00
1965	2,228,794 lbs.	£16,715.75

(Source: Department of Agriculture Annual Report, Kisii District, 1965, p. 14.)

An even more rapid decline in 1966 output was feared; the 1966 crop was being severely damaged by a fungal disease and the future of passion fruit as a source of income for small-scale farmers in the district was therefore difficult to predict. - Interview with Mr. Ogoda, Kisii District Cash Crops Officer, November 14, 1966.

[7]Interview with Mr. Ogoda, Kisii District Cash Crops Officer, November 14, 1966.

of rotation is necessary in almost every case, and small-scale farmers are discouraged from complete dependence upon cash crops. On the other hand, it is these crops--and regularly marketable surpluses of high-value food crops--that are of primary concern here. The factor of land use rotation and the important, but non-marketed, food crops that are part of this rotation will not be included, therefore, in considerations until much later in the work.

Location of Crop Production

Two important sets of information must be obtained before a map of the spatial variation of crop production costs can be made. The cartographer must know where the given crop is grown, and he must know how much it costs to grow that crop in any location within the crop's growing area. Some of the major theoretical difficulties in determining the latter have been discussed. For the reader unfamiliar with the very real problem of data availability (and reliability) associated with field research in low income countries, it may be said here that even the presumably simple task of determining the area in which a given crop is grown becomes an exercise in extrapolation, interpolation, and logic. Thus, a number of assumptions often have to be made and acted upon. A discussion of the various aspects of this exercise, and the assumptions associated with developing a map of the variations in

production costs for the crops to be considered, provides a clear example of the problems with such data. More importantly, the discussion illustrates the manner in which several important steps were made in the application of the method for developing a series of priorities for development investment presented in Chapter III. Readers directly concerned with such investment decisions, therefore, may be better able to test some of the assumptions made here, or to obtain more specific data not available to the author.

Knowledge of the crop production areas' locations in the four Kenya districts under consideration in this volume (Central Nyanza, South Nyanza, Kisii, and Kericho) varies in degree of reliability with each crop and each district. Tea production can be pinpointed with the greatest accuracy. All smallhold tea production in Kenya is under the tight administrative control of the Kenya Tea Development Authority (KTDA). The KTDA was founded to assist smallhold African farmers in establishing tea in a profitable manner through control of loans, sale of tea stumps, and marketing arrangements. Tea is an expensive crop to establish, about Shs. 3000/- per acre in Kericho and Kisii Districts,[8] requires particular care during the maturing period, and must be

[8]Interview with Mr. R. Moore, Acting Senior Tea Officer, West of Rift, Kericho, November 12, 1966.

marketed quickly and in large quantities because of rapid leaf deterioration. The green leaf must reach the factory for processing within six to eight hours after it is picked.[9] In order to maintain high prices, there is also a high quality standard demanded--and maintained. For all these reasons, the KTDA carefully limits tea production to those areas environmentally suitable for successful production. One result of this control has been the explicit definition of the areas in Kericho and Kisii which are available for smallhold tea development.[10] These areas are shown on Figure 5-1a.

The areas in which pyrethrum and coffee are grown can be deduced from a combination of each crop's environmental limits on successful growth and the distributions of pyrethrum collecting points or coffee factories. By outlining the distribution of pyrethrum buying posts in Kisii District,[11] for example,

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[9] _Ibid_.

[10] Boundaries were taken from: Edwards and Burrow, Consulting Civil Engineers, "Preliminary Report to the Permanent Secretary, Ministry of Works Communications and Power, Government of Kenya, on Tea Roads," Nairobi, 1964(?) (unpublished). Note: The Kericho limits may not be precise; a map of Kericho's tea area posted on the wall of the Senior Tea Officer's office in Kericho town showed another boundary enclosing a slightly larger area.

[11] Obtained from the office of the Cash Crops Officer, Kisii District, on November 14, 1966.

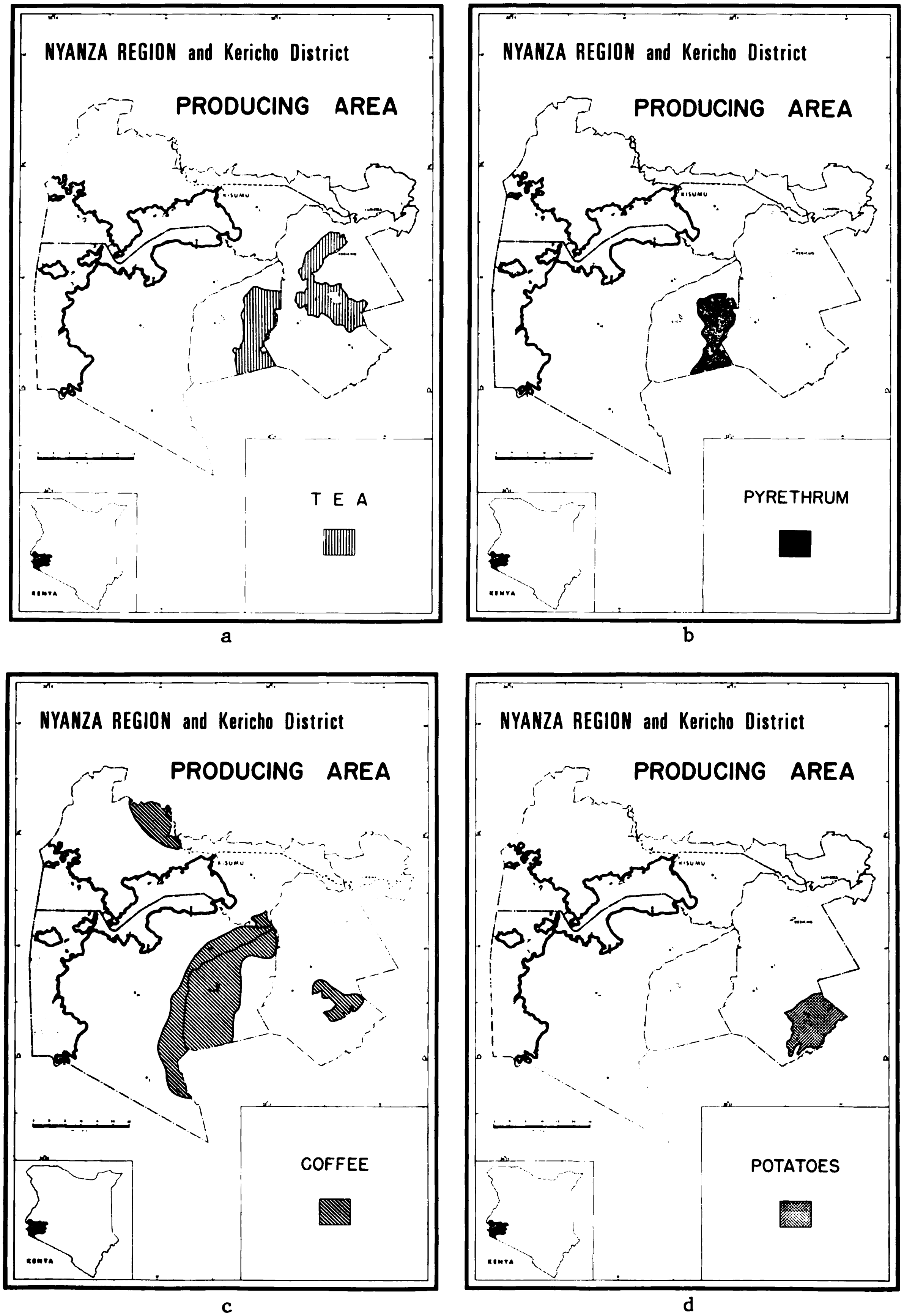
NYANZA REGION and Kericho District
PRODUCING AREA
KISUMU
T E A
KENYA
a
NYANZA REGION and Kericho District
PRODUCING AREA
KISUMU
PYRETHRUM
KENYA
b
NYANZA REGION and Kericho District
PRODUCING AREA
KISUMU
COFFEE
KENYA
c
NYANZA REGION and Kericho District
PRODUCING AREA
KISUMU
POTATOES
KENYA
d

FIGURE 5- 1

and using as a guide the minimum altitude of 6200 feet, above which all pyrethrum is grown in Kisii,[12] an area enclosing pyrethrum production in Kisii can be mapped (Figure 5-1b). Similarly, the study region's coffee production areas have been drawn on the basis of the distribution of coffee factories in each district with some modifications made to approximate temperature, soil, or precipitation limitations (Figure 5-1c).

Beyond these three crops (tea, coffee, and pyrethrum), it is increasingly difficult to determine the areas in which one or another of the remaining major cash crops is being grown. The 1965 Annual Report for the Department of Agriculture in Rift Valley Province reported that 30,000 bags of European (i.e., white) potatoes were sold as surplus in 1965 from Kericho District.[13] This considerable surplus could have been grown in a great many areas within the district according to the general growing limits available for this crop (see Table 5-1). By examining the East African Railways and Harbours shipment billings at Lumbwa Station, it was discovered that all shipments of potatoes out-bound from this station originated in either Sotik or Bomet. Partial confirmation of this was made by reference to

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[12]Interview with Mr. Ogoda, _op_. _cit_.

[13]_Loc_. _cit_., p. 16.

TABLE 5-1

PRIMARY ENVIRONMENTAL GROWING LIMITS ON MAJOR CASH CROPS
GROWN WITHIN THE STUDY REGION

CROP	Altitude or Temperature	Precipitation	Soil	Slope
coffee (Arabica)	[1] optimum 60-70°F maximum 75°F ave.	45-50 inches plus mulch	loamy; neutral to sl. acid	moderate
	[2] 4800-6200 ft. altitude			
rice	[3] 3-4000 degree days F per year min. 68°F	"adequate" or irrigated	grumosols, latosols, and alluvium; pH 6.5; high clay and silt content	flat
	[4] 0-5000 ft. alt.			
sugar cane	[5] minimum 68°F ave. warmer is better	min. 45-50 in. per year	medium to good porosity but water-holding	very slight
	[4] 0-5000 ft. alt.	min. 40 in. well-distributed	most soils	

TABLE 5-1--Continued

CROP	Altitude or Temperature	Precipitation	Soil	Slope
tea	[6]about 65^{o}F ave.	min. 50 in. and well-distrib.	[7]max. pH 6-6.5 & permeable	moderate
pyrethrum	[8]min. alt. 6200 ft. best above 6500 ft.	min. 35 in. preferably 40-45 in.		
cotton	[4]0-5000 ft alt.	min. 25 in.	any soil	
	[9]five consecutive months with temp. ave. over 70^{o}F	min. 20 in./yr. & 8 in. during growing season	any soil	
groundnuts (peanuts)	[4]0-5000 ft. alt.; dry, warm season is essential	min. 25 in.; dry, warm season is essential	"light" only; not on heavy or waterlogged soils	slight to moderate
potatoes (European)	[4]min. alt. 4500 ft. but best above 6000 ft. alt.	min. 35 in.	light to medium	slight to moderate

Sources: 1. A. E. Haarer, Coffee Growing (London: Oxford Univ. Press, 1963), pp. 18-26, passim.

TABLE 5-1--Continued

2. District Agricultural Officer *Annual Report*, Kisii District, 1962, Appendix "B."

3. D. H. Grist, *Rice* (4th ed.; London: Longmans, 1965), pp. 11-17, *passim*.

4. L. H. Brown, *A National Cash Crops Policy for Kenya*, Parts I and II, 1963, *passim*.

5. Charles S. Frank, *The Sugar Industry in East Africa* (Nairobi: The East African Institute of Social Research, 1965), pp. 26-28.

6. Mr. R. Moore, interview, *op. cit.*

7. T. Eden, *Tea* (London: Longmans, Green and Co., 1958), p. 10 and p. 12.

8. Mr. Ogoda, interview, *op. cit.*

9. John W. Alexander, *Economic Geography* (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1963), pp. 196-97.

increased yields in Bomet Division[14] and an early beginning of production, also in Bomet.[15] With attention thus re-focussed in southeastern Kericho District, the environmental limits on white potato production could be applied to a specific portion of the district and a map of the study region's potato production area was drawn (Figure 5-1d).

It may be necessary to make clear here that the present author does not propose that the boundaries of these and the following crop growing areas are precisely those which exist. An attempt has been made to construct the boundaries of these mapped areas in an inclusive, rather than a specific manner. Since the data are not available for the latter, it was deemed desirable to include areas in which the given crop is not currently being grown rather than not provide later in the work such cost-return information as will be derived for these areas. If the purist balks at these admitted errors, he should be reminded that a major purpose of the present work is to offer a first application of a method of investment priority determination. If this method can be accepted as one valid in form and function after the example is completed, then details of this method and the specific data that

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[14] District Agricultural Officer _Annual Report_, Kericho District, 1965, p. 2.

[15] Government of Kenya, _Kenya African Agricultural Sample Census, 1960/61_, Part II, Economics and Statistics Division, Office of the Minister of State for Constitutional Affairs and Economic Planning, 1962, p. 100.

are required for policy decisions can be obtained directly.

The growing areas of the other cash crops to be studied--cotton, rice, sugar cane, and groundnuts (peanuts)--were determined in much the same manner as those already covered. Cotton buying posts were located in the study region by names supplied by the Kenya Cotton Lint and Seed Marketing Board. Using the environmental growth limits listed in Table 5-1 and the distribution of these buying posts, with aggregate production indications from published and unpublished reports,[16] the area in which most cotton is grown was delimited (Figure 5-2a). The sugar cane growing area was based on personal observations, published and unpublished reports,[17] as well as the plant growth limits listed in Table 5-1. This area is shown on Figure 5-2b. The areas in which rice and groundnuts are presumed grown were delimited on the basis of environmental suitability and references made to divisional

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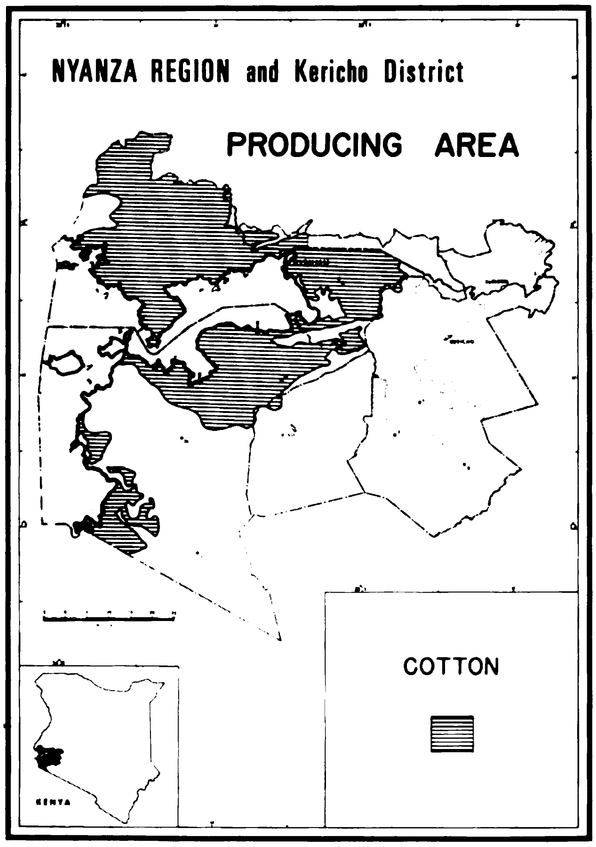
[16] _Ibid_.; Nyanza Province, report for 1966-1970 Development Plan (mimeographed), p. 8.

[17] In addition to the reports used for cotton (footnote 16), also: District Agricultural Officer _Annual Report_, South Nyanza, 1965, p. 6; Colony and Protectorate of Kenya, _Report of the Committee to Carry Out an Economic Survey of South Nyanza and Kericho District_ - with a view to advising whether the economic potential would justify Rail Development, (C. J. Martin, Chairman) (Nairobi: The Government Printer, 1957), _passim_; and, Republic of Kenya, _Report on Agricultural Roads Miwani:Chemelil: Muhoroni Areas_ (Nairobi: Sir Alexander Gibb & Partners (East Africa), 1965).



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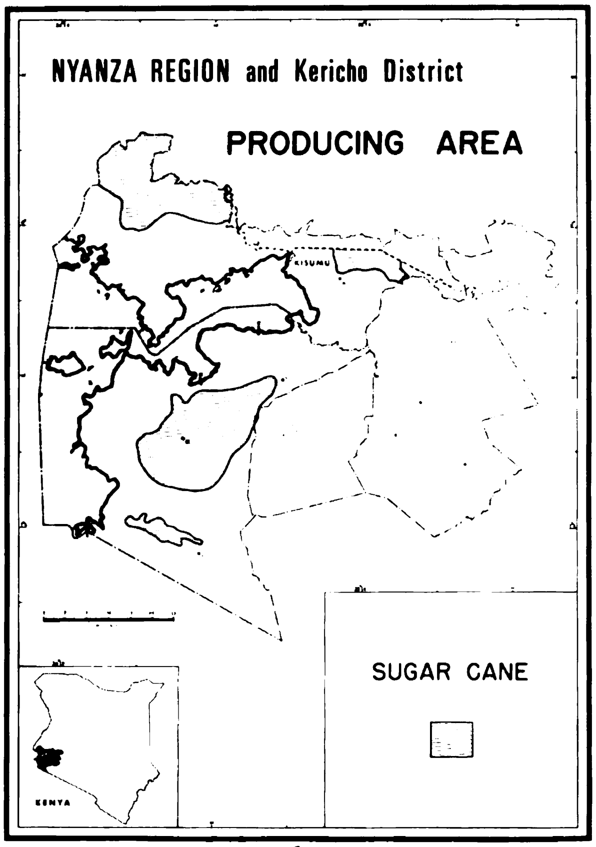

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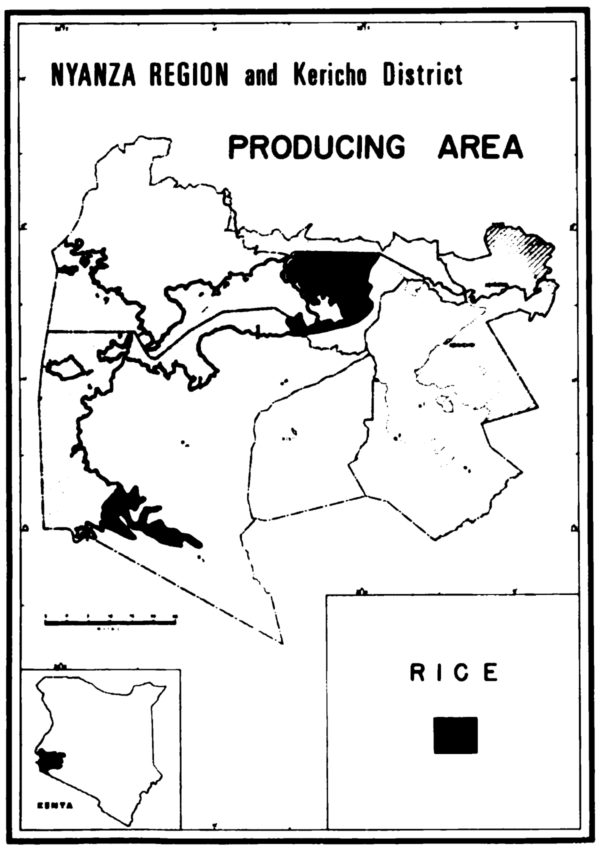

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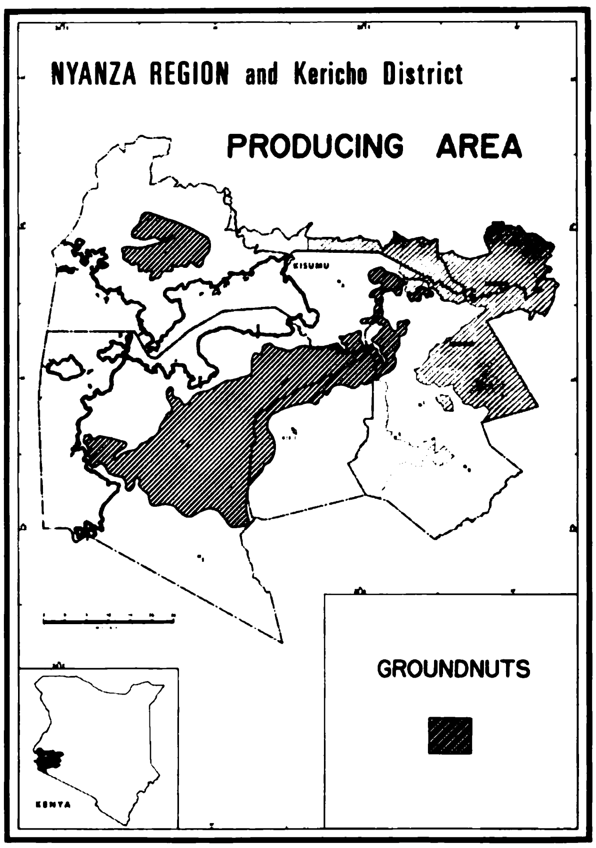

d

FIGURE 5- 2

(sub-district) agricultural units[18] (Figures 5-2c and 5-2d). It is within these areas that the spatial variation in crop production costs, total production costs, and profitability of farming have been determined.

Location of Production Costs

The figures representing the annual cost of producing each of the crops concerned were taken from several sources. None of these sources deals specifically with agricultural conditions within the study region. In a number of cases, however, the ecological conditions under which the cost studies were performed (in Nyeri District, Kenya) are the same as those found in the Kisii highlands and throughout much of Kericho District. The ecological similarity between the region in which these cost figures have been determined and the region of interest in this volume can only be seen as fortuitous, remembering the considerable difficulties of cost-of-crop-production studies, as discussed earlier, and the scarcity of such studies. For those crops not covered in the Nyeri studies, other sources of production cost data have been found. Although there is less support for their

[18] Kenya, Sample Census, op. cit.; Nyanza Province, report for 1966-1970 . . . , op. cit.; Colony and Protectorate of Kenya, Report of the Committee . . . , op. cit.; and, District Agricultural Officer Annual Reports for the districts, 1960-1965.

application to conditions in the study districts, these data do provide some basis for costing on which the method for determining investment priorities may be demonstrated. Of course, before policy decisions are made, cost studies of some sort would have to be conducted within the region of concern.

The annual per acre costs of producing the crops to be examined in this volume are listed in Table 5-2. These costs should be viewed as those necessary regardless of the yield level or the environmental suitability of the regions in which the crops are grown. That is, they will be presumed constant. Although this presumption cannot in fact be made, the manner in which available data are reported makes such an assumption a practical one. This will be further explained later during the discussion dealing with the value of production.

The spatial variation in total agricultural costs, as defined earlier in the work, is obtained by summing the variation in transport cost from the locations of crop production to the major regional outlets and the costs of producing these crops. There are costs of marketing and production other than those considered, of course, but these additional costs have not been included for reasons of simplicity and clarity. In most cases, the pattern of total agricultural costs for each crop has been drawn by adding the production cost for that crop (Table 5-2) to the movement cost-distance pattern (Figure 4-1) for the area in which

TABLE 5-2

AVERAGE COST OF ANNUAL CROP PRODUCTION

Crop	Cost/Acre/Year	Source
coffee[1]	Shs. 290/-	FESU
rice[2]	Shs. 180/-	Brown:CC
sugar cane[3]	Shs. 440/-	Brown:CC
tea[4]	Shs. 240/-	FESU
pyrethrum	Shs. 80/-	FESU (1962-63 ave.)
cotton[5]	Shs. 100/-	Smith & Brown
groundnuts	Shs. 200/-	Brown:CC
potatoes	Shs. 500/-	Brown:CC

[1]Average costs, third through fifth years after planting, 1963 report (rounded).

[2]Two-thirds of Brown's figure, as there are no irrigation costs here; all rice is grown on seasonal swampland.

[3]Five year average: planting, first ratoon, and second ratoon crops with 20-month growing season for each mature crop.

[4]Does not include cost of establishing tea plots; labor costs are 1962-63 average, materials costs are from the 1962 report.

[5]Does not include labor costs; Shs. 50/- per acre each for spray and for pump use.

Sources: FESU - Kenya, "Some Aspects of Agricultural Development in Nyeri District," 1962 (Report No. 21 - August, 1964) and 1963 (Report No. 24 - August, 1966), Farm Economics Survey Unit.

TABLE 5-2--Continued

Brown:CC - L. H. Brown, A National Cash Crops . . . , op. cit. (Part II).

Smith & Brown - R. Smith and R. A. Brown, "Improved Methods of Cotton Growing in Eastern Region, Tanganyika," The Empire Cotton Growing Review, XL (1963), 268-77.[19]

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[19]Smith and Brown refer to a Shs. 140/- cost per acre of cotton for pump and insecticide (p. 273). Another article refers to costs per acre, probably including labor costs, of about Shs. 200/- for a farmer producing 720 lbs. of seed cotton per acre ("Revenue and Cost of Production of African Grown Crops in Nyasaland," Nyasaland Farmer and Forester, VI (1962), 8, abstract in Empire Cotton Growing Review, XL (1963), 145-46.). Because of the low cotton yields per acre in Central and South Nyanza (about 300 lbs. per acre per year), the cost level for this region was set at Shs. 100/-.

the crop was grown (Figures 5-1a to 5-1d, Figures 5-2a to 5-2d). The areal distribution of different levels of total production costs for groundnuts, for example, were constructed in this rather straightforward manner (Figure 5-3). The variation of these costs from place to place for pyrethrum (Figure 5-4), potatoes and sugar cane (Figure 5-5), and coffee (Figure 5-6) were also drawn in this way.

The marketing arrangements for cotton, tea, and in part for rice, are so different from those of the five crops referred to above that each total cost pattern required individual treatment. Rice grown in the southwestern corner of South Nyanza, for example, is marketed by moving it to Mohoru Bay pier by land and then shipment to Kisumu by lake services. Although quite a bit of this rice has moved via East African Railways and Harbours lake carriers (see Table 5-3), an unde-

TABLE 5-3

RICE AND RICE FLOUR SHIPMENTS, MOHORU BAY TO KISUMU, BY EAST AFRICAN RAILWAYS AND HARBOURS

Year	weight, in lbs.	
1965	3,264,468.	
1964	1,712,500.	(estimated)
1963	556,894.	
1962	491,289.	

Source: E. A. R. & H. monthly records

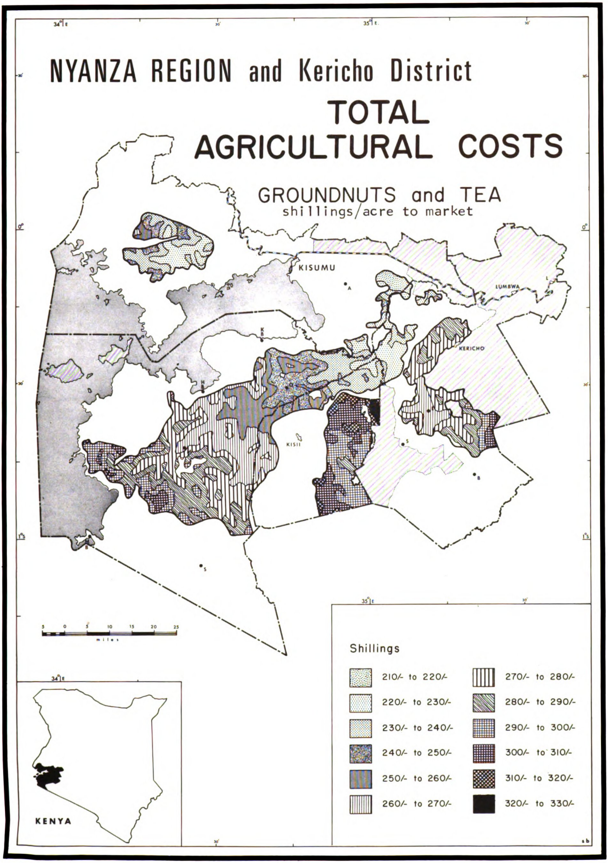

NYANZA REGION and Kericho District
TOTAL AGRICULTURAL COSTS
GROUNDNUTS and TEA
shillings/acre to market
KISUMU
LUMBWA
KERICHO
KISII
miles
Shillings
210/- to 220/-
220/- to 230/-
230/- to 240/-
240/- to 250/-
250/- to 260/-
260/- to 270/-
270/- to 280/-
280/- to 290/-
290/- to 300/-
300/- to 310/-
310/- to 320/-
320/- to 330/-
KENYA

FIGURE 5- 3

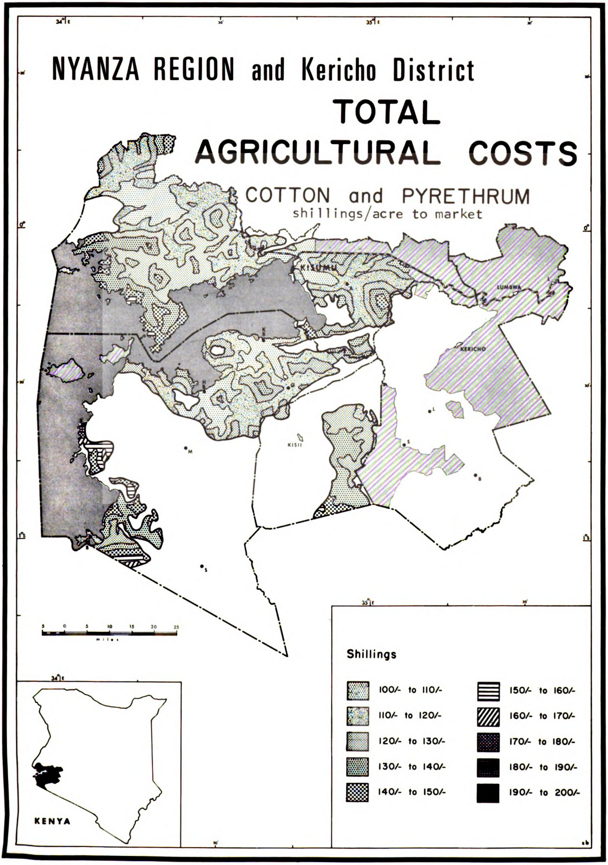
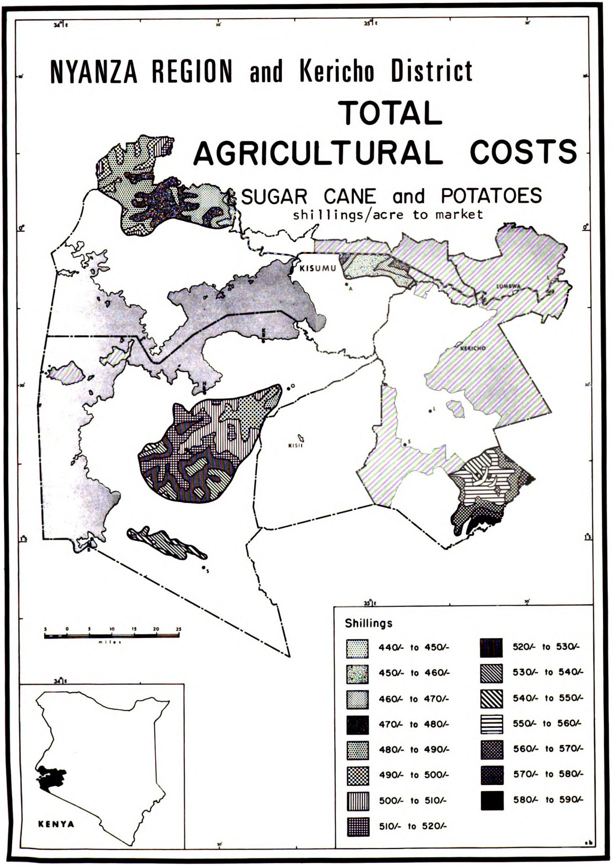
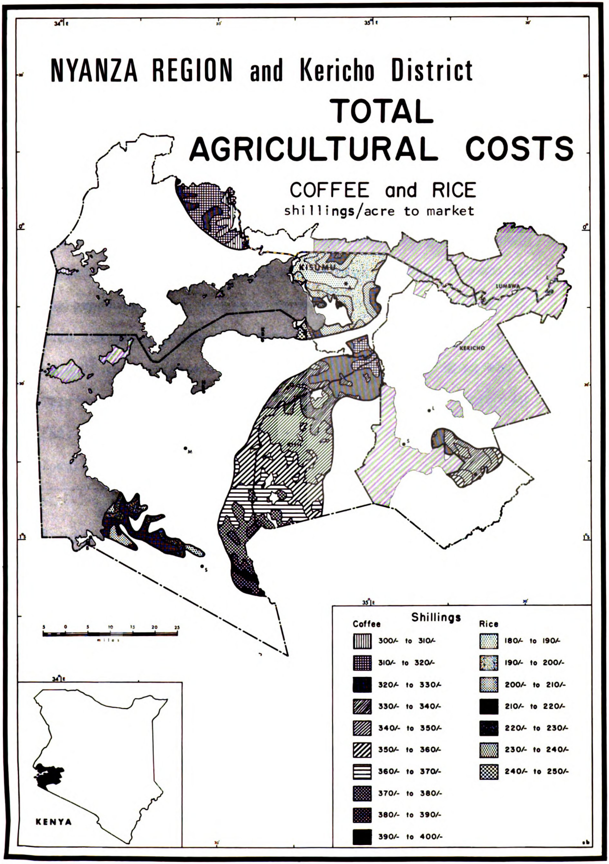

NYANZA REGION and Kericho District
TOTAL
AGRICULTURAL COSTS
COTTON and PYRETHRUM
shillings/acre to market
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Shillings
100/- to 110/-
110/- to 120/-
120/- to 130/-
130/- to 140/-
140/- to 150/-
150/- to 160/-
160/- to 170/-
170/- to 180/-
180/- to 190/-
190/- to 200/-

FIGURE 5- 4



NYANZA REGION and Kericho District
TOTAL
AGRICULTURAL COSTS
SUGAR CANE and POTATOES
shillings/acre to market
KISUMU
KERICHO
LUMBWA
KISII
miles
KENYA
Shillings
440/- to 450/-
450/- to 460/-
460/- to 470/-
470/- to 480/-
480/- to 490/-
490/- to 500/-
500/- to 510/-
510/- to 520/-
520/- to 530/-
530/- to 540/-
540/- to 550/-
550/- to 560/-
560/- to 570/-
570/- to 580/-
580/- to 590/-

FIGURE 5- 5



NYANZA REGION and Kericho District
TOTAL AGRICULTURAL COSTS
COFFEE and RICE
shillings/acre to market
KISUMU
LUMBWA
KERICHO
KENYA
miles
Shillings
Coffee
300/- to 310/-
310/- to 320/-
320/- to 330/-
330/- to 340/-
340/- to 350/-
350/- to 360/-
360/- to 370/-
370/- to 380/-
380/- to 390/-
390/- to 400/-
Rice
180/- to 190/-
190/- to 200/-
200/- to 210/-
210/- to 220/-
220/- to 230/-
230/- to 240/-
240/- to 250/-

FIGURE 5- 6

termined portion of it must move by cheaper--and probably less reliable--private dhows. In order to make the present application of the method proposed in Chapter III as realistic as possible, the transport cost isopleths have been revised for this somewhat isolated rice-growing region. On Map 5-6, which shows the spatial variation of total production costs for rice as well as for coffee, the pattern of costs for rice in southwestern South Nyanza is based on land-water movement costs plus the production cost per acre estimated for rice. The cost of lake freight transport has been taken to be -/20 cents per ton mile;[20] the distance from Mohoru Bay to Kisumu is 98 miles.[21] This explains the relatively low total cost of rice output in this area considering the distant Shs. 110/- "cost-miles" it is located from Kisumu by land routes.

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[20]One E. A. R. & H. office memorandum refers to a 1958 figure of 16 cents per ton mile for "working expenditure." - (E. A. R. & H. Memorandum, from Chief Operating Superintendent to the General Manager, 22nd February 1960, Appendix A, p. 2.) Another memo refers to the "average for Lake Victoria traffic of . . . 17.9 cents." - (E. A. R. & H. Memorandum CD/97, 2nd March 1962, Statement 'B,' Note (b).) And more recently, the operating cost for the newly instituted wagon ferries at 1964 tonnage levels was set at 22 cents per ton mile, although this cost could be much lower with closer-to-capacity loads. - (Office Communication from Chief Operating Superintendent to the General Manager, E. A. R. & H., 19th October 1965, p. 5). As a probably high compromise, the figure of 20 cents (Sh. -/20) per ton mile will be used as the cost of goods transport on Lake Victoria.

[21]East African Railways and Harbours, <u>Temporary Distance Tables</u> (being sections 371 to 377 of Tariff Book No. 3, January 1965).

The marketing systems for cotton and tea have the same general impact on the pattern of total agricultural costs as occurs in the "anomalous" area of rice production, although the reasons for the distinct market patterns are different. For cotton, the transport costs paid by the individual smallholder, whether paid directly through a cess or indirectly by means of lower prices, is based on the cost of moving the crop from the farm to the ginnery via one of the numerous cotton buying posts. There are four such ginneries within Nyanza Region: two in South Nyanza (Homa Bay and Kendu Bay) and two in Central Nyanza (Kibos and Ndere, the latter just over 17 miles west of Yala). The isopleths of cost-distance, to which production costs are added to obtain the spatial variation of total agricultural costs, have been drawn to focus upon one of these cotton ginneries. All cotton grown in South Nyanza, for example, south and west of a line extending roughly six miles eastward from the small bay northeast of Homa Bay, and then running southeast to Kisii, is taken to Homa Bay ginnery. This "line" results from adherence to a rule of drawing the isopleths on the basis of least-cost to either of the adjacent ginneries. That portion of cotton production arising in the isolated southwestern corner of South Nyanza is presumed land carried to Mohoru Bay before being shipped by water carrier the 86 miles to Homa Bay. The remainder of the cotton grown in the district is taken to Kendu Bay for ginning.

It is interesting to note that the locations of cotton buying posts associated with each ginning factory are within the minimum transport-cost region for that ginnery relative to the others. That is, each buying post located by the author sends its raw seed cotton to the closest cost-distant ginnery, as determined here. Although there is no formal policy reason for this, as far as could be determined, this fact does give additional support to the practical validity of the relative levels of movement costs.

An unusual pattern of movement costs for tea marketing results from the nature of the crop itself. Because of rapid deterioration, it is necessary to transport newly picked green leaves to the factory for fermenting within six to eight hours after it has been picked. With requirements this stringent, the patterns of movement costs are obviously focussed on each district's respective tea factory. Total movement costs are the cost-distance of shipping green leaf to the factory plus the cost per ton mile for made tea from the factory to Lumbwa.

A brief comment might be made here concerning sugar cane cost patterns. As with tea leaf, there is rapid deterioration in the cane after cutting. The sugar content must be extracted from the cane without delay, at least in some crude form. One estimate places 10 miles as "the maximum economic distance sugar cane can be hauled . . . ."[22] Thus, factories must be frequent in large areas of sugar cane production. These factories may refine sugar to its clean, white form or they may stop at an earlier stage with jaggery.[23] Since the only factory in Nyanza Region refining white sugar is adjacent to the large Asian estates at Miwani--although another is under construction at Muhoroni--much of the cane grown in smallholdings must be first converted to jaggery and then shipped to Miwani for further refinement. As the nature of the crop demands that small jaggery factories be widespread and numerous in areas of production,[24] the pattern of movement costs pertinent to sugar marketing has been taken to be equivalent to the pattern drawn directly from the fields where the crops are produced to either the Kisumu or Lumbwa market outlets. While this is not strictly accurate, the distortion is not great.

As a summary, a set of maps has been constructed illustrating the place-to-place variation in total agricultural costs to produce and market the major cash crops in Nyanza Region and

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[22]District Agricultural Officer Annual Report, Kericho District, 1964, p. 4.

[23]Jaggery, or "jaggre," is a coarse, brown, lumpy sugar only partially refined.

[24]There are some 65 factories converting cane to jaggery located in the small but important region of sugar production immediately east of Kisumu. - Republic of Kenya, Report on Agricultural Roads, Miwani: . . . , op. cit., p. 6.

Kericho District. These several patterns of cost outlay for the African smallholder are based on the costs of producing each crop and the cost of transporting the produce from the fields where they are grown to the major market centers. The transport costs are, in turn, based on operating costs for a three to five ton vehicle over road surfaces of differing quality. The patterns of total cost may also differ somewhat among the crops considered because of variations in marketing requirements. A striking feature of these maps is their complexity. Although customarily it is a principle of map construction that the result must be clear and readable, the areal heterogeneity of reality cannot be presented in anything other than a very involved pattern. It is with one portion of reality that the present work is directly concerned.

CHAPTER VI

THE PROFITABILITY OF PRODUCTION

A necessary step in the determination of investment priorities in agricultural regions is some calculation of existing and potential profitability of the land within the region under study. It is accepted that profitability of land use, or more specifically, that profitability of endeavors using the land as a primary resource, will be higher in some places than others. Land is not, after all, everywhere equally suitable for any given agricultural use. The patterns of both present and potential profitability can be expected to be as complex as those already drawn. These maps, illustrating the spatial variation of African smallhold farmers' annual outlay, have been drawn as necessary preliminaries to determination of equivalent variation in income and profit. It is necessary in this chapter to, first, calculate the place-to-place variation in gross income, and second, obtain maps showing the real variation in profitability of present agricultural efforts by subtracting the patterns of cost from those of income. Later, it will be necessary to determine the spatial differences in potential profitability of agricultural undertakings in order that the locations of areas of greatest profitability improvement may be made clear.

Spatial Variation of Farm Income

One of the most difficult problems to be overcome in mapping locational differences in agricultural profitability is concerned with the income derived from crop sales. If a given crop yields the same amount per unit area wherever it is grown and is sold at the same price wherever it is marketed, there is little difficulty in calculation of the spatial variation of profit, for only costs would vary with location. This is rarely, if ever, the case. As pointed out earlier during discussion of production costs, the environmental suitability for a given crop is clearly the dominant factor in its productivity within regions having few of the "environment compensating" aids developed rather recently by more technologically advanced countries. This suitability varies from place to place in an extremely involved manner, for slight deficiencies in one environmental requirement may be compensated for in crop growth by a super-sufficiency in one of the other factors. Although there may be an "optimum" association of climate-soil-relief-angle of solar radiation-etc. for any crop, no such grouping of environmental characteristics has ever been determined. It is unlikely that such an optimum will be settled upon as long as it is technically more efficient to develop a new crop strain to suit the environment than to modify the environment to the needs of existing crop varieties. The important points here are that there is considerable variation in environmental support for crop production and that this variation is reflected in an individual smallholder's farm income and farm profit.

Determination of Income Variability

It is clear that there are gross income differences in the region under study in this volume. For every cash crop being examined here, there is a district-by-district variation in average annual yield per acre, average sale price, or both. The yield differences, for example, are illustrated in Table 6-1. Similarly wide differences exist between the prices paid for these crops in the several districts. By ruling out such possible causes of price differences as consistent error in reporting the figures[1] and purposeful prejudice against those receiving low prices by the agencies setting the prices, the dominant sources of price variation from place to place for a given crop must be roughly equivalent to variation in yield quality. The spatial pattern of value per acre for each of the cash crops being examined must be attributable in large part to differences in en-

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[1]A number of apparent errors of this nature have been discovered in the DAO Annual Reports' yield figures; many of these are referred to below in association with Table 6-2. There is no assurance that all such errors have been discovered.

TABLE 6-1

AVERAGE DISTRICT YIELDS FOR SELECTED CASH CROPS, 1963-1965
(PER ACRE)

	Central Nyanza			South Nyanza			Kisii			Kericho (calc.)		
Crop	1965	1964	1963	1965	1964	1963	1965	1964	1963	1965	1964	1963
coffee: (cwt)												
cherry	--	--	--	6	19	19	6	6	na	8	na	7.5
mbuni	4	3	3	5	--	5	--	2	na		na	
rice (bags)	24	24	20	8	8	8	--	--	--	--	--	--
sugar cane (tons)	25	25	20	20	20	20	--	--	--	--	--	--
tea (leaf) (lbs)	--	--	--	--	--	--	4500	4500	4500	1000	1000	1000
pyrethrum (lbs)	--	--	--	--	--	--	400	400	400	--	--	--
cotton (lbs)	300	300	200	450	300	300	--	--	--	--	--	--
g'nuts (bags)	5	5	3	5	5	5	15	15	20	3	na	na
potatoes (bags)	--	--	--	--	--	--	--	--	--	50	45	na

Sources: District Agricultural Officer Annual Reports, 1963, 1964, 1965.

vironmental suitability for production of these crops in those areas where they are presently being grown. That is to say, differences in price per unit output must be caused primarily by differences in the quality of the good sold, and differences in yield per unit area must be caused by differences in the quantity and quality of the inputs--which may be either environmental or human. While it is recognized that the quality of human inputs are often equally as important in determining output quality as are non-human inputs, an accurate judgement of the relative quality of the human inputs in this, or any other, area requires much more detailed research than was possible at this stage of model development. The primary source of place-to-place differences in a crop's average value per acre (price per unit weight multiplied by weight yield per acre) is here considered to be spatial variation in environmental suitability for that crop's production in the locations where it is grown.

On the basis of this conclusion, a major problem is presented: How can the differences in <u>average district</u> value per acre be translated into place-to-place variations in crop value per acre as reflected by the appropriate level of environmental support for that crop? And equally as important, how can this be done without loss of areal specificity, without resorting to gross areal generalizations which would undermine the rationale of the present undertaking? That the differences in average crop value per acre between the districts are too great and varied to be attributed entirely to measurement or recording error may be seen by examining Table 6-2.

These difficulties have been met by accepting a small amount of generalization, well suited to the present scale of the problem, and making several assumptions concerning the ecological requirements of the crops being examined. First, a series of suitability levels was outlined for each important element of the environment for each crop. Each level was assigned a number. The more "optimum" the temperature level, the higher the number assigned (see Table 6-3). The major bases for the level rating assigned each crop were the environmental growing limits, or requirements, as outlined in Table 5-1. With this suitability rating established for each crop, a square grid with units of one square mile was placed in turn over each of the maps illustrating a pattern of some environmental element pertinent to each of the crops. When determining the pattern of suitability for cotton, for example, the grid was placed alternatively over the map of average annual temperature (Figure 6-1), the map of average annual precipitation (Figure 6-2), and the map showing the pattern of soils (Figure 6-3). In each square mile within the area in which cotton is grown (see Figure 5-2a) the appropriate number was noted for that square mile's suitability level depending upon the pattern of temperature, rainfall, or soil type. By adding the

TABLE 6-2

AVERAGE DISTRICT VALUE PER ACRE FOR SELECTED CASH CROPS, 1963-1965 AVERAGE (SHILLINGS)

Crop	Central Nyanza	South Nyanza	Kisii	Kericho
coffee[1]	1270/-	1840/-	2100/-	1480/-
rice[2]	780/-	260/-	--	--
sugar cane	1080/-	530/-	--	--
tea[3]	--	--	1550/-	1550/-
pyrethrum	--	--	600/-	--
cotton	140/-	180/-	--	--
groundnuts[4]	350/-	430/-	375/-	--
potatoes[5]	--	--	--	675/-

[1]Since the quality, and therefore price, difference between clean and mbuni coffee is based almost entirely on the quality of human inputs in the production process, value per acre was adjusted to the proportional level that would have existed if all coffee produced had been clean; only 1965 figures were used for coffee; corrections in multiplication have been made.

[2]A correction in multiplication (price x yield) for the reported 1964 value has been included.

[3]Because of possible error in price calculation for reported Kericho District data, the value per acre of tea production in Kericho has been assumed to be the same as in Kisii District; also, corrections in multiplication of Kisii figures have been made.

[4]The figure for Kisii District is based on the author's calculations. Recorded yields rose sharply from 5 bags in 1962 to 20 bags in 1963 and 15 bags in 1964 and in 1965 (three to five times the yield recorded elsewhere). At the same time, the recorded prices for groundnuts in the district fell even more sharply

TABLE 6-2--Continued

to Shs. 11/- per bag in 1963, one-seventh the price of 1962 and one-seventh to one-ninth that in other districts at the same time. Therefore, based on total sales recorded elsewhere in the reports for Kisii District, the average Shs. 375/- figure was calculated. Data for Kericho District groundnut production was considered by the author to be unreliable after 1962.

[5]This figure is based on a yield of 45 bags per acre and a price of Shs. 15/- per bag.

Sources: District Agricultural Officer Annual Reports, 1963, 1964, 1965.

TABLE 6-3

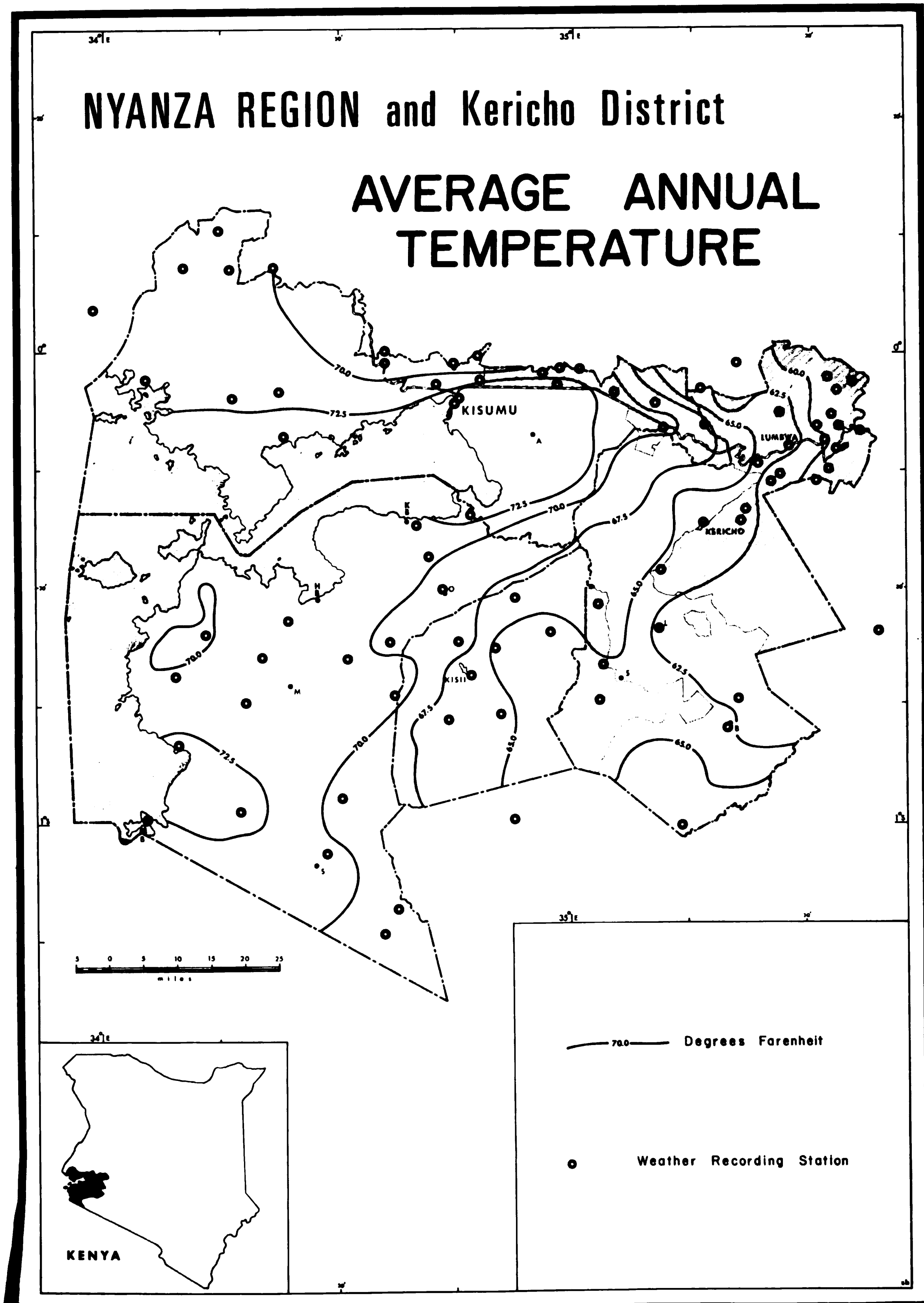
ENVIRONMENTAL VARIABLES FOR INDICES OF CROP PRODUCTION SUITABILITY

Crop	Average Annual Temperature, or Altitude		Average Annual Precipitation		Soil Type	
	variable	index no.	variable	index no.	variable	index no.
coffee	62.5°-67.5°F	3	over 60 in.	3	#5, #15	4
	67.5°-70.0°F	2	50-60 in.	2	#6	3
	over 70°F	1	40-50 in.	1	#18	2
					#19, #22	1
			consecutive months wet*			
rice	72.5°-75.0°F	3	4 or more	5	#22	4
	70.0°-72.5°F	2	3	4	#26	3
	67.5°-70.0°F	1	2	3	#30, #21	2
			1	2	others	1
			none	1		
sugar cane	72.5°-75.0°F	3	over 60 in.	3	#22	4
	70.0°-72.5°F	2	50-60 in.	2	#18, #6, #21	3
	67.5°-70.0°F	1	40-50 in.	1	#26, #5, #4 #20, #27	2
					#19, #30	1
tea	under 62.5°F	3	over 60 in.	2	(all grown on soil #5)	
	62.5°-65.0°F	2	50-60 in.	1		
	65.0°-67.5°F	1				

TABLE 6-3--Continued

Crop	Average Annual Temperature, or Altitude		Average Annual Precipitation		Soil Type	
	variable	index no.	variable	index no.	variable	index no.
pyrethrum	(insufficient variation in ecologic base for value per acre differentiation)					
cotton	72.5°-75.0°F	3	over 60 in.	4	#5, #15	5
	70.0°-72.5°F	2	50-60 in.	3	#22, #27, #6	4
	67.5°-70.0°F	1	40-50 in.	2	#26, #18, #4	3
			under 40 in.	1	#21, #20	2
					#19	1
			consecutive months dry*			
groundnuts	under 4000 ft.	3	3	4	#6, #5	4
	4000-5000 ft.	2	2	3	#15, #18	3
	over 5000 ft.	1	1	2	#19	2
			none	1	#22, others	1
potatoes	over 6000 ft.	3	over 50 in.	3	#5	3
	5000-6000 ft.	2	40-50 in.	2	#19	2
	under 5000 ft.	1	under 40 in.	1	#22	1

*"wet" here defined as average precipitation exceeding eight inches in that month; "dry" here defined as average precipitation not exceeding two inches in that month.


NYANZA REGION and Kericho District
AVERAGE ANNUAL TEMPERATURE
KISUMU
KERICHO
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72.5
70.0
67.5
65.0
62.5
60.0
miles
KENYA
70.0 Degrees Farenheit
Weather Recording Station

FIGURE 6- 1

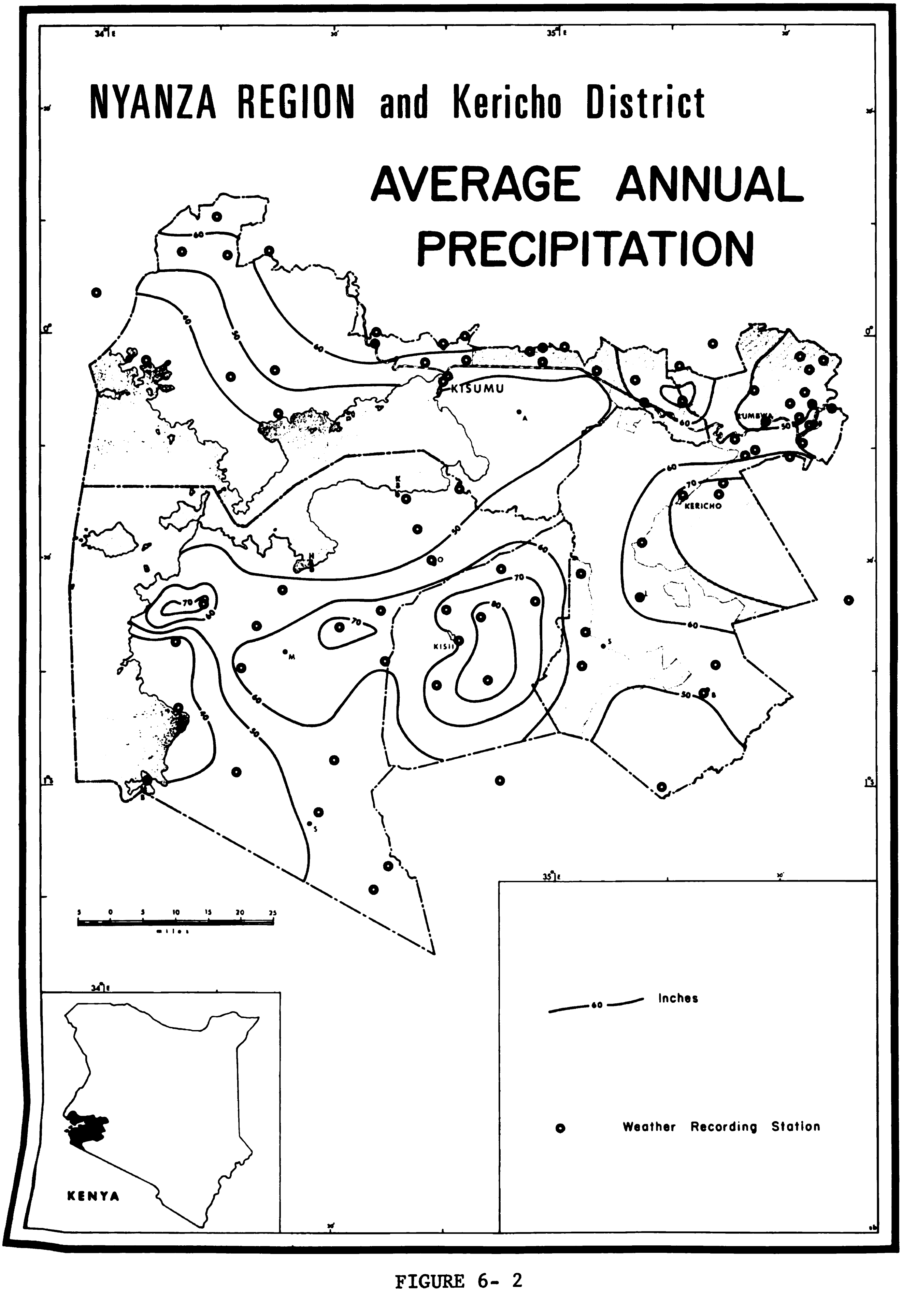

NYANZA REGION and Kericho District
AVERAGE ANNUAL PRECIPITATION
KISUMU
KERICHO
KISII
KENYA
Inches
Weather Recording Station

FIGURE 6- 2

Key to Soil Type Numbers (Figure 6-3)

Well-Drained Soils

4. Yellow-red sandy clay loams (latosolic)
5. Dark red friable clays (latosolic)
6. Red friable clays (latosolic)
8. Red to yellow-red, gritty, sandy clay loams (latosolic)

Soils with Slight Seasonally Impeded Drainage

15. Brown clay loams to clays
18. Red to dark red friable clays with laterite horizon
19. Brown to yellow-red sandy clay loams with laterite horizon
20. Strong brown to pale yellow loamy sands with laterite horizon

Seasonally Waterlogged Soils

21. Light grey to white mottled loamy sands with laterite horizon (ground-water laterite)

Soils with Impeded Drainage

22. Black to dark grey clays (grumosolic)

Poorly Drained Soils

26. Greyish brown, mottled, clays (Gley or "Vlei")
27. Dark grey to greyish brown compacted loamy sand (solodized solonetzic)
28. Very dark brown clays with light textured top-soils (planosolic)

Others - Lithosols and Regosols

30. Alluvium, recent lacustrine deposits and peaty swamps
35. Shallow stony soils with rock outcrops

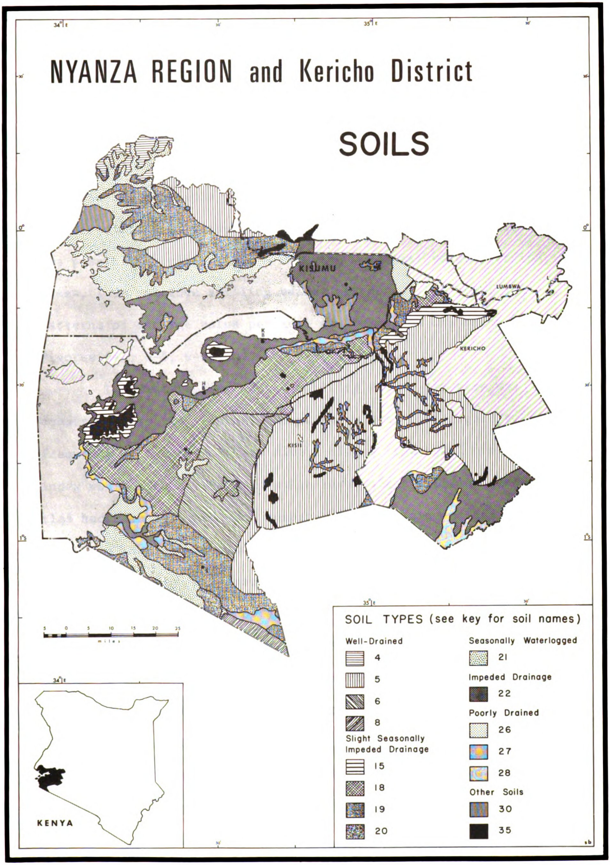

NYANZA REGION and Kericho District
SOILS
KISUMU
LUMBWA
KERICHO
KISII
KENYA
SOIL TYPES (see key for soil names)
Well-Drained
4
5
6
8
Slight Seasonally Impeded Drainage
15
18
19
20
Seasonally Waterlogged
21
Impeded Drainage
22
Poorly Drained
26
27
28
Other Soils
30
35
miles
5 0 5 10 15 20 25

FIGURE 6- 3

individual levels in each square mile, the result is a numerical pattern of relative environmental suitability for production of cotton (or tea or . . .) within the area accepted as producing that crop. For an example of this process, see Appendix I. Based on the principle that an average value per acre figure for any district masks production values above and below itself, it was possible to transform the relative numerical values, or indices, into relative shilling values per acre. The resulting patterns of average value per acre of production are shown on Figures 6-4, 6-5, 6-6, and 6-7.

The distribution of the shilling values per acre was constructed so that the mean numerical index, with regard to frequency of occurrence, and almost always, the modal numerical index would also be the mean value level after shilling quantities had been assigned each number. The resulting values for each crop (Table 6-4) always included, at the bottom of the suitability scale, at least one index of production value per acre which was less than or equal to the level of total production costs for that crop. This provides a check on the total spread of values, for as was stated earlier, the areas to be considered producing areas for each crop were drawn to accept errors of excessive areal inclusion in order to minimize possible errors of exclusion. Thus, there are undoubtedly areas in which no profit can be gained, i.e., where cost exceeds value, without

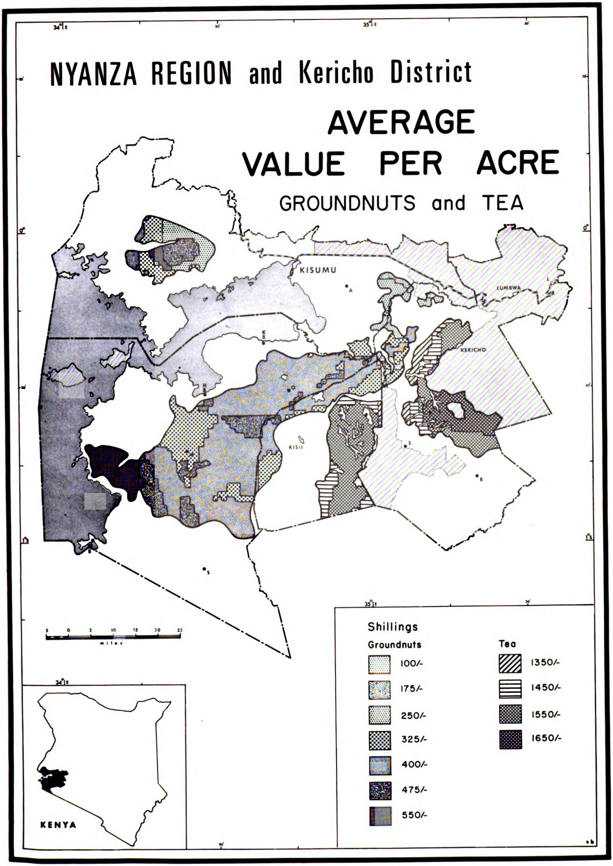

NYANZA REGION and Kericho District
AVERAGE
VALUE PER ACRE
GROUNDNUTS and TEA
KISUMU
LUMBWA
KERICHO
KISII
Shillings
Groundnuts
100/-
175/-
250/-
325/-
400/-
475/-
550/-
Tea
1350/-
1450/-
1550/-
1650/-
KENYA
miles

FIGURE 6- 4

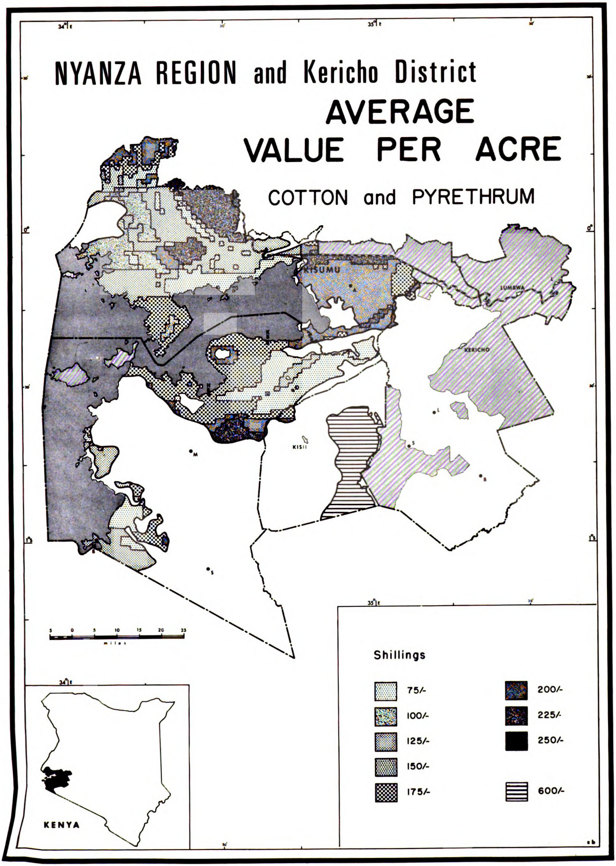

NYANZA REGION and Kericho District
AVERAGE
VALUE PER ACRE
COTTON and PYRETHRUM
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Shillings
75/-
100/-
125/-
150/-
175/-
200/-
225/-
250/-
600/-
miles

FIGURE 6- 5

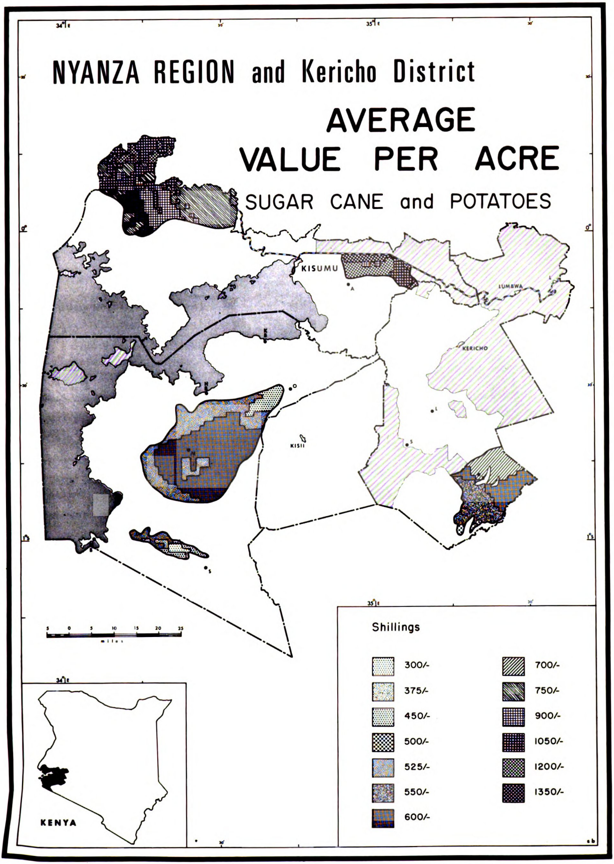

NYANZA REGION and Kericho District
AVERAGE
VALUE PER ACRE
SUGAR CANE and POTATOES
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Shillings
300/-
375/-
450/-
500/-
525/-
550/-
600/-
700/-
750/-
900/-
1050/-
1200/-
1350/-

FIGURE 6- 6

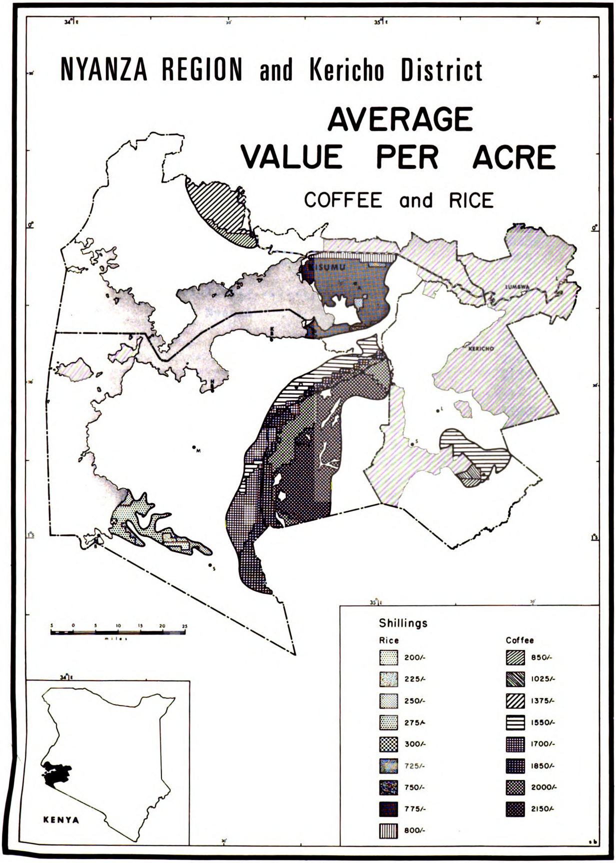

NYANZA REGION and Kericho District
AVERAGE
VALUE PER ACRE
COFFEE and RICE
KISUMU
LUMBWA
KERICHO
KENYA
miles
5 0 5 10 15 20 25
Shillings
Rice
200/-
225/-
250/-
275/-
300/-
725/-
750/-
775/-
800/-
Coffee
850/-
1025/-
1375/-
1550/-
1700/-
1850/-
2000/-
2150/-

FIGURE 6- 7

TABLE 6-4

VALUE PER ACRE EQUIVALENTS FOR NUMERICAL INDICES OF ENVIRONMENTAL SUITABILITY FOR CROP PRODUCTION, IN SHILLINGS

Crop	District	Index number	Value per Acre
coffee	Central Nyanza	6	850/-
		7	1025/-
		8	1200/-
		9	1375/-
	South Nyanza	6	1550/-
		7	1700/-
		8	1850/-
		9	2000/-
		10	2150/-
	Kisii	7	1700/-
		8	1850/-
		9	2000/-
		10	2150/-
	Kericho	5	850/-
		6	1025/-
		7	1200/-
		8	1375/-
		9	1550/-
rice	Central Nyanza	6	725/-
		7	750/-
		8	775/-
		9	800/-
	South Nyanza	5	200/-
		6	225/-
		7	250/-
		8	275/-
		9	300/-

TABLE 6-4--Continued

Crop	District	Index number	Value per Acre
sugar cane	Central Nyanza	4	600/-
		5	750/-
		6	900/-
		7	1050/-
		8	1200/-
		9	1350/-
	South Nyanza	4	300/-
		5	375/-
		6	450/-
		7	525/-
		8	600/-
tea	Kisii and Kericho	2	1350/-
		3	1450/-
		4	1550/-
		5	1650/-
pyrethrum	Kisii	all production =	600/-
cotton	Central Nyanza and South Nyanza	4	75/-
		5	100/-
		6	125/-
		7	150/-
		8	175/-
		9	200/-
		10	225/-
		11	250/-
groundnuts	Central Nyanza, South Nyanza, Kisii, and Kericho	3	100/-
		4	175/-
		5	250/-
		6	325/-
		7	400/-
		8	475/-
		9	550/-

TABLE 6-4--Continued

Crop	District	Index number	Value per Acre
potatoes	Kericho	5	500/-
		6	550/-
		7	600/-
		8	650/-
		9	700/-

elimination of some cost factor, for example, by considering family labor costs as non-accountable.

This method for determining the spatial variation of environmental support for a crop's production, and the impact of this suitability variation on the pattern of production value per acre, has a number of problems as well as advantages which should be recognized before proceeding. The advantages are several. Little detail of the place-to-place variation is lost even when using the existing data. Considerable flexibility also is inherent in the process. It may be used with possibly greater validity on problems at the micro-level, for the achievement of accuracy in problems at this scale is both more likely with the suggested approach and more generally desirable in the solution of such research. It is also flexible in the sense that an improvement in the information relevant to any aspect of "suitability" determination may be accepted and the entire pattern modified, if necessary, by insertion of the appropriate data within a relatively short time.

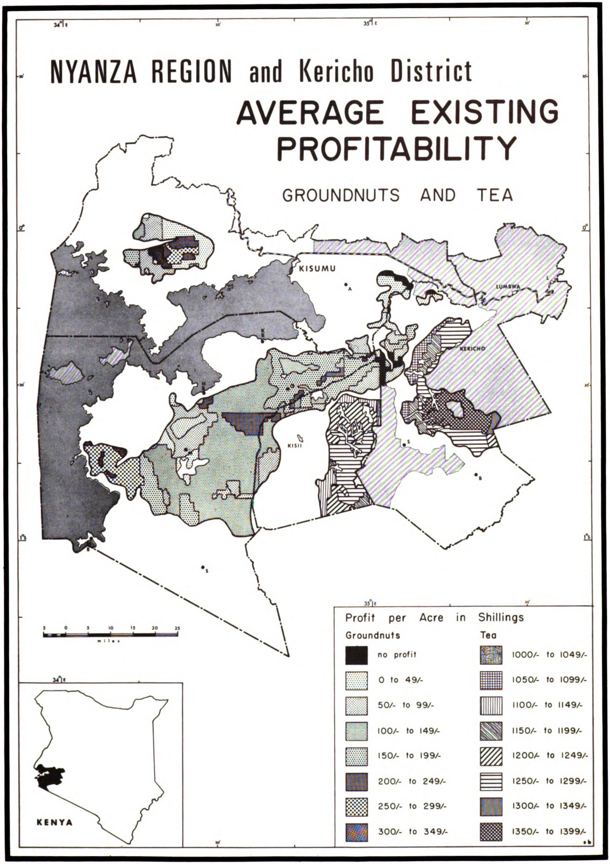
The most important difficulties associated with this method of determining spatial variation in crop value per acre result from the assumptions necessary to its operation. In the first place, it might be argued, the method implies that the same relative quantities of each crop are grown in every square mile considered for that crop. Without data indicating where crops are produced and in what volume, however, this assumption must be made in spite of the slight "homogenizing" of real spatial variation which results. The objection loses some of its force also when it is remembered that by working through environmental suitability to the value of production per unit area, the method describes what the value of production would be _if_ that crop were to be produced there. With the proper data, labeling suitability levels with their correct shilling value is much more possible, including the proper spread of these values along the numerical index range. A second objection could be that the method assumes equal importance for each of the ecological factors considered relevant to the crop's growth. It also assumes an equal division of importance between the several numerical levels within each factor. While it must be accepted as a valid objection, for example, that in calculating the value per acre of cotton, the impact of a difference of 2.5 degrees in average annual temperature is not likely to be the same as a difference of 10 inches of precipitation, until more precise information is available dealing with ecologic support for crop production in the region concerned, or in one ecologically similar, there is no alternative to acceptance of this assumption.

Exception to the stated exclusion of human quality-inputs and their impact on crop value per acre might also be raised again. Careful examination of Table 6-4, however, will show that some non-environmental, and presumably human, factor has been included in making the monetary assignments to a number of the numerical index scales. Sugar cane marketed in Central Nyanza, for example, averaged slightly over twice the price per unit volume of sugar cane marketed in South Nyanza. This difference is not justified on the basis of the patterns of environmental support for cane production in the districts. Although the price difference may be related to the higher grade of refinement possible in Central Nyanza, much of it must be caused by the pool of cane-growing experience available to Central Nyanza farmers from the Asian-owned cane plantation located immediately north of the railroad between Kibos and Koru. A similar difference in shilling - numerical index assignments was accepted in the case of rice produced in South and Central Nyanza. In this case, the average price received for rice in each district was the same but yields were three times as great in Central Nyanza. It was deduced from this that output quality was approximately equal while inputs were not; the scale for South Nyanza is therefore one-third that of Central Nyanza. There were similar, but smaller, adjustments made to the district scales for coffee value per acre figures, based on differences in average value per acre.

In sum, although possible objections to the procedure used to establish value per acre variation must be given due consideration in any operation of the present method resulting in policy decisions on investment priorities, it is believed that these objections could be answered with proper research into the relevant aspects of agricultural production in the region being examined. This belief is held regarding procedural as well as factual elements of the model. The procedure is sufficiently flexible to allow drastic revision, for example, in the assumptions made concerning the relative weighting of the several environmental characteristics when developing a pattern of ecological support for a crop's production. Similarly, the method has enough latitude to include measures of human influences on crop output or on crop marketing procedures and costs, should such measures ever be determined. And of course, improvements in data reliability can be readily absorbed. Arguments raised at this point are concerned primarily with the example being presented rather than with the model itself.

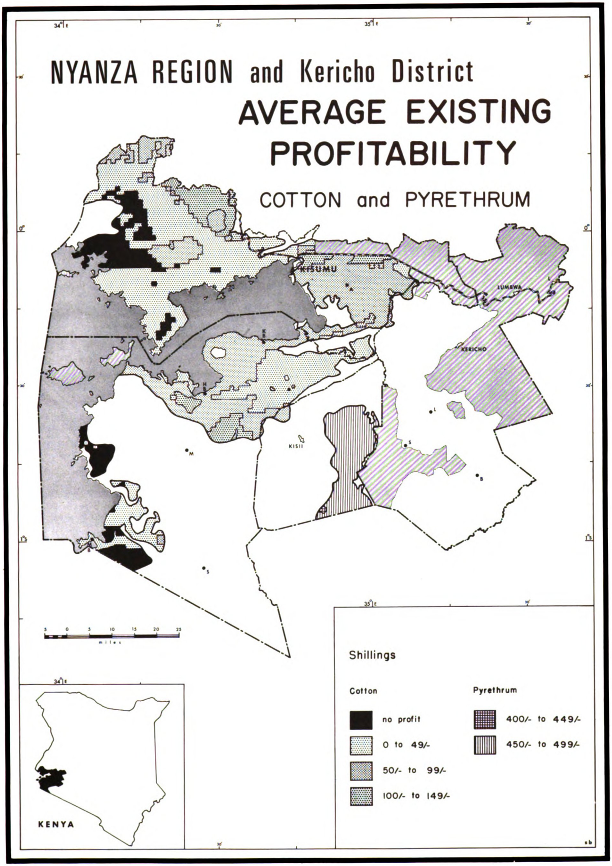
Patterns of Existing Profitability

The maps drawn by subtracting the patterns of cost per acre from the patterns of average return per acre, i.e., the maps showing the average profitability of the several cash crops (Figures 6-8, 6-9, 6-10, and 6-11), are even more difficult to read at a glance than their predecessors. There is a general trend in most of these maps indicating relative cost levels;



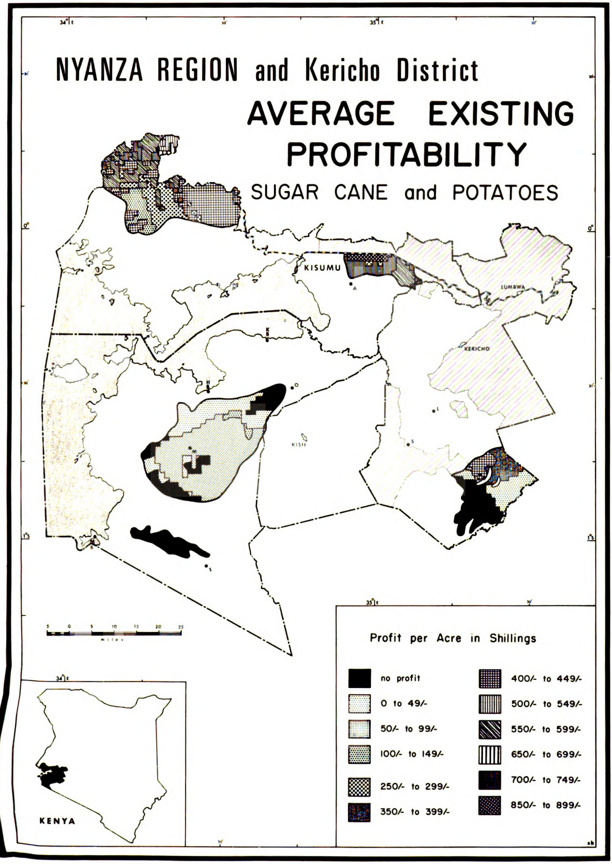
NYANZA REGION and Kericho District
AVERAGE EXISTING PROFITABILITY
GROUNDNUTS AND TEA
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Profit per Acre in Shillings
Groundnuts
no profit
0 to 49/-
50/- to 99/-
100/- to 149/-
150/- to 199/-
200/- to 249/-
250/- to 299/-
300/- to 349/-
Tea
1000/- to 1049/-
1050/- to 1099/-
1100/- to 1149/-
1150/- to 1199/-
1200/- to 1249/-
1250/- to 1299/-
1300/- to 1349/-
1350/- to 1399/-

FIGURE 6- 8



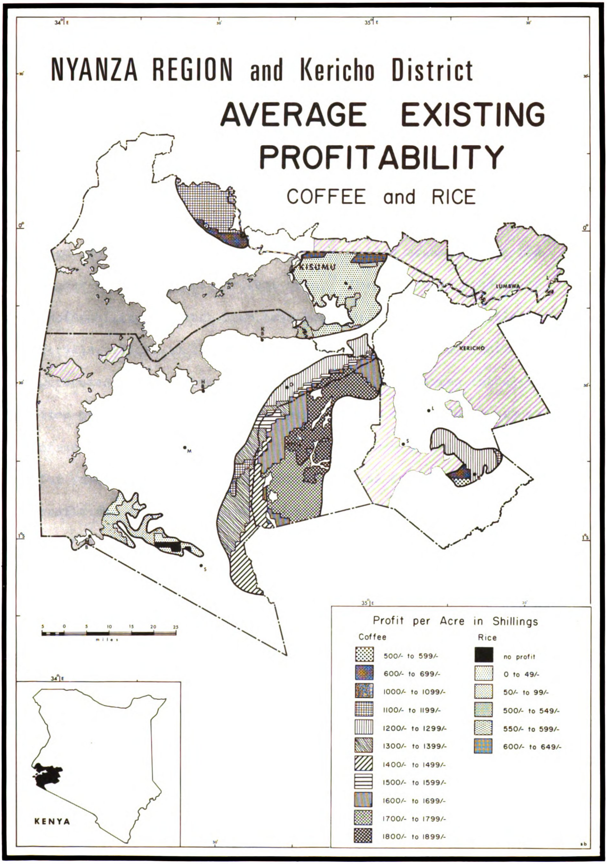
NYANZA REGION and Kericho District
AVERAGE EXISTING PROFITABILITY
COTTON and PYRETHRUM
KISUMU
LUMBWA
KERICHO
KISII
Shillings
Cotton
no profit
0 to 49/-
50/- to 99/-
100/- to 149/-
Pyrethrum
400/- to 449/-
450/- to 499/-
KENYA

FIGURE 6- 9



NYANZA REGION and Kericho District
AVERAGE EXISTING PROFITABILITY
SUGAR CANE and POTATOES
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Profit per Acre in Shillings
no profit
0 to 49/-
50/- to 99/-
100/- to 149/-
250/- to 299/-
350/- to 399/-
400/- to 449/-
500/- to 549/-
550/- to 599/-
650/- to 699/-
700/- to 749/-
850/- to 899/-

FIGURE 6-10



NYANZA REGION and Kericho District
AVERAGE EXISTING PROFITABILITY
COFFEE and RICE
KISUMU
LUMBWA
KERICHO
KENYA
Profit per Acre in Shillings
Coffee
500/- to 599/-
600/- to 699/-
1000/- to 1099/-
1100/- to 1199/-
1200/- to 1299/-
1300/- to 1399/-
1400/- to 1499/-
1500/- to 1599/-
1600/- to 1699/-
1700/- to 1799/-
1800/- to 1899/-
Rice
no profit
0 to 49/-
50/- to 99/-
500/- to 549/-
550/- to 599/-
600/- to 649/-
miles

FIGURE 6-11

profits tend to be lower within a given crop pattern at greater distances from the relevant market outlet.[2] On the other hand, the dominance of the pattern of crop production value per acre is obvious, not only in the broad boundaries but also in the occasional countering of the higher cost - lower profit trend. Some areas are simply well-suited to production of a crop, and high profits may be expected even though this area is among the higher cost locations for that crop.[3] The levels of production profitability for each crop have been based on fifty shilling intervals, except in the case of coffee where Shs. 100/- intervals were used. This has maintained comparability between the eight crop profitability patterns in spite of the wide absolute range of such profitability, as high as Shs. 1800/- to 1900/- per acre for some places of coffee production and as low as no apparent profit for occasional crop producing locations.

The fact that areas of no profitability do exist on the maps for groundnuts (Figure 6-8), cotton (Figure 6-9), sugar cane and potatoes (Figure 6-10), and rice (Figure 6-11) should not be surprising. It may be objected that no area can be cropped at a loss for very long. Eventually, such sub-marginal land will re-

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[2]See, for example, the changing profitability of groundnut production in South Nyanza, Figure 6-8.

[3]Again, see Figure 6-8; this dominance is also very clear in the sugar cane pattern, Figure 6-10.

vert to subsistence production, and should therefore not be shown as part of the growing areas for the relevant crops. In response to this argument, it must be remembered that the crop growing areas were drawn as large as believed necessary in order to include all locations where each crop was currently grown. This admittedly may have included areas that are not producing any of the particular crop for the very reason put forth by the objection. More importantly, however, are the assumptions, incorrectly made, that costs have been completely and accurately accounted in the present example of investment priority determination.

Also important is the assumption that the African smallholder cannot or will not remain in an area, producing a given cash crop, if he must regularly "invest" more in that crop's output than the return justifies. At the macro-level, this may appear correct. But for the individual farmer who can draw upon a family for labor, upon less direct kinship ties for transport from field to market at "bargain" rates, upon fresh soil every three years in regions where shifting cultivation is possible, the land may offer returns that are acceptable. Such returns may be viewed as even more acceptable, in spite of their apparent position below the no-profit margin, because of the likely concentration, emphasis, and dependence upon subsistence activities for the family's immediate needs with cash cropping being of relatively peripheral concern. It is not accidental that the "no profit"

portions of the growing areas for the cash crops under study are all located in either poor environmental conditions or outside the portions of the study region cultivated by well-established African smallholders. On this latter point, for example, the only sub-profitable farming carried on in Kisii or Kericho Districts, both containing aggressively profitable farmers, is that area in the extreme southeastern corner of Kericho District; this area comprises part of the expanding frontier of African agricultural settlement in the district.[4] In sum, there are strong arguments for indicating crop areas where costs appear to exceed returns.

The four maps of "Average Existing Profitability" contain several strong patterns. Coffee, especially that grown in Kisii District, is by far the most profitable source of African smallhold agricultural income. As Ruthenberg has written: "Smallholder development in Kenya would be bright and easy indeed if more coffee could be planted. No other event has put such a strain on future African agricultural development as the restriction on coffee."[5] As can be easily seen on Figure 6-11,

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[4]For an earlier reference to this, see, Kenya, Ministry of Agriculture, Animal Husbandry, and Water Resources, African Land Development in Kenya, 1946-1955 (Nairobi: The Government Printer, 1956), pp. 145-60, passim.

[5]Hans Ruthenberg, African Agricultural Development Policy in Kenya 1952-1965 (Berlin-Heidelberg, New York: Springer-Verlag, 1966), p. 114.

wherever coffee is grown, it brings a high return per acre. Although the present author does not hold such unreserved feelings concerning the implications of the current coffee restrictions, it was definitely in Kenya's long-term interest to accede to the International Coffee Agreement. Kenya's first-year quota under the agreement, in 1964, was set at 30,100 tons. Because large coffee acreages had been planted during the last years preceding Kenya's accession to the ICA, a ban on further planting was imposed by the government at the end of 1963 so that production would not too rapidly outrun the ICA sales quota.[6] Nevertheless, total coffee output was expected to reach 60,000 to 70,000 tons per year, even without further planting.[7] Emphasis, therefore, has recently been placed--and will continue to be so directed--on quality improvement among the existing plantings without additional acreages being put under cultivation. The high output per acre, therefore, can be expected to increase even though the area under coffee will not be enlarged.

It is also apparent from the four profitability maps that tea is the only cash crop which approaches coffee's net return per acre in Kericho and Kisii Districts. The primary cost dif-

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[6]Kenya, Some Economic Aspects . . . , 1963, op. cit., p. 12.

[7]Brown, A National Cash Crops Policy . . . , op. cit., p. 10.

ference between tea and coffee production by the smallholder is not truly indicated by the derived pattern of profitability, because this cost is short-run and the present interest is in average existing long-run costs. There is a rather formidable cost barrier for most Africans with regard to tea production.

> The bottleneck in smallholder tea production lies in the establishment expense which mainly consisted of the cost of the planting material and labour. Although in fact the price per piece of the tea stumps is not very great (30 cents each which is somewhat less than the price of coffee seedlings) the cost of putting down an acre of this crop is high because of the number of stumps required to fill one acre (around 3,500 at normal spacing). Establishment also requires a lot of labour for the preparation of the land before planting.[8]

First year costs for coffee establishment in ecologically similar Nyeri District were estimated to be Shs. 584/89 per acre while expenses per acre to establish tea were set at Shs. 1586/31.[9] Furthermore, significant yields from tea plants are not achieved until the fourth year after planting while coffee plants yield a year more quickly (see Table 6-5). It is apparent that although tea can be a relatively lucrative cash crop for the African smallholder, the more rigorous environmental requirements and economics of production make tea only a partial replacement for new coffee in smallhold agriculture.

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[8] Kenya, _Some Economic Aspects_ . . . , _1963_, _op_. _cit_., p. 27.

[9] _Ibid_., p. 15 and p. 28.

TABLE 6-5

ESTIMATED AVERAGE YIELDS FROM SMALLHOLDER TEA PLOTS, PER ACRE

450 lb. green leaf	(100 lb. made tea)	- third year after planting
1350 lb. green leaf	(300 lb. made tea)	- fourth year after planting
2700 lb green leaf	(600 lb. made tea)	- fifth year after planting
4050 lb. green leaf	(900 lb. made tea)	- sixth year after planting

Source: The Operations and Development Plans of the Kenya Tea Development Authority (Nairobi: K.T.D.A., 31st December, 1964), p. 16.

Most of the remaining patterns of crop profitability follow closely from environmental or cost variation. Rice appears to be a profitable crop in Central Nyanza on the Kano Plain but close to the no-profit margin in South Nyanza. This latter pattern is in contrast to that which might be expected on the basis of rice and rice flour shipments from this area (see Table 5-3). The explanation which will be offered for this apparently low-return area producing an increasing quantity of rice is an acceptance by the farmer of these low returns per acre as adequate, or at least sufficient to encourage efforts the following year. Groundnut patterns of profitability appear to vary more closely with environmental support for production than cost. The pattern of net returns from sugar cane production is very mixed; it is marginal in South Nyanza, related to environmental variation in northern Central Nyanza, and highest on the Kano

Plain in Central Nyanza adjacent to the well-established sugar plantations immediately north of the railway.

Cotton is obviously a marginal crop wherever it is grown in Nyanza Region. The pattern of profitability appears related to both the variation in value per acre and the spatial differences in total cost. The cost levels used are extremely low considering possible additional sources of cost, such as labor, implements, bags, and the like. The relatively low average return over most of the cotton producing area is largely attributable to the low average yields obtained. Yields of about 300 pounds per acre are common in the region adjacent to Lake Victoria while yields may exceed 1000 pounds per acre in other cotton growing areas in Kenya.[10] It is difficult to ascribe this difference to environmental variations alone.

Summary

The work thus far on the applied example of the method proposed earlier (Chapter III) has dealt with existing costs, existing production, and estimates of existing profit gained per acre. Each of these factors of farming economics has been presented as far as possible in a manner approaching its actual place-to-place variation within the chosen study area in Kenya.

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[10]Interview with Mr. J. Adero, Kenya Cotton Lint and Seed Marketing Board, Nairobi, November 25, 1966.

The data were presented in this fashion because it is felt that attempts to formulate investment policy in a given portion of a country cannot fully succeed unless the reality of spatial heterogeneity is recognized, accepted, and the proper variations in policy are made. Possibly of even greater importance is the interaction within the many segments of this space such that a change in one part alters the conditions in the other portions of the total. Investment produces--or presumes--change. A series of investments should therefore include some consideration of changing conditions within and around the location of the previous investment of that series. In the present volume, it is necessary to prepare an estimate, or estimates, of _potential_ output before any priority schedule of systematic investments can be developed. It is this pattern of potential net income that must next be determined.

CHAPTER VII

THE DERIVATION OF AGRICULTURAL POTENTIAL

Investment Decision Criteria

Justification for proposed investments should be made on the basis of expected returns. Those investments having the greatest possibility of reaching fruition with profitable results are obviously investments which should receive first attention, non-economic factors aside. Investments expected to return low benefits, or moderate benefits with low probability of occurrence, should under normal circumstances be deferred until higher-return investments have been made. The so-called "cost-benefit" analysis approaches the problems of investment by making an accounting of expected investment project costs, and comparing total costs with the sum of expected benefits.[1] Although there are methodological difficulties with most estimates of total benefits, this approach has been used frequently in the United States to justify or oppose public in-

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[1]The literature is much too extensive to list an adequate cross-section of applications. For a good review article, however, see, A. R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey," The Economic Journal, LXXV (December, 1965), 683-735.

vestment projects.[2]

Most road improvement investments in Africa are made on a largely subjective basis. A road benefits the area through which it passes in a number of obvious ways: without the road there could be little interchange of goods, people, information, ideas, and so forth, with all the associated benefits of regional and personal specialization. A road is a means of facilitating movement, of minimizing the costs needed to overcome distance. Unfortunately, although construction of a new road may have easily accountable results (increased total expenditure on fuel following a rise in traffic, and the like), many presumed benefits are confounded with events that may or may not be a result of the new road, and in any case are difficult to evaluate (e.g., a rise in school attendance). With assurance of indefinite results from objective attempts to analyse proposed road investments, it is not surprising that subjective decisions are made.[3]

As far as could be determined, choices between road projects to receive investment funds are made, basically, on a

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[2]For a procedural discussion on this method of analysis, see either, Arthur Maas, _et al._, _Design of Water Resource Systems_ (Cambridge, Mass.: Harvard University Press, 1962); or, Roland N. McKean, _Efficiency in Government through Systems Analysis_ (New York: John Wiley and Sons, Inc., 1958).

[3]Additional problems along this line, presented when the road improvements are considered within agricultural areas, were discussed in Chapter I, above.

subjective basis in Kenya. To be sure, cost research is conducted to determine on a crude basis the possibilities for agricultural development. The final decision, from which limited funds will be spent, is liable to be founded on reports from the Ministry of Agriculture and the Ministry of Communications and Works, and some over-all plan developed within the various units of the Ministry of Economic Planning and Development. Within each ministry, a series of subjective decisions have undoubtedly already been made. In agriculture, for example, the ministry headquarters must condense the reports received from each province or region relating, among other things, the areas within the region which "deserve" better roads because of their potential contribution to the regional and national economies. If some form of priority listing was not made at this level, the final planner would be overwhelmed with information on which to base his decision. Such is one advantage of bureaucracy. Each provincial report, however, is largely based on the set of district reports comprising each province's total. The district reports will also have been condensed, in this case by the provincial office, on order to facilitate ministerial decisions. The district reports, in the rare instance when they do pertain specifically to road improvements, usually present comments on road quality rather than the various investment possibilities and their justification. Such comments as are offered are, in turn, based on subjective estimates made by the District Agricultural Officer or his assistants. It is little wonder that limited investment funds may be allocated for low-return road improvements--or what may be worse, not allocated for high-return projects--when the long series of subjective priority "thinnings" are considered.[4]

Dependence upon subjectivity and indefinite foundations for road investment decisions are by no means newly developed means of avoiding responsibility for unfulfilled expectations.[5] Nor is this method of determining investment priorities necessarily irresponsible; the more objective means of determining these priorities can be very expensive, time-consuming, and result in too vague a series of priorities to be acceptable. No less an authority than the World Bank survey mission to Kenya has written, with respect to agricultural feeder roads:

> The mission is not in a position to recognize firm or detailed priorities as between either areas or individual roads. In this group, changing developments in different parts of the country, will require a flexible plan rather than the establishment of rigid priorities. The method used by the authority of nominating a list of roads in

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[4]This system also tends to be detrimental to inter-regional road projects, whether Kenya-Tanzania or Kenya-Uganda, because it focusses project information almost entirely on _internal_ needs and potentialities.

[5]See the reference to Hirschman, _The Strategy_ . . . , _op. cit._, in Chapter I, above.

> each area, with work to be performed on selected items, or substitutes, as funds are found, satisfies this criterion.[6]

Thus, with easy assurance of "flexibility" the means of selecting projects is left to subjective judgement. The present volume, of course, is offering a means of transport investment priority determination in rural areas which is objective and yet maintains methodological flexibility.

Foundations of Agricultural Potential Determination

At the root of subjective attempts to formulate investment priorities is the difficulty of estimating probable returns from a given investment in a given region. The technique most commonly used, after subjective ones, is that of accounting the monetary benefits expected to result from the given investment. The expectations are based on population, traffic, and crop production trends within the area. As such, they are relatively inflexible with respect to regions and individual projects as argued by the World Bank mission, above. The sum total of the expected benefits is also liable to error having its source in judgements made by the research team concerning which aspects of the area's society will benefit, and to what degree these benefits will accrue in the short- and the long-run.

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[6]International Bank for Reconstruction and Development, The Economic Development of Kenya (Baltimore: The Johns Hopkins Press, 1963), p. 184.

It is argued here that a more dependable approach to the problem of establishing possible agricultural returns from transport improvements can be achieved through examination of the ecological potential of the region. Ecological regions, as defined in Chapter III, are for present purposes contiguous areas on the earth's surface which indicate a basically similar support for plant growth by the similarity of their environmental characteristics.

To argue that the non-human factors in plant growth are more important than the human elements, or to argue that they are the final control in maximizing production even if labor, attitude, and other such human inputs are "perfected," is to ignore the nature-changing abilities of human technology. Malthus was, after all, wrong in the narrowest, short-run sense. On the other hand, to imply that in a given set of environmental circumstances there is no maximum output which can be expected--because the maximum at one level of technology may be increased with some higher technical knowledge--is to pass from reality to theory. The concern here is with the levels of output within the reach of African smallholders engaged in cash crop production. In this sense, engineered alterations in the environment are less likely than changes in human attitudes toward production.[7] Environmental

[7]Retired District Officers, some theoretical economists, and others may disagree with this. The author trusts that anthropologists and Africans would not.

interaction, described in the form of ecological regions, are therefore used as the basis for setting levels of crop production potential in different portions of a given agricultural region.

The use of environmental characteristics as indicators of possible crop production can scarcely be considered new. On the other hand, the use of these elements in combination, as ecological units, in order to indicate place-to-place variation in crop productivity is not common in the literature. Three outstanding examples of this approach in Africa are known, although only two have been published in a complete form. It may be helpful here to make brief, but explicit reference to each of these examples before proceeding.

Agro-ecology in Zambia

William Allan, while Assistant Director of Agriculture in Northern Rhodesia (now Zambia) during the 1940's, undertook with Colin G. Trapnell and others to classify a great deal of the land in the country then devoted to African agriculture. The primary purpose of this task was apparently to classify these areas in terms of their suitability for different crops.[8] On the basis of information gathered during field surveys, Allan devised a method of determining the total number of people who could be supported

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[8] See "Foreword," by Max Gluckman, in William Allan, *The African Husbandman* (London: Oliver and Boyd, 1965), pp. v-viii.

by a given unit area of land, i.e., the total "carrying capacity" of the land.

It is obvious that Allan and Trapnell were well aware of the spatial variability of land suitability for their method deals directly with this variability. In contrast to the often glib implication of a homogeneous land input in some production equation, Allan used Trapnell's previous work as a guide in conducting vegetation-soil association surveys. The vegetation-soil data gained from these surveys were mapped, and the areas of each distinct association were measured. Using the fact, often missed or ignored in the averaging of data, that varying proportions of the land are cultivable in the different association areas, Allan could then derive a series of cultivability levels which applied throughout each of the vegetation-soil areas.

In any given portion of the survey area, it was possible to determine how much of the area was suitable for continuous or partial cultivation and how much was truly useless for agriculture.[9] Each major vegetation-soil association was assigned to one

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[9]Allan proposed six primary land categories:

Permanent Cultivation Land, where land is cultivated and left fallow for roughly equivalent alternating periods;
Semi-Permanent Land, land which may be cultivated continuously for fairly long periods but which requires longer periods of "rest" than permanent land;
Recurrent Cultivation Land, requiring three to five

of a set of land quality categories and a land use index was, in turn, assigned each category. The index for a given category indicated roughly the number of fallow years required for each year of cultivation. The better the vegetation-soil indications for crop growth, the lower the index because fewer fallow years are necessary to maintain soil fertility. Then, using the average family size and the number of bags of corn required to feed this "producing unit" from a farm of given size with given average yields together with the land use factor and the cultivable percentage of each quantity of the various land qualities present in the region, Allan was able to calculate the "Critical Population Density" for that region. "For a single Vegetation-Soil type, the area of land required per head of population may be expressed by the formula 100 L.U. x C/P, when L.U. is the Land-Use Factor, C the Cultivation Factor and P the Cultivable Percentage for the type."[10] The Cultivation Factor, in turn, is ". . . the average acreage cultivated per 'producing unit' . . . ."[11]

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times the cultivation period for rest and recuperation of fertility;

Shifting Cultivation Land, which must be left fallow extended periods, say, twenty to thirty years, after only two to three years cultivation;

Partial Cultivation Land, basically uncultivable land but containing small pockets of usable soil;

Uncultivable or Waste Land.

Allan, The African Husbandman, op. cit., pp. 30-35.

[10] Ibid., p. 89.

[11] Ibid., p. 42.

The goal in this method is to permit determination of the critical population density of places before this density is reached. Gradual deterioration of the land may in this way be circumvented, at least in theory. As Allan points out,

> The term "Critical Population Density" was coined as a descriptive label for this concept of the human-carrying capacity of an area in relation to a given land-use system, expressed in terms of population per square mile, and it was defined as the maximum population density the system is capable of supporting permanently in that environment *without damage to the land*.[12]

Although designed to prevent land destruction by over-cultivation in semi-subsistence economies, this approach could be modified to apply to over-use and erosion by cash crop producers as well. Since this volume deals with the spatial variability of cash crop production, at existing and potential levels of production, Allan's procedure must be examined from the viewpoint of its possible usefulness in determining these levels of crop output.

There are several aspects of the method used by Allan which are of direct applicability to the requirements of the present volume's procedural outline. In order to delimit a region's ecological vegetation-soil associations, field surveys were made along traverse lines forming a grid having unit sides of one mile and two miles.[13] Using this fine a grid with supplementary guides

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[12] *Ibid.*, p. 89.

[13] See Allan's earlier, *Studies in African Land Usage in Northern Rhodesia* (Rhodes-Livingstone Papers Number 15; 1949), pp. 3-7.

from aerial photographs, it was possible for considerable variation to be discerned and mapped. It was necessary, of course, to have a thorough knowledge of the local region's expected joint vegetation-soil occurrences. Two associations placed in the same group by Allan, for example, from a survey taken in the Ndola district of (then) Northern Rhodesia, are called

> Red Earth Types: (a) Woodland of *Brachystegia spiciformis* and *B. longifolia* with evergreens in the understory; on generally deep, brownish-red to lighter red clay-loams. (b) Woodland of *B. floribunda*, *Julbernardia tomentosa*, and *J. paniculata*; on bright red to orange-red clay loams.[14]

Once such associations are made, however, a sizable area may be rapidly mapped by a small survey team.

Allan recognized that ecological surveys taken as a means of assessing land potential have limitations. An ecological survey

> . . . is not readily applicable and may be of little value in regions where biotic and climatic factors, most commonly the former, obscure the relationship between vegetation and soil. By burning, cutting, cultivating, and grazing, man and his animals can change vegetation radically.[15]

Dependence upon vegetation as the primary indicator of ecological suitability for crop production may, therefore, be rather tenuous in regions that have been long, or destructively, cultivated. Fortunately, the association which can be made between land potential and vegetation remains relatively undisturbed across much of

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[14] Allan, *The African* . . . , *op. cit.*, p. 17.

[15] *Ibid.*, p. 13.

Africa, and especially in eastern and south-central Africa. For purposes of the present study, then, value from Allan's work can be associated with recognition of the varying agricultural potential of vegetation-soil areas and with the relatively rapid field mapping which can be done by survey teams basing their classification of areas on these vegetation-soil groups.

There is little, however, that can be directly obtained from Allan's further use of these ecological areas for this volume's immediate needs. In developing a procedure to calculate the total or per acre population which may be supported by a given region's agricultural capabilities, Allan first determines the existing yields per acre for each of the six to eight ecological associations. The total area of each vegetation-soil grouping is then obtained by field surveys. This allows calculation of total yields in the study region. Once the average acreage required to feed one person is determined, it is a simple matter to calculate the total population which may be supported by the land resources without soil destruction or deterioration. This procedure is not usable for present purposes because of its dependence upon existing yields. Undoubtedly because of a major concern with a land use situation which was even then becoming serious for future production, Allan dealt basically with existing land pressures and output rather than some future level of production. Unfortunately, it is precisely this potential output, and its relation to the locational variation in environmental support, which is of primary interest here. Therefore, it may be concluded that although there are points of support in Allan's works for the ecological method of determining spatial patterns of crop production, they offer no direct contributions to the problem of relating ecological indicators to potential levels of agricultural output.

Agro-ecology in Rhodesia

A two-part survey which was much closer in its goals to those of the present work was made in Southern Rhodesia during the later 1950's.[16] Although the authors of Part I, "Agro-Ecological Survey," based the rainfall-soil-vegetation relationships used in this study upon an earlier work by J. Smith dealing with the Sudan,[17] there was some apparent influence from the much closer efforts of Colin Trapnell.[18] This set of reports attempted

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[16]Federation of Rhodesia and Nyasaland, An Agricultural Survey of Southern Rhodesia, Parts I and II (Salisbury: The Government Printer, 1959).

[17]Reference made, loc. cit., p. 32, to J. Smith, "Distribution of Tree Species in the Sudan in Relation to Rainfall and Soil Texture," Agric. Pub. Comm., Khartoum (1950).

[18]In, Federation of Rhodesia and Nyasaland, An Agricultural . . . , op. cit., p. 32, footnote 22, reference is made to an anonymous work, "The Soils, Vegetation and Agriculture of North Eastern Rhodesia,": Report of the Ecological Survey: Govt. Printer, Lusaka (1943). This work is referred to by Allan as ". . . Colin Trapnell's remarkable pioneer survey of Northern Rhodesia . . . ," Allan, The African . . . , op. cit., p. 13, and bibliography item no. 171, p. 482.

to classify Southern Rhodesia into "Natural Regions" based on associations of environmental characteristics bearing upon crop production. The classification was made in order to define ". . . the field of [land] uses toward which, with due regard for economic influences, the planners will aim in any programme to achieve optimum physical outputs . . . ."[19] The aim of the study, in other words, was to delimit areas of varying total potential output on the basis of their ecological characteristics.

In this regional determination, primary emphasis was placed on soil-formation and soil-fertility in so far as it could be related to crop yields. Climate, for example, was considered important in crop production but was placed, by strong implication, in a position secondary to the nature of the parent material in the soil-formation process.[20] Vegetation was also seen to follow soil character here rather than the reverse. Nevertheless, the relationship between plant growth and rainfall-soil texture combinations was given considerable emphasis, and as in the case of the earlier Trapnell-Allan surveys, vegetation was used as the basic indicator of soil-precipitation areas of relative agricultural suitability.[21] On the basis of these environmental indi-

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[19]Fed. of Rhod. and Nyas., _An Agricultural_ . . . , _op. cit._, p. 2.

[20]_Ibid._, p. 16.

[21]See, _Ibid._, pp. 32-39.

cators, the authors of this study divided their total area of concern into Natural Regions, and then into Natural Areas within each Natural Region. Each National Area contained smaller sub-areas of specified agricultural potential. Unfortunately, for present purposes, the means by which the total potential of each of these ecological groupings was determined is not clearly and explicitly outlined. Furthermore, the resulting areas of production potential are not strictly transferable to the present volume's study region because of environmental differences. In spite of these limitations of detail, The Agricultural Survey of Southern Rhodesia does provide greater conceptual justification for using ecological associations as indicators of "optimum," or at least equivalent levels of potential crop output. This report also is an example of the research thoroughness necessary in order that policy decisions may be made with reasonable confidence, although again, a more complete discussion of the precise manner in which the potentialities of each ecological region were calculated would have lent more credence to the policy proposals made.

Agro-ecology in Kenya

Kenya's agricultural policy has fortunately been guided by several productive ecologists. After a period of service in Northern Rhodesia, Colin Trapnell apparently spent a number of years in Kenya initiating the outlines of present agricultural policy insofar as it is based upon ecological criteria. Leslie Brown carried on the work begun by Trapnell, expanding its coverage and proceeding with directness into applications of ecological criteria to specific farming programs. Trapnell's influence, for example, is apparent in Brown's observation that

> . . . natural vegetation is the best indicator available of the potential of any area of land, resulting as it does from the sum of the effects of rainfall, soil type and temperature. From a knowledge and understanding of the grasses and trees--especially grasses--it is possible to arrive at a fair estimate of the agricultural potential of almost any area. It is the natural vegetation which is the key to the whole matter.[22]

With this approach toward estimating the agricultural potential of African farming areas, at least two draft policies were outlined by Brown, one each for the two provinces containing the most productive areas of African agriculture, Central Province and Nyanza Province.

Fortunately for the purposes of the present work, Brown's note on agricultural potential in Nyanza Province has remained accessible, insofar as the files of the Kenya Ministry of Agriculture are accessible, in spite of its being overshadowed by the better-known Swynnerton Plan.[23] In this unpublished, mimeo-

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[22]L. H. Brown, "Development and Farm Planning in the African Areas of Kenya," _East African Agricultural Journal_ (October, 1957), quoted in Allan, _The African_ . . . , _op_. _cit_., p. 14.

[23]R. J. M. Swynnerton, _Plan for the Intensification of African Agriculture in Kenya_ (Nairobi: The Government of Kenya, 1954).

graphed, indeed, unsigned and undated report,[24] Brown describes the general locations of a series of ecological zones grouped on the basis of their potential agricultural productivity. The farming systems suitable for each of these zones are given in detail, providing for the present work guidelines for profitability estimates which also vary from zone to zone. That is to say, suggested systems of operating a farm of given size within each of the zones of farming potential are detailed, including the proper series of annual rotation and allowance of land area for non-cash crop efforts. Unfortunately, the only known map of these ecological regions is restricted to the Central Nyanza District alone, leaving South Nyanza, Kisii, and Kericho District patterns in verbal form only. It has been necessary, therefore, to construct such a map on the basis of the verbal description given in the report, available soil-vegetation-relief information, and personal observations of a non-systematic nature. Once the general map of the ecology and the potential of the several land areas is drawn, it is possible to apply knowledge of crop prices to the various levels of potential output.

The Pattern of Ecological Zones

The most direct source, almost the only source, of informa-

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[24] L. H. Brown, "Draft Agricultural Policy: Nyanza Province," for the Government of Kenya, Ministry of Agriculture, *about* 1957 (unpublished).

tion concerning Brown's conception of the several agro-ecological regions within Nyanza Province[25] is his "Draft Agricultural Policy" referred to above. Because of its importance for the present work and for others of the same nature yet to be undertaken, and also because of the difficulty of obtaining this reference outside of Kenya, that portion of the note describing the ecological "farming zones" is quoted at length. These descriptions follow, in what Brown himself referred to as ". . . a rough classification of the main ecological zones."[26]

A. Balanced Mixed Farming Zones.

(1) Kikuyu - Star Grass Zone. This Zone occurs on Mount Elgon in Maragoli - Bunyore, Kisii Highlands, and Kericho, and is characterised by the presence of Kikuyu grass or Star grass dominant in pasture. The original vegetation was either forest of the *Acacia abyssinica - Vernonia - Hyparrhenia cyarbaria* associations common in Sotik. Although there is considerable variation in altitude, temperatures etc., this zone is all capable of intensive cultivation with one or other high-priced cash crop and of supporting a heavy stocking of productive animals. It is the most important and valuable Agricultural area in Nyanza Province, as is demonstrated by the very high populations carried in parts of it, e.g. Maragoli - Bunyore and Kisii Highlands.

(2) High Rainfall Savannahs. This is the next most important zone in Nyanza province. It consists of short tree-high grass associations of various sorts, but the following grasses are

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[25]At the time this report was written, Nyanza Province comprised the land now divided into Western Region (less properly, Western Province although this earlier terminology persists), Nyanza Region, and Kericho District, the last now included within the Rift Valley Region.

[26]Brown, "Draft . . . ," *op. cit.*, p. 1. Passage quoted, pp. 1-3.

important; Cymbopgon validus, Hyparrhenia rufa, Hyparrhenia filipendula and Imperata cylindrica; wherever one of these grasses, with Combretums, Erythrinas, and Bauhineas among trees are dominant this is the zone concerned.

Most of this zone is of high potential agriculturally, though less so than (1) above; a proportion of it is useless for arable land owing to stones and murram. At present much of the grassland is poor and coarse, and this zone generally is capable of great development.

B. Impeded Drainage Sub-Zones.

Poor drainage is a condition affecting possibly one thousand square miles in Nyanza province, and the areas which result require different treatment to the balanced mixed farming zones although they may have equally favourable rainfall. Generally, they contain small pockets of good arable land surrounded by large areas of land which are useless for arable cultivation or of very limited value only; their proper usage thus seems to entail the gathering of fertility from outside the arable and more or less continuous cropping on the small pockets of good soil. The typical appearance of such zones is the grouped tree grassland of Butende, Trans Mara, and Sotik, but one important area is simply a grass plain dominated by Pennisetum catabasis. The following are distinct types:-

(1) Sub Zone of A.(1). Sotik highlands and part of Sotik division of Kipsigis. The hillside pockets in this case originally supported Acacia abyssinica - Hyparrhenia cymbaria associations, still to be seen in Sotik, but heavily cultivated in Kipsigis. Hilltops are stony and covered with Themeda triandra, Loudetia kagerensis grassland; on the flats the grasslands between the hillocks are dominated by Setarias and pennisetum catabasis.

According to our present knowledge this type of country is only of limited usefulness agriculturally. The hilltops are potentially very poor, and the very large area of flats are only of limited value for stock keeping unless the drainage problem can be solved.

(2) Sub Zone of A.(2). Butende country - 150-200 square miles on Tanganyika border. This zone is similar to the above except that it is generally flatter with no sharp hills. The patches of potential arable land carry vegeta-

tion similar to Zone A.(2) and occur on ridges where the soil is deeper; cropping range in these patches will be similar to A.(2). In impeded drainage conditions grouped tree grassland dominated by Themeda trianda and Loudetia kagerensis occurs.

This zone is generally valuable stock country with patches suitable for cultivation. The potential of the land will depend upon the proportion of it which is suitable for arable farming.

(3) Sub Zone of A.(2). Pennisetum catabasis seasonal swamp. This occurs over about four hundred square miles of South Nyanza district. It is simply a grass plain on black clay soil with an almost uniform association of Pennisetum catabasis with Star grass. As opposed to the last two zones the impeded drainage is caused by the soil type rather than by the presence of a hard pan just below the surface. This zone is thought to be of high potential for sugar production.

C. Less favourable Zones.

These zones are not referred to as Marginal, as the rainfall is nowhere so low that cultivation under a reasonable system would be really precarious, as in drier parts of Kenya.

(1) Lake shore savannahs. (Acacia-Balanites plus Bothriochloa). These are somewhat similar to the Central Province savannahs in potential. Typically the grassland is Themeda - Bothriochloa with some Hyparrhenia, and Loudetia kagerensis dominant on stony ground. Trees are mainly Acacias with Balanites also very common. There are patches where impeded drainage occurs in slight degree, indicated by an association of Setarias with Acacia sayal as on the Uyoma peninsular.

With care this zone can support a balanced agriculture provided the importance of fodder feeding is recognised and allowed for by growing a fodder crop. Probably four months fodder feeding a year, or even more, may be necessary, - possibly in the form of silage.

(2) Kano Plains (Acacia-Balanites plus Bothriochloa). This zone appears in similar rainfall conditions to (1) above but on a different soil, which is a silt loam with

some impeded drainage. The vegetation is largely Acacias and Balanites with Star Grass, Bothriochloa, Themeda, and Sporobolus. Parts are definitely swampy and subject to flooding from rivers. The pristine state of this type of country may possibly be seen in the Lambwe Valley. The conditions occur not only on the Kano plains but in many smaller areas round the Lake shore.

There is a high potential under irrigation in this zone (for rice), and a farming system should be possible for non-irrigible areas similar to, with slight variations from, that suitable for (1) above. In both this and (1) the importance of fishing must be recognised as a food source.

(3) Masai Grasslands. This name is given to a small zone, marginal for agriculture, in Sotik division in the lower part of the Amala basis. Vegetation is Acacia and shrubs with Star grass, Eragrostis, and Digitaria. This zone should ideally be left uncultivated and used as ranching country. Cultivation would only destroy it.

A map drawn exclusively from this verbal description would indeed be general. With slight reference, therefore, to the map of soil types (Figure 6-3), a map was drawn approximating that described by Brown in the above passage (see Figure 7-1). Perhaps the most striking pattern of agricultural potential illustrated by this map is the dominance of high potential areas (A.1. - Kikuyu-Star Grass) in Kisii and central Kericho Districts. This ecological indicator is also found on the periphery of northern Central Nyanza with the major area covered by this second zone of high potential located around Maragoli and Bunyore in what is now Western Region. Of equal important for the study region is the sizable portion of South Nyanza District classified A.2.--high rainfall savannah--for the presence of this

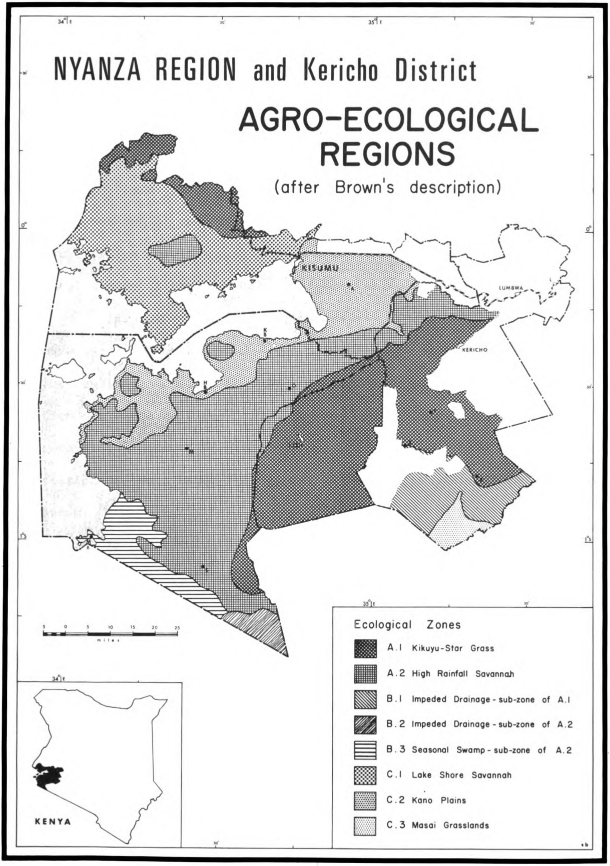
NYANZA REGION and Kericho District
AGRO-ECOLOGICAL REGIONS
(after Brown's description)
KISUMU
LUMBWA
KERICHO
miles
KENYA
Ecological Zones
A.1 Kikuyu-Star Grass
A.2 High Rainfall Savannah
B.1 Impeded Drainage - sub-zone of A.1
B.2 Impeded Drainage - sub-zone of A.2
B.3 Seasonal Swamp - sub-zone of A.2
C.1 Lake Shore Savannah
C.2 Kano Plains
C.3 Masai Grasslands

FIGURE 7- 1

ecology is said to represent an area "generally . . . capable of great development."[27] A point should be made here of the nearly total inclusion of Central Nyanza within one or the other of the two major "less favourable zones," Lake shore savannah and the Kano Plain. Emphasis is laid here on the extent of these zones because of the demands made on this environment by the rather large population living in Central Nyanza. The agricultural aspect of these demands will be discussed later.

This map of ecological regions may be made more specific by a careful comparison with the derived soil map (Figure 6-3). The resulting modifications to the pattern of ecological variation are shown on Figure 7-2. The dominant patterns remain; the generalized pattern of Figure 7-1 was, after all, guided by associations between major soil groups and the verbal description by Brown.

In addition to increased attention given to soil-type boundaries, an additional category of land potential has been added to Figure 7-2. The land in this new category is, in many instances, land which is waterlogged throughout the year, i.e., swamp and marsh land. Some drainage of these areas may produce good agricultural land; under present conditions, only the margins are feasibly used. Another portion of this new category repre-

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[27] Ibid., p. 2.

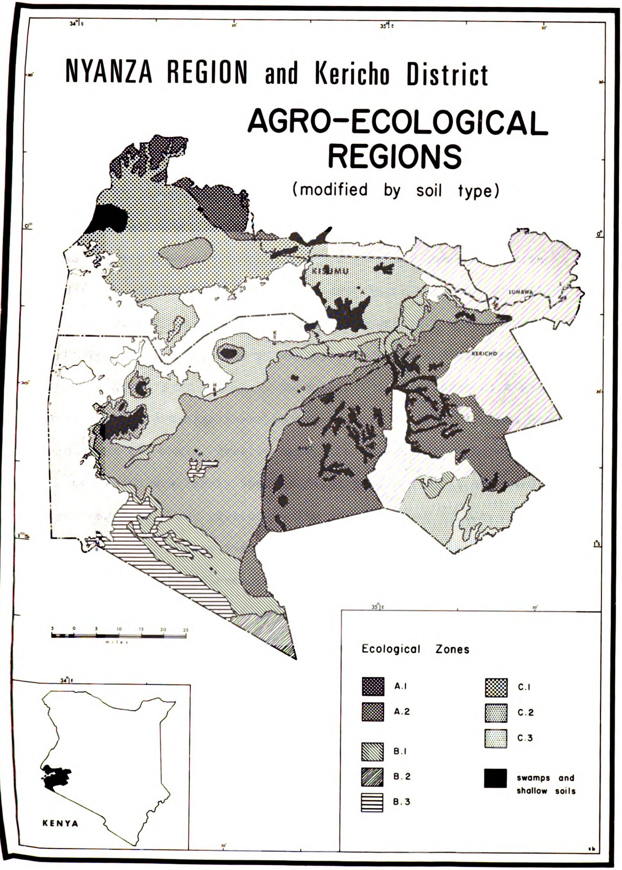
NYANZA REGION and Kericho District
AGRO-ECOLOGICAL REGIONS
(modified by soil type)
KISUMU
LUMBWA
KERICHO
miles
KENYA
Ecological Zones
A.1
A.2
B.1
B.2
B.3
C.1
C.2
C.3
swamps and shallow soils

FIGURE 7- 2

sents land which is not usable for agriculture because of the absence of soil, either on steep slopes or hilltops. Several volcanic remnants may be identified by the presence of this land category along the northern shore of South Nyanza.

The most drastic changes in Figure 7-1 were made on the basis of soil associations. A large portion of southern Kericho District was changed from B.1. to C.2. because the entire area classified in the Kano Plains zone associated with the so-called "black cotton" soil is also indicated as present in southern Kericho. Similarly, a large section in southern South Nyanza was re-classified B.1. from A.2. because of the dominance of a soil with impeded drainage there as was typical of the described B.1. zone. On the whole, greater attention to boundaries between soil types (which are rarely boundaries at this scale, in any case) provides detail not present in the verbal report of these zones' locations, but the over-all pattern is basically unchanged.

It may be relevant here to discuss briefly the basis upon which the soil map was constructed. The importance of soil patterns in providing a foundation for the agro-ecological zones is obvious. And since the ecological differences are crucial to an understanding of agricultural potential, a proper soil map is of equivalent importance. Because there is no soil map of the study region available, the data used here are derived from patterns of soil-topography associations compiled by R. M. Scott.[28] The regular association which can be made between a succession of soils down a slope is called a "catena," and it is on this concept that the combinational map drawn by Scott was based. As Scott writes: "It has been noted in the field that a given topography having a similar climate and parent materials tends to give similar soil sequences. As the topography or parent material changes so do the soil sequences."[29] Since associated soil-topography patterns may be constructed by indicating the location and extent of dominant catenas, it is not illogical to presume that the relief pattern may be "subtracted" leaving a map of soil types. This, in fact, is what has been done. By matching soil-topography associations with moderate scale relief maps of the study region and defining soil differences on the basis of topographic changes, a map of major soil patterns was drawn (Figure 6-3).[30]

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[28] R. M. Scott, "The Soils of East Africa," The Natural Resources of East Africa, E. W. Russell, ed. (Nairobi: East African Literature Bureau, 1962), pp. 67-76, and map.

[29] Ibid., p. 71.

[30] The only available alternative source of soil information was the soil map provided in the Atlas of Kenya (Nairobi: Survey of Kenya, 1959). This map was judged unsatisfactory for present purposes because of the peculiar manner in which relative soil dominance is represented. The fractions of sub-primary soils in an area are shown as proportionately wide linear patterns within the dominant soil, but the specific locations of these secondary soils within their general area of occurrence are not indicated in any respect.

The agro-ecological regions delimited in Figure 7-2 were based primarily on the derived soils map for several reasons. The soil pattern has within it an element of the variations in relief, an important element in land utilization. The soils map was, after all, drawn from soils-relief associations. The boundaries between soils could also be drawn with a fairly strong degree of certainty as they were often accompanied by a sharp change in relief. And finally, the description by Brown of the agro-ecological zones he had based on his experience in this part of Kenya seemed to follow most closely the pattern of soils as drawn from the map by Scott.

A Measure of Climatic Influence

A complete definition of agro-ecological zones cannot be obtained from soil characteristics alone. In an area where the soil-vegetation associations can be accurately mapped, further environmental factors may, in fact, be no more than refinements of the derived pattern. In the present case, however, although the vegetation indicators of agricultural potential are well described by Brown, the precise areal extent of each set of indicators is not. It is therefore necessary to include some further elements of the environment which will be surrogates for the unknown distribution of vegetation. In much of East and Central Africa, climate may be used as this proxy for natural vegetation when soil type is also included. "Vegetation and soil are closely related, but it is the soil together with the climate that determines the vegetation, not the vegetation the soil as in some parts of the world."[31]

A desirable climatic measure would be one which relates in some manner to vegetation requirements for temperature and precipitation. Evapotranspiration is such a measure. Developed independently in 1948 by Penman[32] and Thornthwaite,[33] the concept of potential evapotranspiration relates plant moisture requirements to the availability of this moisture. Thus, potential evapotranspiration

> . . . represents the water that would be lost by evaporation from the ground surface and transpiration from vegetation in an area where there is always an adequate moisture supply. This water loss is unaffected by type of vegetation cover, soil type, cultivation practice or changing soil moisture content. Potential evapotranspiration is primarily a function of the available energy from the sun. Thus it is also an index of thermal efficiency. It is not merely a growth index since it expresses growth in terms of the water that is needed for growth. It combines both the moisture and heat aspects of climate.[34]

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[31] Fed. of Rhod. and Nyas., An Agricultural Survey . . . , op. cit., p. 16.

[32] H. L. Penman, "Natural Evaporation from Open Water, Bare Soil and Grass," Proceedings of the Royal Society, CXCIII (1948), 120-45.

[33] C. W. Thornthwaite, "An Approach toward a Rational Classification of Climate," Geographical Review, XXXVIII (1948), 85-94.

[34] C. W. Thornthwaite, J R. Mather and D. B. Carter, "Three Water Balance Maps of Southwest Asia," Publications in Climatology, XI (1958), Laboratory of Climatology, Centerton, N. J., p. 23.

Potential Evapotranspiration (PE) therefore provides a means of including the major climatic impact on crop growth within a single measure and is suitable to be used here as a modifying agent to the agro-ecological zones based largely on soil type.

In spite of the conceptual attractiveness of this measure, there is still much controversy over the best method of determining a location's PE. Mechanical means of measuring PE have yielded varying results. A number of formulas have been offered by researchers following Penman and Thornthwaite as more accurate or easier to manipulate. The precise relationship between individual crop water requirements in terms of PE and crop yields has not yet been firmly established. The variability of results found to follow calculations of the various methods for determining PE in different environmental extremes has brought each of these methods into question.[35] Regardless of these problems of detail, it is not difficult to accept the conceptual attractiveness and potential of this approach to agro-climatology, and to agree with Baier that ". . . eventually those methods which include soil moisture estimates, either measured or calculated, are the most promising as a basis for evaluating agro-climates, land use, agri-

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[35]For a review article of these problems and much of the literature on PE, see, W. Baier, "The Interrelationship of Meteorological Factors, Soil Moisture and Plant Growth," International Journal of Biometeorology, IX (1965), 5-20.

cultural production potential of a region and for crop forecasting."[36]

As a means of modifying the previously defined, soil-based agro-ecological zones within the study region, the levels of potential evapotranspiration, water surplus and water deficit were calculated for 85 weather recording stations in Nyanza Region and Kericho District. The Thornthwaite method of PE determination was used because of the simple data requirements.[37] The map of PE (Figure 7-3) can be considered an illustration of water need in the sense that it represents the amount of water transpired from plants which have sufficient moisture for complete growth-use, i.e., enough moisture to forestall any diminution of plant growth due to less-than-optimum water availability. The patterns of water surplus (Figure 7-4) and water deficit (Figure 7-5) represent the variation in annual totals of monthly excesses and inadequacies in the available moisture with respect to that amount needed. In this way, high water surplus indicates an area wherein soil moisture is almost always sufficient for successful crop growth, while high water deficit is an indication of an area where a crop

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[36] Ibid., p. 14.

[37] Mean monthly temperature, mean monthly precipitation, average length of day (not pertinent here, because the study region is located astride the equator), and the water-holding capacity of the soils. Temperature and precipitation records are available from the East African Meteorological Organization.

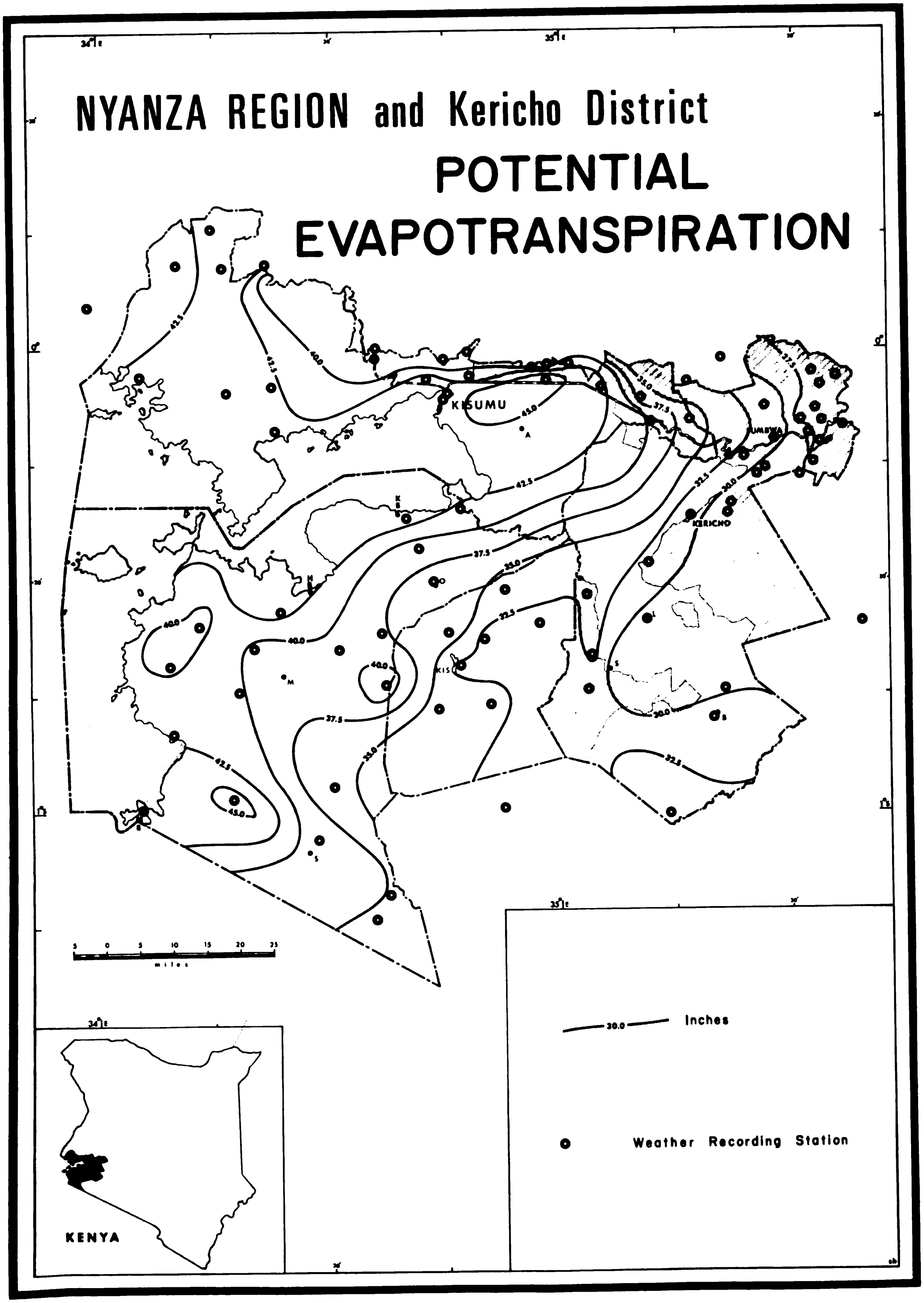
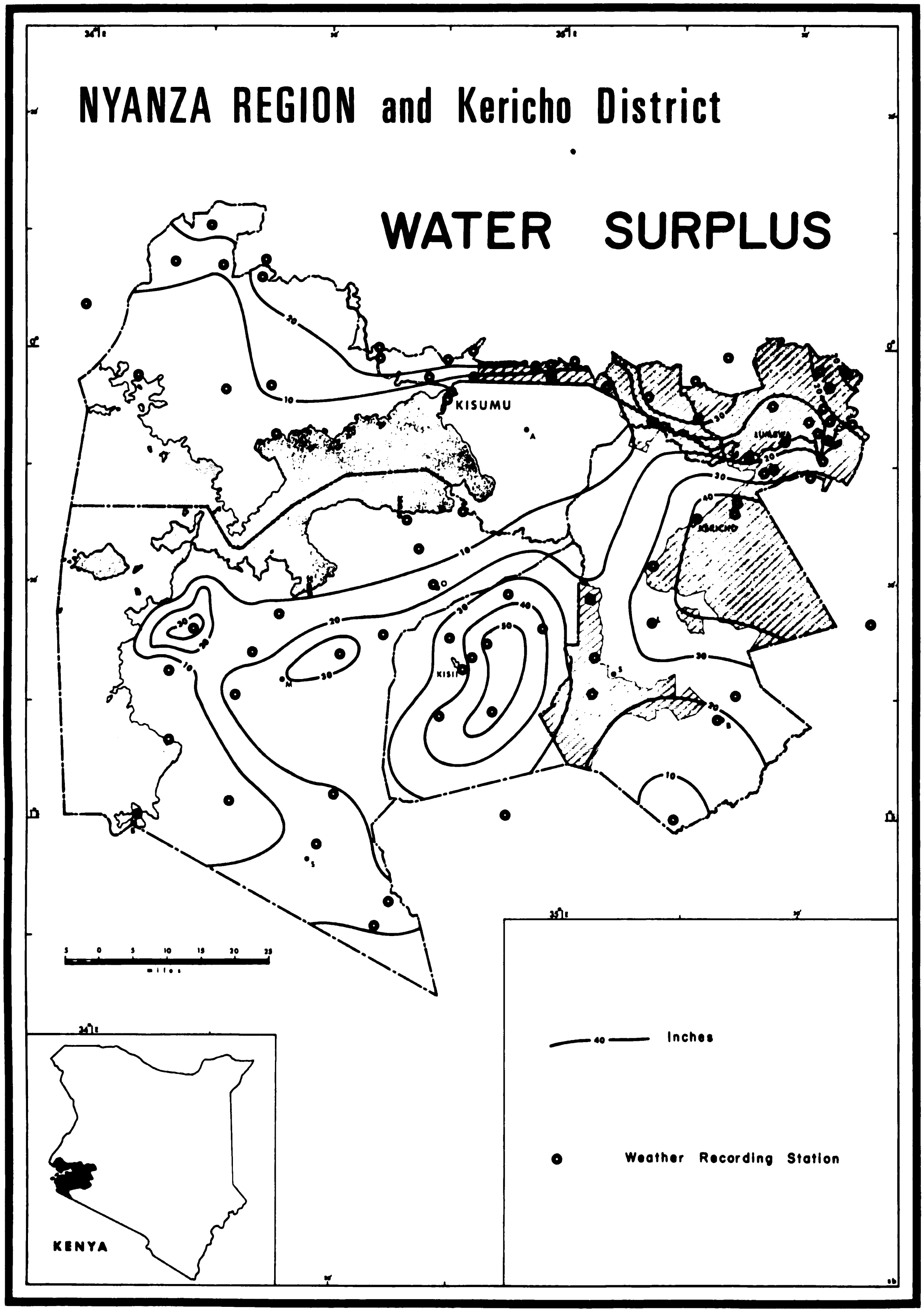

NYANZA REGION and Kericho District
POTENTIAL
EVAPOTRANSPIRATION
KISUMU
KERICHO
miles
KENYA
Inches
Weather Recording Station

FIGURE 7- 3



NYANZA REGION and Kericho District
WATER SURPLUS
KISUMU
KISII
KERICHO
KENYA
miles
Inches
Weather Recording Station

FIGURE 7- 4

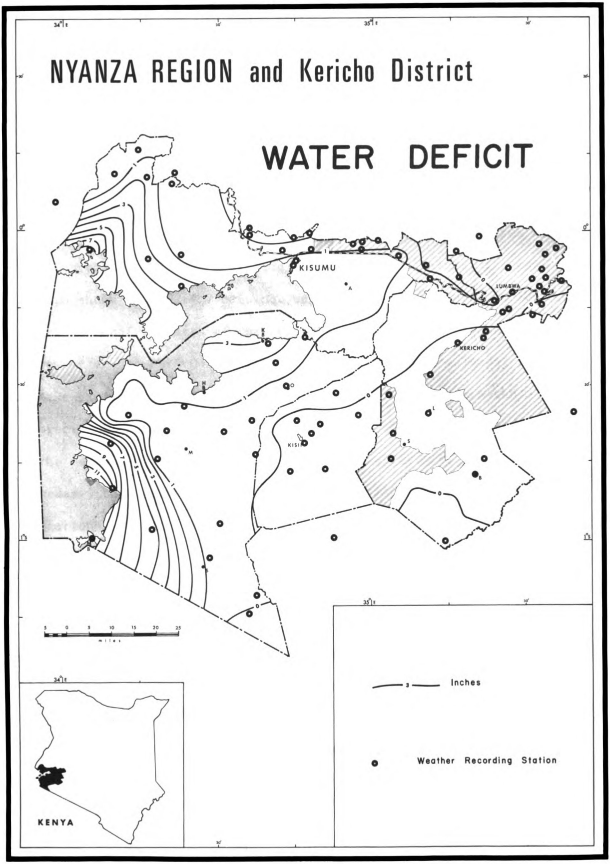

NYANZA REGION and Kericho District
WATER DEFICIT
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Inches
Weather Recording Station
miles

FIGURE 7- 5

will yield poorly unless specifically suited to a dry climate or an adequate source of ground water is available.

The pattern of potential evapotranspiration in the study region is much as might be expected a priori. If PE is viewed as water need, it is not difficult to imagine the close relationship between PE and temperature. When PE isopleths are drawn with some reference to the modifying importance of altitude, the pattern shown by Figure 7-3 is not unexpected. The highest altitudes are the coolest parts of the region and, therefore, have the lowest annual PE. Conversely, the low-lying lands adjacent to Lake Victoria generally have a rather high PE. Although the precise boundaries between the interval classes used to illustrate the pattern may be inaccurate--there are, after all, several large areas with little change in elevation and few meteorological stations--the general pattern of water need is undoubtedly close to that shown.

The map of water surplus (Figure 7-4) is also one whose general form is easily predicted. Since water surplus ". . . refers to the part of the precipitation at a place which cannot be evaporated, transpired or held in the soil for later evapotranspiration . . . ,"[38] those places having low PE and high precipitation will have a large average annual water surplus. In Nyanza

[38]Thornthwaite, Mather, and Carter, "Three Water Balance Maps . . . ," op. cit., p. 28.

Region and Kericho District, the Kisii Highlands and the rising land in eastern Kericho District show the highest mean annual water surplus while the warmer lake margin, Kano Plain and southwestern Central Nyanza average less than a 10-inch annual water surplus. Although water surplus is ordinarily an important element of the water balance of an area because of the inferences which may be made about stream flow and irrigation needs, it may be seen here as an indicator of relative precipitation dependability. In those parts of the study region showing a high average water surplus, there is a lower probability of region-wide drought having agriculturally serious consequences.

The map of water deficit (Figure 7-5) is generally an inverted water surplus pattern. This is not to imply that water deficit is the reverse of water surplus, for each is related to the other only through the concept of water need, or PE. Relative levels of water deficiency do, however, provide a more accurate map of drought probability than lists of successive rainless days. Thornthwaite and Mather have pointed out

> ". . . that we cannot define drought as a shortage of rainfall alone because such a definition would fail to take into account the amount of water needed . . . . Drought does not begin when rain ceases but rather only when plant roots can no longer obtain moisture in needed amounts."[39]

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[39] C. W. Thornthwaite and J. R. Mather, "The Water Balance," Publications in Climatology, VIII (1955), Laboratory of Climatology, p. 36.

When water deficit is considered in this light, Figure 7-5 provides clear climatic justification for Brown's judgement: "The great majority of the Province is of high potential agriculturally, and there are only comparatively small areas, chiefly around the Lake shore, which can be regarded as marginal for agriculture."[40] The map clearly indicates that only along the shore margin in western South Nyanza, and possibly in southwestern Central Nyanza, is drought a sufficiently regular occurrence to seriously handicap most agricultural undertakings.

As informative as Figures 7-3, 7-4, and 7-5 are, it is more meaningful to combine the effects of water need, surplus and deficit as support for, or inhibition of, successful crop production. Thornthwaite and Mather provide such a measure in the form of a moisture index, where

$$\text{Moisture Index} = \frac{\text{water surplus - water deficit}}{\text{water need}}\,.$$ [41]

By relating surplus to deficit at a place and dividing by the amount of precipitation required to maintain optimum crop growth at that location, the relation between these concepts is standardized. Obviously, where mean annual water surplus exceeds the average water deficit for a year, the index is positive, while the

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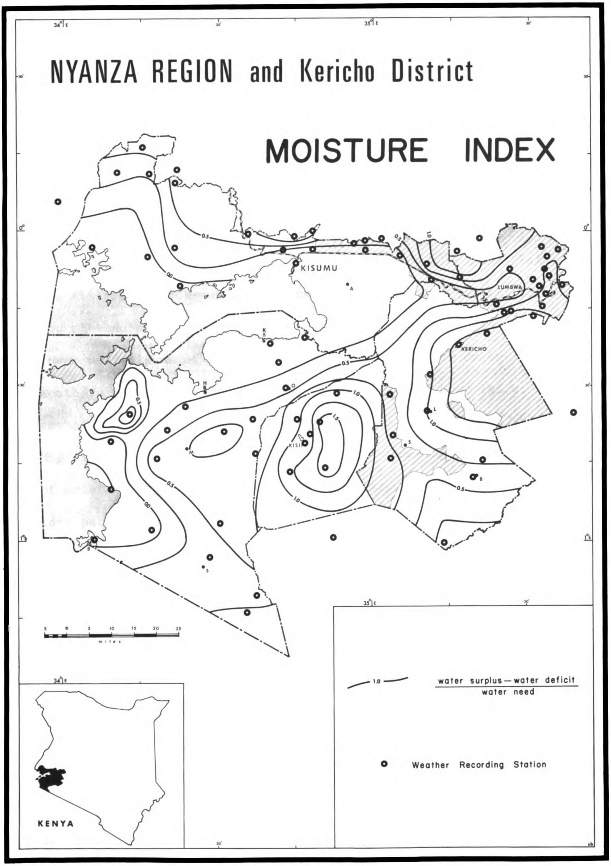
[40] Brown, "Draft . . . ," _op_. _cit_., p. 1.

[41] Thornthwaite and Mather, "The Water Balance," _op_. _cit_., p. 71.

reverse sign results where average deficit is larger than average surplus, regardless of the potential evapotranspiration. By dividing the surplus-deficit difference by water need, the index is standardized as areas of large surplus are related to areas of large deficit through a common factor, i.e., how much of a proportion of water need is extra, or lacking, as the case may be. This has the effect, shown on Figure 7-6, of portraying more accurately the rather small proportion of the study region which is climatically marginal for agriculture. Perhaps more importantly, the relatively mild water deficit in these coastal areas is correctly shown in contrast to the exaggerated impression which might be gained from Figure 7-5. Since the map of standardized moisture availability provides an illustration of the spatial variation of an index combining the agro-climatic factors of water need (PE), water surplus and water deficit, this map is a suitable pattern by which the soil-based agro-ecological zones might be modified, or strengthened, to include the obviously important elements of precipitation and temperature.

The agro-ecological zoning is, in fact, little modified by the pattern illustrated on Figure 7-6. At first thought, this may seem a bit surprising, for one map is based on soil and, partly, vegetation patterns while the other map is explicitly founded on climatically derived indices. After some consideration, however, the two patterns can be seen to approach the same



NYANZA REGION and Kericho District
MOISTURE INDEX
KISUMU
KERICHO
LUMBWA
KISII
KENYA
miles
water surplus — water deficit
water need
Weather Recording Station

FIGURE 7- 6

problem, i.e., relative environmental support for potential agricultural production, albeit from two different directions. The patterns also have another factor in common--relief. Both the soil determination and the temperature pattern (and in part precipitation and vegetation) are closely related to relief. Because of this, the overriding patterns are very close within the clearly sectioned topographic divisions--the flat Kano Plain, the Kisii Highlands and the central Kericho upland, the rolling low plateau of central South Nyanza not too different from the lower near-plains of western Central Nyanza, and the drier southern margins of both Kericho and South Nyanza, the latter emphasized by inland extensions of "coastal" conditions in the Migori River Valley. The only alterations encouraged by the map of moisture index variation on the soil-based agro-ecological zone pattern are some indication of the drier coastal conditions in South Nyanza, changing a small area from "High rainfall savannah," although this latter area is not as well endowed with moisture as central South Nyanza (see Figure 7-7). On the whole, then, the major zonal outline is strengthened rather than modified.

An interesting comparison can be made between Figure 7-7, derived in the manner described, and Figure 7-8, from a report recently published by the German Development Institute.[42] Al-

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[42]Deutsches Institut fur Entwicklungspolitik, "Vorgutachten zur Raumplanung in der Region Kisumu (Kenia)," Berlin: D.I.E.,

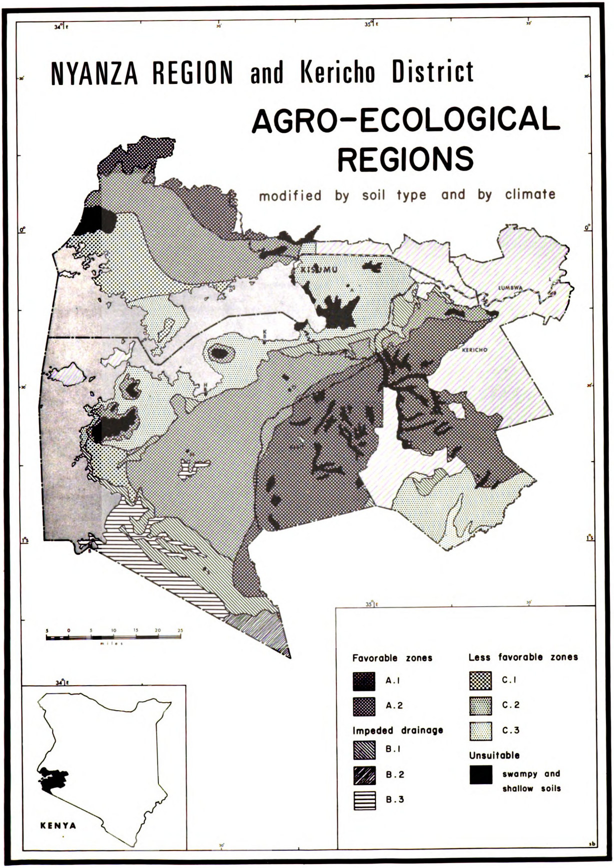
NYANZA REGION and Kericho District
AGRO-ECOLOGICAL REGIONS
modified by soil type and by climate
KISUMU
LUMBWA
KERICHO
miles
KENYA
Favorable zones
A.1
A.2
Impeded drainage
B.1
B.2
B.3
Less favorable zones
C.1
C.2
C.3
Unsuitable
swampy and shallow soils

FIGURE 7- 7

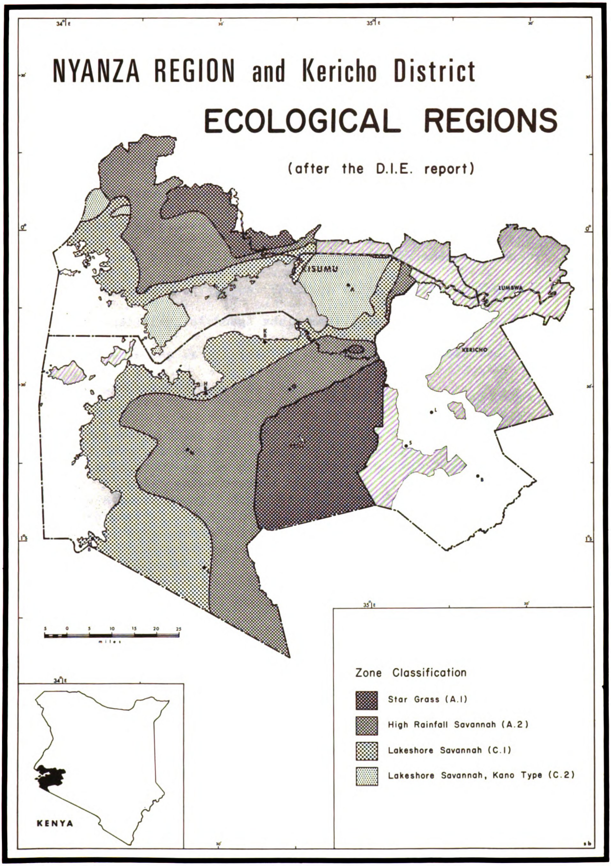
NYANZA REGION and Kericho District
ECOLOGICAL REGIONS
(after the D.I.E. report)
KISUMU
LUMBWA
KERICHO
KENYA
miles
Zone Classification
Star Grass (A.1)
High Rainfall Savannah (A.2)
Lakeshore Savannah (C.1)
Lakeshore Savannah, Kano Type (C.2)

FIGURE 7- 8

though the region of concern for this report did not include Kericho District, an ecological zone map was drawn using the primary categories outlined by Brown. Specific indication of the criteria on which the map was drawn is lacking, but the influence of Brown's report is obvious. What is most important for the present work, the over-all pattern of zones is very close to that obtained by careful climatic and pedologic modification of Brown's written description. Further modifications to Figure 7-7 are not justified, although additional support of the pattern shown on this map is provided by the independently derived, but similar generalized zones of Figure 7-8.

1967, map 9 (p. 59). The research for this report was done by a team of German students from the Development Institute under Dr. P. Waller during the present author's period of research in Kenya. Although paths crossed frequently, it was not possible to arrange a meeting until departure from the field was very near for both parties. Therefore, unfortunately, there was no exchange of data.

CHAPTER VIII

THE VALUE OF POTENTIAL PROFITS

The most important task to be accomplished during this chapter is that of translating the agro-ecological zones, defined and delimited in the immediately preceding chapter, into zones of cash crop output potential, in shillings per acre, and in a form directly comparable to the series of maps in Chapter VI illustrating existing value of production per acre. This will be done both within the context of data available at this preliminary stage, and with reference to the manner in which the translation could be done with the more precise data possible from detailed team surveys of the regional ecological pattern. Once the pattern of relative potential has been altered to indicate maximum production expectations on an absolute level (in shillings) as well, further modifications based on the human factor in production (traditions, production attitudes, and so forth), population density, and rotation of land use within a suitable farming system, could be introduced. In short, the spatial variation in cash crop potential must be made explicit and at the same time more realistic by attention to some of the important non-environmental influences on the average annual potential of the land.

The Expanded Areas of Future Production

Only a moderate amount of new land must be considered when examining areas of growing potential for the cash crops under study. On the basis of previously established environmental growth limits (Table 5-1), there are several growing areas which must be expanded. Previous areas delimited as enclosing the major existing production of the eight cash crops included in the present study were not concerned with possible crop production but with probable existing areas of output.

Not all crop areas can be considered expandable. Coffee, for example, is now under strict planting control. The area devoted to coffee production may even diminish as less productive areas are reverted to other crops when producers in these marginal areas find they cannot maintain quality output. For the present, emphasis is placed on increased quality of output rather than new plantings.[1] The area delimited as suitable for tea production, based on KTDA maps, is not likely to be enlarged. The schedule for new district plantings in Kisii and Kericho has been outlined by the KTDA but will undoubtedly be within the carefully planned administrative, economic, and geographic framework set by the Authority. The boundaries enclosing present groundnut production, an area drawn large because of poor data on the

[1]See the discussion of this in Chapter VI, above.

location of this production, have also been maintained as the most likely outer limits of feasible groundnut production in the near future.[2] As with groundnuts, the areas drawn to include locations of existing rice production were made large, on the basis of a broadly suitable environment, and remain the same size for the present concern with potential rice production. The only locational exception of any significance which might have been made, but was not, about future rice growing areas is the margin of the large Yala Swamp in western Nyanza, presently being investigated as a possible area suitable for irrigated agriculture.[3] The lands usable for coffee, tea, groundnuts, and rice production in the near future are expected to remain much as shown when considering areas of existing output.

Each of the other four cash crops included in the present study--sugar cane, white potatoes, pyrethrum, and cotton--have larger areas of production under the criterion of possible source of profitable output in the near future. Sugar cane potential was

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[2]This reluctance to enlarge the area suitable for growing groundnuts is based objectively on a comparison of soil, temperature, and precipitation records with the limits established earlier. It is possible, however, that groundnuts have become synonymous with agricultural investment bungling and is therefore a crop extra sensitive to predictions of <u>potential</u> returns.

[3]Republic of Kenya, <u>Development Plan</u>, <u>1966-1970</u> (Nairobi: Government Printer, 1966), p. 142.

enlarged in western Central Nyanza, in a small area immediately south of the railway extending to Kibos on the Kano Plain, and expansion of the South Nyanza growing area to include all of the B.3. ecological category designated by Brown (see Figure 7-7). Although this last area appears to lack adequate and dependable precipitation for sugar cane, the impeded drainage caused by the soil may be a sufficient source of moisture.[4]

The land deemed suitable for potato production is much increased over that considered to contain most of the present output. Using the previously listed environmental limits as guides (Table 5-1), the potato growing area in Kericho District was more than doubled. Much of the eastern half of Kisii District was also considered an area with suitable soil, temperature, and moisture resources to be a potential source of this crop. The only major reservation one might have with respect to the Kisii area, the basis of which is not shown on the maps of this district, is the very hilly nature of the countryside. The slopes of this rather strongly dissected upland are possibly too great for successful potato cultivation on a large scale.

A large area in Kericho District appears suitable for pyrethrum, although part of this area is beyond the land available

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[4]Whatever the reason, Brown wrote of this region, it is ". . . thought to be of high potential for sugar production." - Brown, "Draft . . . ," _op_. _cit_., p. 2.

to the African smallholder, i.e., land owned by the large tea estates immediately east of the main Lumbwa-Sotik road. In spite of the small amount of land devoted to pyrethrum production in Kericho,[5] and the fact that the land there closely meets the production suitability criteria, reservations must be expressed on the propriety of encouraging expanded production of the crop. Because pyrethrum is refined to make an insecticide, the threat of an artificial competitor with similar qualities but lower cost of production is always present. While the author has no _firm_ knowledge of the existence of such a competitive insecticide, the added qualification on future levels of supply and demand should be made explicit.

The only significant addition to the area considered suitable for cotton production is that in the Lambwe Valley, in South Nyanza to the southwest of Homa Bay. Although this area is commonly referred to as having potential for future cattle grazing,[6] the ecological character is compared by Brown to that of the Kano Plain.[7] On the basis of this latter reference, and

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[5]Approximately 300 acres in 1966. - Interview with Mr. J. Birir, District Agricultural Officer, Kericho District, November 12, 1966.

[6]Kenya, _Development Plan_ . . . , _op_. _cit_., pp. 144-45.

[7]Brown, "Draft . . . ," _op_. _cit_., p. 3.

the comparable environmental characteristics, it is supposed that cotton could be grown in the valley with some success. The Lambwe Valley is presently unattractive for either crop or animal agriculture because of the extensive areas dominated by the tsetse fly, carrier of trypanosomiasis, or "sleeping sickness." Eradication of the tsetse fly in this area (tentative plans have already been made[8]) would lead to both cultivation and stock-keeping land use.

The Need for Field Research

It should be understood in this, and the following discussion, that crops and crop areas may often be appealing on only a theoretical basis. Considerable research, field testing, and the like, are absolutely necessary before any crop is offered to individual farmers as a new source of possible income. Governmental files are undoubtedly filled with reports relating the unfortunate tale of some cash crop that was "supposed" to be suitable for the environmental conditions in which it was planted. The grand Tanganyika Groundnut Scheme is only one of the more famous experiences of this nature.[9] Low income countries cannot afford the losses which accompany these enterprises. The Government of Kenya, at least, appears well aware of this danger, for

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[8]Kenya, Development Plan . . . , op. cit., p. 145.

[9]For a full report of this venture, see, Alan Wood, The Groundnut Affair (London: The Bodley Head, 1950).

it has written: "Any major development must be preceded by a pilot project in which tenant performance is observed under conditions identical to those which are projected for the major scheme."[10]

Present Data and Spatial Generalization

A guide to translating the derived agro-ecological zones from relative to absolute (shilling) levels of potential is provided again by the report by Brown. In making this translation, however, the cautioning that Brown himself made when formulating his draft policy is a reticence as pertinent to the present work as to Brown's preliminary one.

> Knowledge is lacking on suitable cash crops to use in the areas suited to them, with the exception of some Coffee areas. A programme of experimentation needs to be worked out which will give us this knowledge . . . .
>
> It is possible to work out potential targets for cash crops in the province, but this can only be done in a vague way until the distribution of ecological zones is known, and I have not, therefore, attempted it here.[11] [emphasis mine - S.S.B.]

As far as could be determined, the distribution of ecological zones is not known beyond the description of them left by Brown. The "vague" targets offered by Brown, supplemented by inferences made on the basis of recent data, remain the primary guidelines available for present needs. To pursue the objective of providing

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[10] Kenya, Development Plan . . . , op. cit., p. 139.

[11] Brown, "Draft . . . ," op. cit., p. 6.

an applied example of the method outlined above (Chapter III) with explicit identification of sections of the application demanding more detailed research than has previously been conducted, the guidelines and ecological variation will be assumed more definite than in fact they are.

It may be necessary here to emphasize the degree and manner in which the areas of potential crop production are spatial generalizations. Some uneasiness may be present in the reader because of the stress laid earlier on a methodology which minimized the generalization of spatial variation in order that the truly complex variability of reality be adequately represented, i.e., represented in detail sufficient to maintain the character of interacting elements of the real world rather than suffer great loss of detail in homogeneous administrative or physical regions. This possible unease may be settled in several ways. First, the scale at which data are available does not permit more detailed separation of the localized areas with true production potential from the larger region so classified here. This separation is possible, however, and would provide more justification for any application upon which policy decisions will be based. Second, there will always be a need to balance the desirable level of specificity with the available time and money for research. This balance will, of course, be weighed in light of the marginal information obtained from additional research expenditures. Third, it is possible to make the adjustment necessary to approximate the true proportion of any region's land having potential for production, if the information is known, by multiplying the land area by the percentage of each region which has that potential. If, for example, the Kano Plain was treated as a regional whole, suited in its entirety to rice production, while in fact, part of this area averaged 90% of the land suitable for rice, and of the remainder, only 70% could correctly be considered rice-growing land, the true potential of the whole would be diminished by the proportional amounts in the appropriate locations. In sum, the generalizations accepted here are limited, explicit, and correctable within the over-all methodology if proper data are available and deemed useful.

The Pattern of Future Profit

In comparing the derived ecological zones with the boundaries of land areas considered as having suitable potential for production of each of the cash crops, a strong resemblance between the two is seen. Table 8-1 has been constructed to compare occurrences of each of the cash crop areas with the pattern of ecological zones described as suitable for these crops by Brown.[12] Potential rice production in the High Rainfall Savannah zone is the only occurrence of a description of crop potential by Brown

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[12] *Ibid.*, *passim*.

TABLE 8-1

CONCURRENCE OF AGRO-ECOLOGICAL ZONES AND AREAS OF CROP PRODUCTION POTENTIAL, AS DESCRIBED BY BROWN AND DEVELOPED SEPARATELY IN THE PRESENT WORK

Crops	Agro-Ecological Zones							
	A.1	A.2	B.1	B.2	B.3	C.1	C.2	C.3
coffee	B W	pw					pw	
rice		B	qw		qw		B W	
sugar cane	B W	B W			B W	pw	pw	
tea	B W							
pyrethrum	B W							
cotton	W	B W			qw	B W	B W	
groundnuts*	W	W				W	W	
potatoes	B W						W	

*Brown does not refer to the potentialities of Groundnut production in Nyanza Province.

key: B - from the description in Brown, "Draft . . . ," *op. cit.*
W - from the patterns of existing production and environmental suitability as described in the present work, but not pw or qw.
qw - areas of existing production which must be considered of questionable profitability and having somewhat qualified potential.
pw - small areas peripheral to the main regions of potential production.

not indicated in some manner by the area of potential ouput accepted in the present work. This has not been included because rice production in this zone is likely to be an extremely local undertaking proximate to the small swamps scattered throughout South and Central Nyanza. In addition, aside from areas of groundnut potential which are not referred to in Brown's report, only cotton grown in the Kikuyu-Star grass zone in western Central Nyanza, and the potatoes grown near Bomet in southern Kericho District are crops definitely produced with substantial profit in zones not specified as appropriate by Brown or closely adjacent to these suitable zones. There is considerable justification, then, for using the monetary equivalents set forth by Brown, modified and updated where necessary.

In his approximately ten-year-old "Draft Agricultural Policy" for Nyanza Province, Brown does not always provide satisfactory information for current predictions about potential levels of shilling returns which can be expected from future agricultural efforts. Groundnut information is not present in the report. In other cases, such as that of the white potato, both yield and average price had already exceeded his projections by 1965. The potential levels of farming value per acre for each of the cash crops of interest have been based on Brown's estimates of possible yield per acre and price per unit output with frequent adjustments to these figures based on other, more up-to-date data. These potential values per acre, with their sources, are summarized in Table 8-2.

A somewhat more detailed discussion of the derivation of these levels of potential value per acre may be justified. Presumably, through appropriate efforts toward production control and marketing procedures, the average prices of seven of the eight cash crops could be expected to rise, tea being a possible exception because of the excellent control now being exercised. On the other hand, fluctuations in the world market price and the general long-run decline in the prices of primary products threaten even the existing price levels in all except a few of these crops. In balance, the 1965 prices, as reported in the respective District Agricultural Officers' annual reports for that year, have been accepted as conservative estimates of future price levels.

The estimated annual yields of these crops are also rather moderate and well within the reach of African smallholders in Nyanza Region and Kericho District. Both coffee and sugar cane yield levels were taken from Brown's "Draft Agricultural Policy," although coffee growers in Kisii achieved yields of only 6 cwt. per acre in 1965.[13] Brown's estimate of annual sugar cane yields was reduced for present purposes from an average of 26 tons

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[13]District Agricultural Officer Annual Report, Kisii District, 1965, Appendix F.

TABLE 8-2

ESTIMATED AVERAGE POTENTIAL VALUE OF PRODUCTION PER ACRE, FOR SELECTED CASH CROPS

Crop	Value/Acre	Annual Yield	Price per unit
coffee (clean)	Shs. 2800/-	8 cwt. from: Brown, *Draft* . . . , *op. cit.* Appendix I.	Shs. 350/- from: *Kisii DAO Annual Report, 1965*, App. F.
rice	Shs. 800/-	20 bags[1] from: Brown, *Nat. Cash Crops* . . . , *op. cit.*, p. 130	Shs. 40/- from: *S. Nyanza DAO Annual Report, 1965*, p. 19. *Cent. Nyanza DAO Annual Report, 1965*, Table IV.
sugar cane	Shs. 1200/-	24 tons from: Brown, *Draft* . . . , *op. cit.*, App. I.	Shs. 50/- from: *Cent. Nyanza DAO Annual Report, 1965*, Table IV.
tea (green)	Shs. 1620/-	5400 lbs. from: Kenya, *Devel. Plan, 1966/70* *op. cit.*, p. 380.	Shs. -/30 from: *Kisii DAO Annual Report, 1965*, App. F.

TABLE 8-2--Continued

Crop	Value/Acre	Annual Yield	Price per unit
pyrethrum	Shs. 675/-	450 lbs.[2]	Shs. 1/50 from: Kisii DAO Annual Report, 1965, App. F.
cotton	Shs. 300/-	600 lbs. from: Brown, Nat. Cash Crops . . . , op. cit., p. 36, p. 103.	Shs. -/50 from: Cent. Nyanza DAO Annual Report, 1965, Table IV.
groundnuts	Shs. 800/-	8 bags from: Brown, Nat. Cash Crops . . . , op. cit., p. 123.	Shs. 100/- from: S. Nyanza DAO Annual Report, 1965, p. 19.
potatoes	Shs. 1200/-	60 bags[3] from: Kericho DAO Annual Report, 1965, p. 3.	Shs. 20/- from: Kericho DAO Annual Report, 1965, p. 3.

[1]This is above the goal of 15 bags per acre set in the Kenya Development Plan, 1966-1970, op. cit., p. 376.

[2]Based on a 12 per cent improvement in pyrethrin content above the 1965-66 yield. During the year October, 1965 - September, 1966, Kisii pyrethrum flowers averaged 1.22%

TABLE 8-2--Continued

pyrethrin content versus an all-Kenya average of 1.27% and a goal of 1.50%. - Data from interview with Mr. R. J Munro, Pyrethrum Marketing Board, Nakuru, November 11, 1966.

[3] This is only two-thirds of the maximum yield reported for this district during 1965, although one-third above the average yield that year.

per acre to 24 tons per acre. Of the three crops whose potential yields were taken from Brown's National Cash Crops Policy, groundnuts, rice, and cotton, the last has the greatest likelihood of being grossly underestimated. Both Brown and a member of the Kenya Cotton Lint and Seed Marketing Board place *potential* production levels in Nyanza Region at 900-1000 lbs. per acre per year.[14] Research at Kibos has yielded seed cotton from experimental strains at 2260 lbs. per acre.[15] Because of the persistence of low yields in this region, however, only a moderate increase to 600 lbs. per acre is used. The estimated levels of these and the remaining crops' potential yields are therefore reasonable in a context of African smallhold farmer abilities which may be developed within a decade or so.

It is important to recognize that the crop production values per acre listed in Table 8-2 are averages for the entire study region or some major portion of it. In order to be consistent in avoiding the screening effect of homogeneous criteria within the large areal units, these averages must be broken into their constituent classes in some manner meaningful to the present problem. This difficulty was also faced with respect to *existing* values of production. As in that case, it is possible to argue

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[14]L. H. Brown, National Cash Crops . . . , *op. cit.*, p. 103; and, interview with Mr. J. Adero, November 25, 1966.

[15]M. S. Hastie, (abstract) in Empire Cotton Growing Review, XLII (1965), 318.

that by holding constant the human quality inputs to farming, for they do not, after all, have spatial relevance except on a broad scale, variation in product price and product yield are caused primarily by environmental suitability for production of that crop. By adding the distributions of environmental correctness for each crop, the place-to-place variation in support of each crop's production can be determined.

Fortunately, much of this has already been accomplished. After determining the numerical indices of combined environmental support based on the criteria shown in Table 6-3 for those areas within the study region considered suitable for cash crop production but not presently producing these crops, new shilling-equivalents for these indices could be assigned using potential, rather than existing, value per acre data. Table 8-3 summarizes this breakdown, and has been framed in the same way as Table 6-4 to facilitate comparisons. As with the earlier data, the pattern of agricultural support indicated by these indices was determined by superimposing a one-square-mile square grid over each pattern of a relevant aspect of the environment, covering the land not yet developed but having potential for production, and then adding the indices of each grid unit overlying a given square mile. It is from the mapped pattern described in Table 8-3 that levels of profitability improvement have been constructed.

TABLE 8-3

POTENTIAL VALUE PER ACRE EQUIVALENTS FOR NUMERICAL INDICES OF ENVIRONMENTAL SUITABILITY FOR CROP PRODUCTION, IN SHILLINGS

Crop	District	Index number	Value per Acre
coffee	Central Nyanza	6	1100/-
		7	1350/-
		8	1600/-
		9	1850/-
	South Nyanza	6	2000/-
		7	2200/-
		8	2400/-
		9	2600/-
		10	2800/-
	Kisii	7	2200/-
		8	2400/-
		9	2600/-
		10	2800/-
	Kericho	5	1100/-
		6	1350/-
		7	1600/-
		8	1850/-
		9	2100/-
rice	Central Nyanza	6	725/-
		7	750/-
		8	775/-
		9	800/-
	South Nyanza	5	300/-
		6	325/-
		7	350/-
		8	375/-
		9	400/-

TABLE 8-3--Continued

Crop	District	Index number	Value per Acre
sugar cane	Central Nyanza	4	600/-
		5	800/-
		6	1000/-
		7	1200/-
		8	1400/-
		9	1600/-
	South Nyanza	4	450/-
		5	600/-
		6	750/-
		7	900/-
		8	1050/-
tea	Kisii and Kericho	2	1525/-
		3	1575/-
		4	1625-
		5	1675/-
pyrethrum	Kisii and Kericho	all production =	675/-
cotton	Central Nyanza and South Nyanza	4	150/-
		5	200/-
		6	250/-
		7	300/-
		8	350/-
		9	400/-
		10	450/-
		11	500/-
groundnuts	Central Nyanza, South Nyanza, Kisii, and Kericho	3	200/-
		4	350/-
		5	500/-
		6	650/-
		7	800/-
		8	950/-
		9	1100/-
potatoes	Kericho and Kisii	5	500/-
		6	550/-
		7	600/-
		8	650/-
		9	700/-

It should be noted that where there is a difference between crop value per acre in several districts for the same crop (e.g., coffee)--a feature of the dependence of data on administrative divisions--then the range of gross returns per acre is narrower for estimates of potential vis-a-vis existing output. Although there is no empirical justification at hand for this, the decrease in difference between more progressive and less progressive agricultural areas may be theoretically attributed to the implementation of better land use practices (e.g., enclosure, rotation of crops, terracing, maintenance of proper stock densities, and so forth). This implementation should affect the areas of poorer agriculture relatively more than the better areas because of the already established improved farming practices in the more developed areas.

The problem of potential cost levels is not so easy to solve. Undoubtedly, greater farming costs will be required to gain the higher returns per acre listed in Table 8-3. The spatial variation in these costs, higher outlays required in more demanding environments and lower production costs in more suitable areas, need not be of concern. Although this may seem contrary to the basic methodological goal in this volume, some reflection will indicate that if production costs are treated as spatially variable <u>because</u> of variability in environmental support for production, then the same environmental factor is being counted twice, in both cost and return accounting. The proportions by which the increased value per acre of production would be diminished because of the greater cost requirements necessary to achieve these higher returns are presently unknown. It should be recognized that approximations of these proportions can be determined only by careful research into the economics of farm production within the study region. For the present, to facilitate calculations, the reduction of increased profitability due to higher costs will be considered zero. This is, after all, consistent with the mapping of existing profitability (Figures 6-8 through 6-11), for costs were there assumed constant regardless of output. If cost research supplies answers for existing levels of production, these answers may also be used for estimates of potential production costs.

Using the data of Table 8-3 and the patterns of environmental support for agriculture, maps illustrating the spatial variation of potential profitability may be drawn (Figures 8-1 through 8-4). Comparison of each map with the analogous map of average existing profitability of crop production (Figures 6-8 through 6-11) shows little change in the patterns, with the exception, of course, of those areas added to the growing regions of each crop. Ignoring this last factor, the patterns of potential profitability for cotton and white potatoes are those showing the greatest change. Although the potential of these two crops

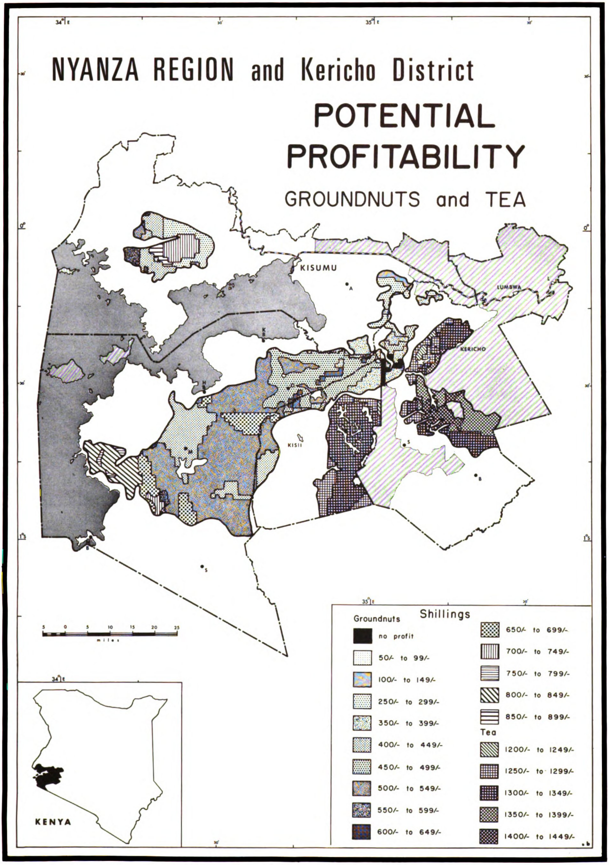
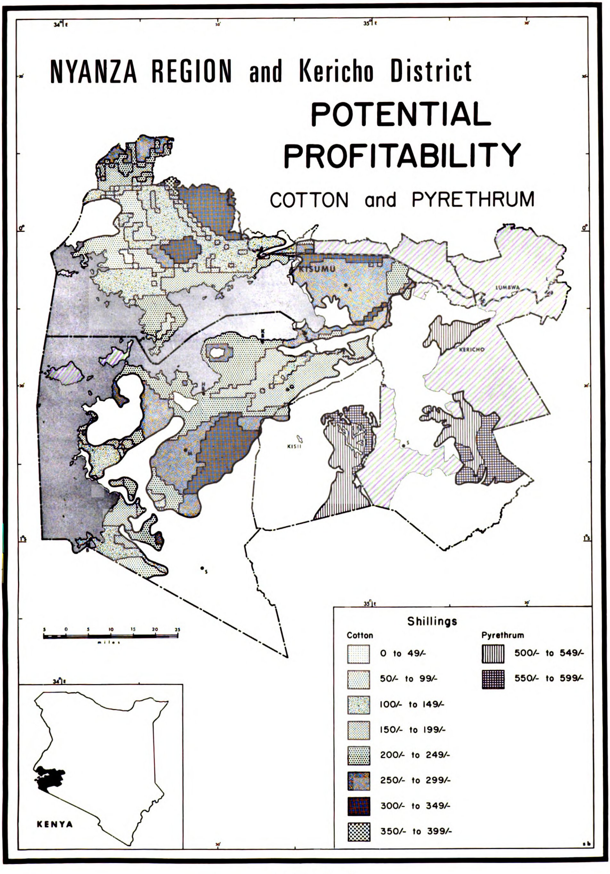

NYANZA REGION and Kericho District
POTENTIAL PROFITABILITY
GROUNDNUTS and TEA
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Shillings
Groundnuts
no profit
50/- to 99/-
100/- to 149/-
250/- to 299/-
350/- to 399/-
400/- to 449/-
450/- to 499/-
500/- to 549/-
550/- to 599/-
600/- to 649/-
650/- to 699/-
700/- to 749/-
750/- to 799/-
800/- to 849/-
850/- to 899/-
Tea
1200/- to 1249/-
1250/- to 1299/-
1300/- to 1349/-
1350/- to 1399/-
1400/- to 1449/-
miles

FIGURE 8- 1



NYANZA REGION and Kericho District
POTENTIAL
PROFITABILITY
COTTON and PYRETHRUM
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Shillings
Cotton
0 to 49/-
50/- to 99/-
100/- to 149/-
150/- to 199/-
200/- to 249/-
250/- to 299/-
300/- to 349/-
350/- to 399/-
Pyrethrum
500/- to 549/-
550/- to 599/-
miles

FIGURE 8- 2

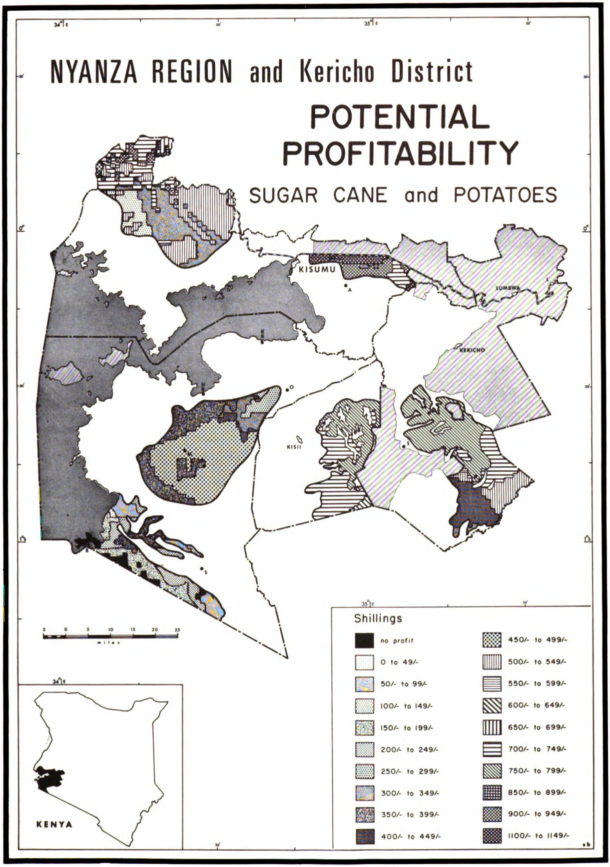

NYANZA REGION and Kericho District
POTENTIAL PROFITABILITY
SUGAR CANE and POTATOES
KISUMU
LUMBWA
KERICHO
KISII
KENYA
miles
Shillings
no profit
0 to 49/-
50/- to 99/-
100/- to 149/-
150/- to 199/-
200/- to 249/-
250/- to 299/-
300/- to 349/-
350/- to 399/-
400/- to 449/-
450/- to 499/-
500/- to 549/-
550/- to 599/-
600/- to 649/-
650/- to 699/-
700/- to 749/-
750/- to 799/-
850/- to 899/-
900/- to 949/-
1100/- to 1149/-

FIGURE 8- 3

was underemphasized when values were being assigned, they are crops for which a considerable profitability increase could be accepted as feasible. In any case, these four maps of potential profitability are intermediate steps in the derivation of maps showing the improvement possible in the profit levels of African smallholders.

Improvement as an Investment Criterion

In the real world of near-subjective decision making, the customary guidepost used to accept or reject road investments is the area's total productive potential. If some agricultural region is considered (believed-reported-"seems") to have high potential for lucrative output of a crop or crops, improvement in the infrastructure connecting this region to established markets is felt justified. Where there is no existing development, where there is no cultivation, no settlement, no road system (or virtually none), then this method of making decisions may be satisfactory. There are, however, few places left in East Africa where these conditions hold. Certainly, no sizable portion of the study region is so bereft of development, except, possibly, the tsetse-infested Lambwe Valley. The framework from which investment alternatives are to be chosen should not be given the latitude of such subjectivity.

Rather than using total agricultural potential as the measure by which road investments are judged, it would be more correct, both in theory and in practice, to base this judgement on the variability of the possible improvement in production. There is a certain level of production possible, and often approached, at a given place without the advantages of improved road connections to market foci. It follows that the benefits to be derived from road upgrading must originate in, and be limited by, the potential improvement in production rather than the total productive capacity of the area. Some crops will reach the markets even with poor roads unless the land is greatly overpopulated. The amount of such production and the state of the existing road system provide the two-fold foundation upon which estimates of improvement can be made. Those areas where production can be improved the greatest amount, i.e., have the largest absolute difference between potential and existing output, justify the greatest upgrading in the road system. Adherence to this principle also has practical utility in that it is difficult to estimate subjectively several areas' improvement levels for comparative purposes; planners are required to rely on more objective methods of determining investment priorities.

Theoretical models and methods derived in the context of well-developed economies often circumvent this distinction between total output and improvement but lose a measure of applicability by doing so. The cost-benefit approach to transport needs, for example, may attempt to make a value accounting of the costs of road upgrading to compare with the sum of the direct and indirect returns, or benefits, expected to follow the investment. The emphasis in this approach is on whether or not the benefits exceed the costs for that transport line or isolated network. Little concern can be directed toward the variability of relative success; this is usually not possible, given the difficulty of determining the number and volume of benefits.[16] By focussing attention on the road, instead of on the regions to be served more efficiently by the road, the ends of agricultural development (land use optimization) are made secondary to the means (in part, the transport route improvement) and priorities for investment cannot be established properly, i.e., on the basis of what is to be developed. The method of analysis outlined in the present volume examines road investments as means of encouraging and allowing agricultural development in light of the potential improvement of the land itself.

By subtracting the patterns of average existing profitability of crop production (Figures 6-8 through 6-11) from the respective maps of potential profitability (Figures 8-1 through 8-4), a set of patterns were derived illustrating for each of the cash crops included in the study, the spatial variability of average potential profitability improvement (Figures 8-5 through 8-8). For each crop, the average improvement possible in the

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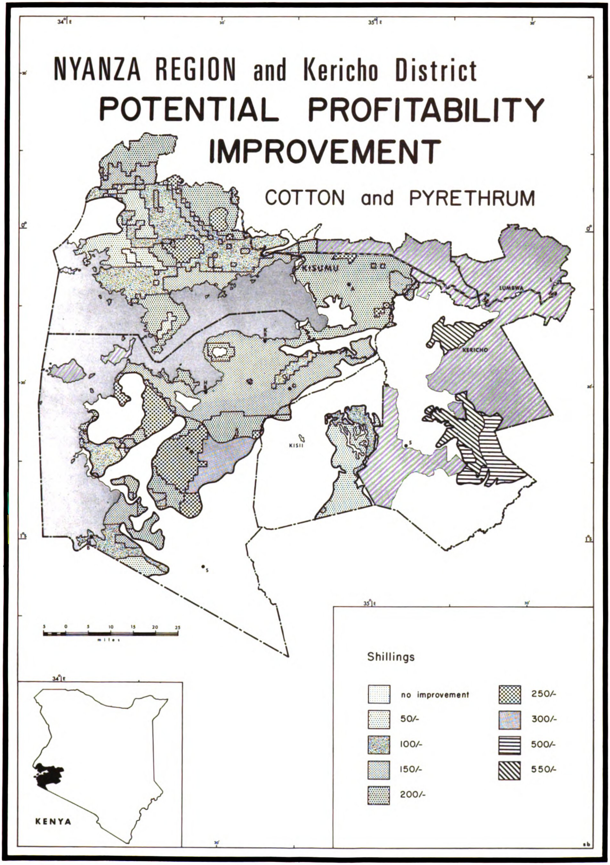
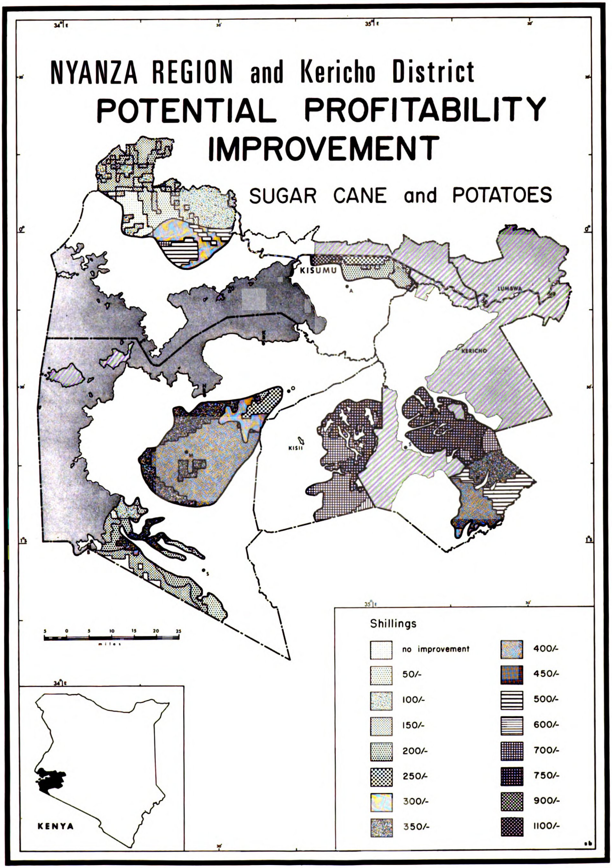
[16] McKean, Efficiency in Government . . . , op. cit.



NYANZA REGION and Kericho District
POTENTIAL PROFITABILITY IMPROVEMENT
COTTON and PYRETHRUM
KISUMU
LUMBWA
KERICHO
KISII
KENYA
miles
Shillings
no improvement
50/-
100/-
150/-
200/-
250/-
300/-
500/-
550/-

FIGURE 8- 6



NYANZA REGION and Kericho District
POTENTIAL PROFITABILITY
IMPROVEMENT
SUGAR CANE and POTATOES
KISUMU
LUMBWA
KERICHO
KISII
KENYA
Shillings
no improvement
50/-
100/-
150/-
200/-
250/-
300/-
350/-
400/-
450/-
500/-
600/-
700/-
750/-
900/-
1100/-

FIGURE 8- 7

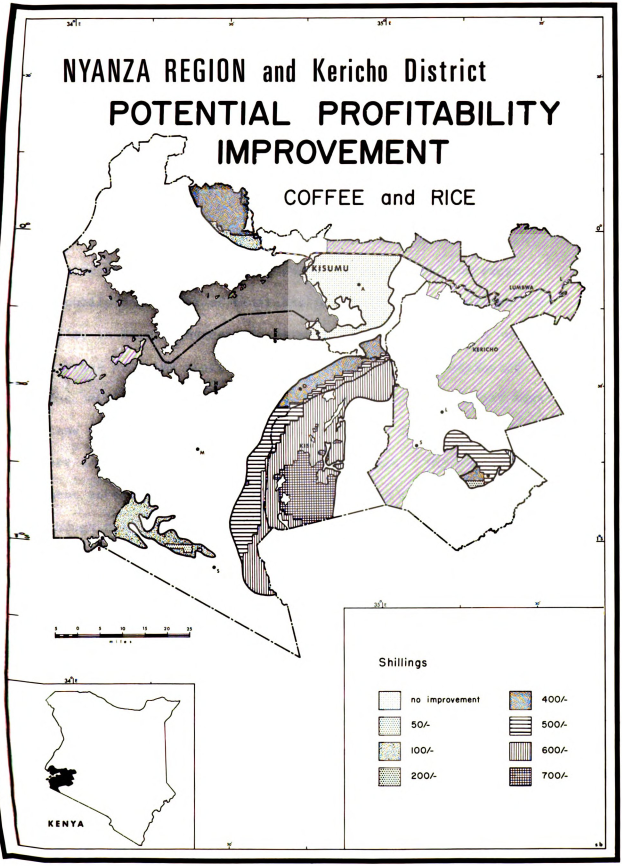

NYANZA REGION and Kericho District
POTENTIAL PROFITABILITY IMPROVEMENT
COFFEE and RICE
KISUMU
LUMBWA
KERICHO
KENYA
miles
Shillings
no improvement
50/-
100/-
200/-
400/-
500/-
600/-
700/-

FIGURE 8- 8

level of annual profit gained by the African smallholder, within the limits of assumptions made earlier, varies in the manner and degree shown on these last four maps. In those areas where there was no apparent profit in current _or_ foreseeable cultivation, the areas were not shown on the improvement patterns, even as areas of "no improvement." The average levels of profitability increase were calculated using the lower value for each range (usually Shs. 50/-) of profitability. The land to the west of Yala, in Central Nyanza, for example, was calculated to have an average existing profitability for sugar cane production of Shs. 400/- to 450/- per acre, while it was estimated that sugar cane _could_ yield African farmers returns of Shs. 500/- to 550/- per acre on the same land in the near future. The mean improvement potential was considered Shs. 100/- in such areas, for although the range of improvement is Shs. 50/- to 150/-, the standard error is undoubtedly small.

One of the strongest patterns to appear is the relatively high potential improvement indicated for central South Nyanza. In this area, both groundnuts and sugar cane are shown to be capable of increased returns at the level of about Shs. 400/- for each crop. Other regions and crops capable of great improvement are found in those portions of the study region where environmental conditions are suitable for a crop's production but are not presently supporting any measurable output of this crop. Potato production in Kisii, for example, may increase per acre profitability by a large amount because there is no significant existing potato production in Kisii. Most striking in a negative sense is the very low increase in profitability of rice production, especially on the apparently attractive Kano Plain. This lack of profit improvement reflects the necessarily conservative estimates of potential rice yields, a conservatism forced by the lack of reliable data concerning the land's capabilities in this regard.

The Impact of Population

A simple composite of these patterns of potential profit improvement is not an adequate basis for investment policy decisions; it is both incomplete and misleading. Any study such as the present one cannot limit its scope to generalized "average totals." It must be concerned with the proportion of the total area which is likely to be devoted to production of each crop. The true potential of a region lies not only in its capability of yielding high value-per-acre crops in localized areas, but in the possibility of producing a large quantity of these crops at high quality levels throughout the growing areas. Knowledge of total over-all output from a given area is more important as justification for road investments than some average value of output for an indefinite quantity of land.

Also important in attempts to estimate relative potential returns from a given region is the concept that some proportion of each average square mile must be subtracted from the total for "unusable" land. Land which cannot be used for cash crop production includes non-agricultural land (trees, housing, and wasteland, such as swamps), land which must be regularly devoted to food crops and pasturage,[17] and a factor which accounts for reduced land use due to proper rotation of crops. In this way, the returns expected from a specific area can be viewed in a more realistic perspective. Without such adjustment, any region would appear to hold much greater promise than was actually present.

The work by Brown is again helpful. In his "Draft Agricultural Policy: Nyanza Province," Brown attempts "to assess the population carrying capacity of each /_ecological_/ zone on a basis of minimum economic holdings for each, based upon the farming systems devised as suitable for each type of country."[18]

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[17]The government presently recognizes that individual African smallhold farmers will probably cultivate at least subsistence quantities of food crops before devoting land to cash crops, regardless of possible economic arguments against food crop production. Most farmers, that is, will provide themselves and their families with at least minimum security in case of a price drop for the cash crop, or a general crop failure in the major Kenyan food producing regions, as occurred in 1965. See Kenya, Development Plan, . . . , op. cit., p. 168.

[18]Loc. cit., p. 10.

Based on admittedly arbitrary but entirely reasonable farming schemes for each major producing zone, with family returns between Shs. 2195/- and Shs. 2870/- per year for the several schemes, the minimum size farm which will support a family in each zone is outlined.[19] Extending further, by using an average family size of 7.5 people per family, Brown offers the relative population carrying capacities of the several agro-ecological zones (Table 8-4). Much higher population densities than those shown could be supported by the agricultural resources of the area, but the inhabitants' level of living would be substantially lower than that outlined by Brown. Greater densities, in other words, could be supported at carefully managed subsistence levels, but this is obviously an undesirable situation both for the local population and for national economic development efforts.

In order to correctly estimate the proportion of a unit area which may be devoted to cash crop production, the variable density of population to be supported by the land must be appraised and included with the other factors that reduce cash crop land use. Unfortunately, population density data are not available in detail more precise than the Location level, these

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[19] For the reader's reference, these schemes are reproduced in Appendix II.

TABLE 8-4

LAND CARRYING CAPACITY, BY ECOLOGICAL ZONE

Zone	Minimum Holding (acres)	Possible population density in productive agriculture alone (per square mile)	Possible density with full use of trades and other employment
A.1	7	688	1,082
A.2	12	400	633
B.1	?	Unknown	?
B.2		Unknown	
B.3*	20?	240	300
C.1	14	344	573
C.2	14	344	573
C.3		Unknown	

*This figure could almost certainly be increased.

Source: Brown, "Draft . . . ," _op_. _cit_., p. 10.

Locations averaging 70 to 100 square miles each in area.[20] Even at this scale, however, significant variation in density is apparent (see Figure 8-9). The Kisii Highlands stand out as a region of dense population ranging from an average 488.6 people per square mile in Wanjare Location, immediately to the west of Kisii town, to the high average population density of 876.9 per square mile in the Kitutu Locations. A second concentration of population can be seen around Kisumu and stretching to the north and northwest toward the very high densities in Bunyore and Maragoli (exceeding 1200 per square mile in 1962) outside the study region. Equally striking are the low densities in the southwestern third of South Nyanza District, a result, in part, of poor soils, and the relatively empty land from the Lambwe Valley westward resulting from both the large areas of steep relief near the lakeshore and the presence of tsetse flies throughout much of the Valley.

Potential land productivity must be based on future population patterns rather than on densities which were counted in 1962. To this end, an average population increase of 2 per cent per year for the ten years, 1962-1972, has been assumed and a map of the resulting 1972 densities drawn (Figure 8-10). The patterns

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[20]Data on this and other population statistics in this section are from, W. T. W. Morgan and N. Manfred Shaffer, Population of Kenya; Density and Distribution (Nairobi: Oxford University Press, 1966).

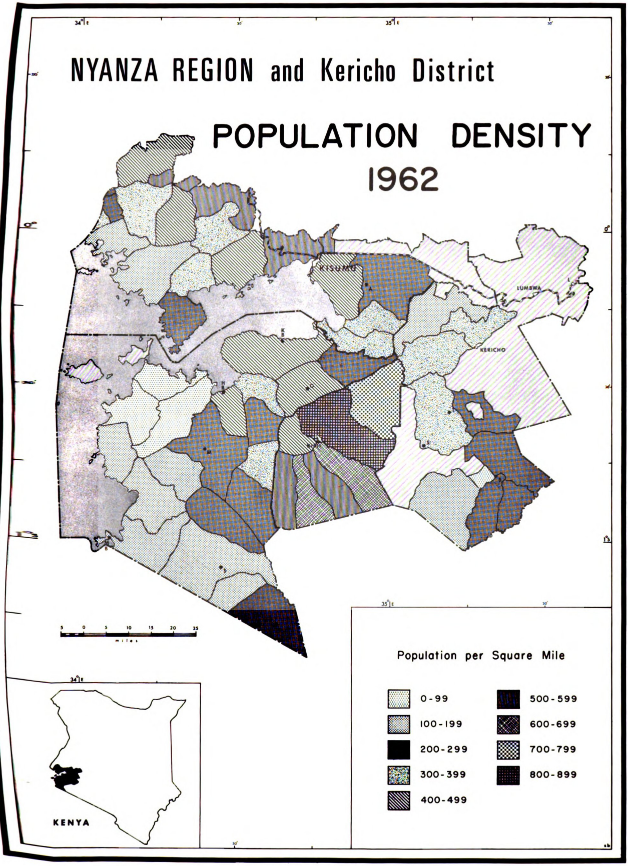
NYANZA REGION and Kericho District
POPULATION DENSITY
1962
KISUMU
LUMBWA
KERICHO
Population per Square Mile
0-99
100-199
200-299
300-399
400-499
500-599
600-699
700-799
800-899
KENYA

FIGURE 8- 9

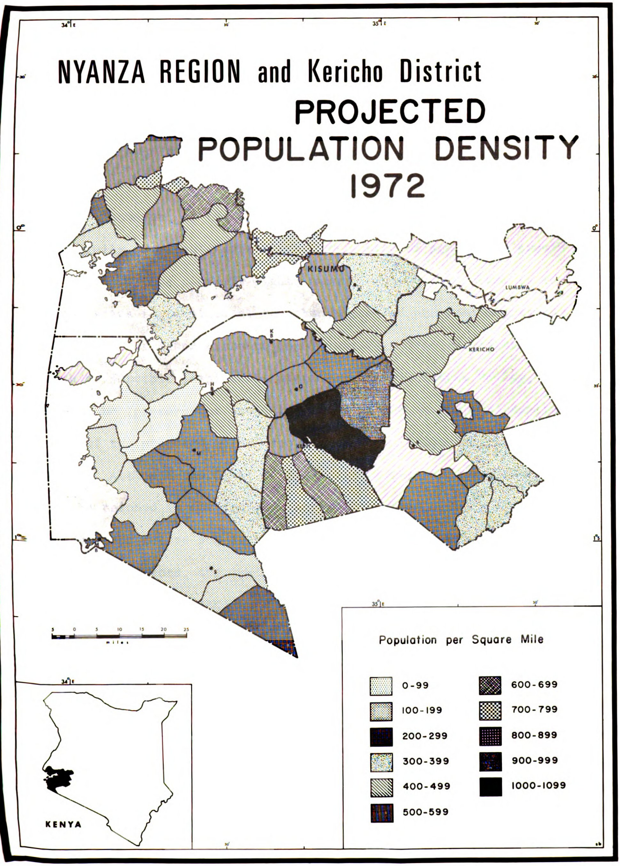
NYANZA REGION and Kericho District
PROJECTED
POPULATION DENSITY
1972
KISUMU
LUMBWA
KERICHO
KENYA
Population per Square Mile
0-99
100-199
200-299
300-399
400-499
500-599
600-699
700-799
800-899
900-999
1000-1099

FIGURE 8-10

formed only intensify the range in 1962 population density variation as shown on Figure 8-9. Admittedly, the two per cent annual rate of increase is somewhat arbitrary, and possibly a little low; there are no reliable indications of real population growth, however, as the 1948 Census of Population does not provide fully comparable data units. This rate of population growth is set below the possibly higher natural increase in order to include intra-regional rural to urban migration and some migration to Nairobi or other extra-regional centers. Planned migration, such as possible large-scale settlement in the Lambwe Valley, cannot be foreseen but could be accounted for in any real application of the proposed method for determining investment priorities.

Although the level of productivity per unit area which can be reached in the region's agriculture must reflect the pressure of future population upon the land resources for minimum food requirements, the spatial variability of these resources must also be taken into account. Obviously, the land is more or less able to produce foodstuffs as well as cash crops depending upon the ecological characteristics of the place. A sufficiently small population may well be able to live at a higher standard on large quantities of poor land than an extremely large group of people on a small amount of land regardless of the excellence of the agricultural environment. A reflection of this is the variation in size, from ecological zone to zone, of minimum holdings required to return to a single farm family produce valued at three to four hundred dollars, shown in Table 8-4. The place-to-place variation of the combined effects of population pressure and land suitability can be illustrated in a derived index, or factor.

The cash crops Land Use Intensity Factor is intended to measure the relative proportion of a given area of land which may be devoted to production of cash crops given the area's population density and the ability of the land to supply minimum food needs for that population. Each farm system offered by Brown, regardless of the ecological zone, included only one acre of the total farm to be devoted to cash crops. Non-cash crop acreage in the Kikuyu-Star Grass Zone (A.1) should average six out of the total seven acres per farm. In the zone of High Rainfall Savannah ecology, eleven out of the average farming family's twelve acres must be devoted to non-cash crop efforts. The index of Land Use Intensity, then, is the difference between this subsistence land requirement and the average amount of land available to each family, divided by average farm size.[21] That is,

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[21] In calculating the average number of farm acres per family in each of the locations, some portion of each square mile should be taken from "total agricultural land" as non-arable. On the other hand, some of each location's population is not farm population. It has been assumed here that these balance each other. The population density totals were used, as was the consideration that there are 640 acres per square mile. Also, in

$$\text{Land Use Intensity Factor} = \frac{\text{farm size - subsistence land requirements, by zone}}{\text{farm size}}$$

As population pressure decreases, there is more available land per family and the proportion of each farm that can be devoted to cash crops increases, assuming, of course, that average farm size also increases to occupy all the land available to each family. Although this assumption could (and should) be eliminated by appropriate adjustments in practice, the assumption has been kept in the present case. It is likely to apply only in the Lambwe Valley and to the west, regions of very sparse population at present.

No adjustment in the final average farm size per family was made in those locations containing sizable uninhabited areas. For example, the low settlement in the Nyando River Swamp on the Kano Plain undoubtedly raises the average population density--and decreases the average family farm size--in the remainder of West Kano Location above the average figure recorded. On the other hand, there is sure to be an above average drain on the rural population caused by the proximity to Kisumu and the employment opportunities there, real or imagined. In any case, with the more detailed field research encouraged throughout this volume as a requisite to rational policy decisions, adequate information

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lieu of reliable methods of estimating varying farm family size from district to district, Brown's figure of 7.5 people per family, implied in calculations on page 10, Brown, "Draft . . . ," *op. cit.*, has been used.

would be available to eliminate this objection. The required data should, in fact, be contained within that gathered specifically for estimates of production and ecological zoning.

The Intensity Factor is attractive in that it can also indicate realistically zones of overpopulation. When the available land is less than the space required for a subsistence existence by the average family, the factor becomes negative. Although an appalling proportion of the study region is expected to suffer such a condition by 1972, according to the growth assumptions and calculations made here, no portion is shown to have a negative Land Use Intensity Factor (see Figure 8-11). Wherever population pressure was such that little or no land could be expected to be devoted to cash crops--all the land being required for bare subsistence, and the average available land per family reduced below the quantity required under Brown's farming systems--then the figures reverted to those which would hold if the minimum amount of land per farm could be devoted to cash crop production. Thus, one acre in twelve or one in fourteen (factors of .08 and .07) were used as representative of conditions in zones A.2 and C.1 or C.2, respectively, wherever population density was over the carrying capacity of the land. A minimum land use factor of .14 was similarly applied to portions of A.1 ecology which were very densely populated. These minimums were used primarily to maintain the complexity of the demonstration, but would not, of

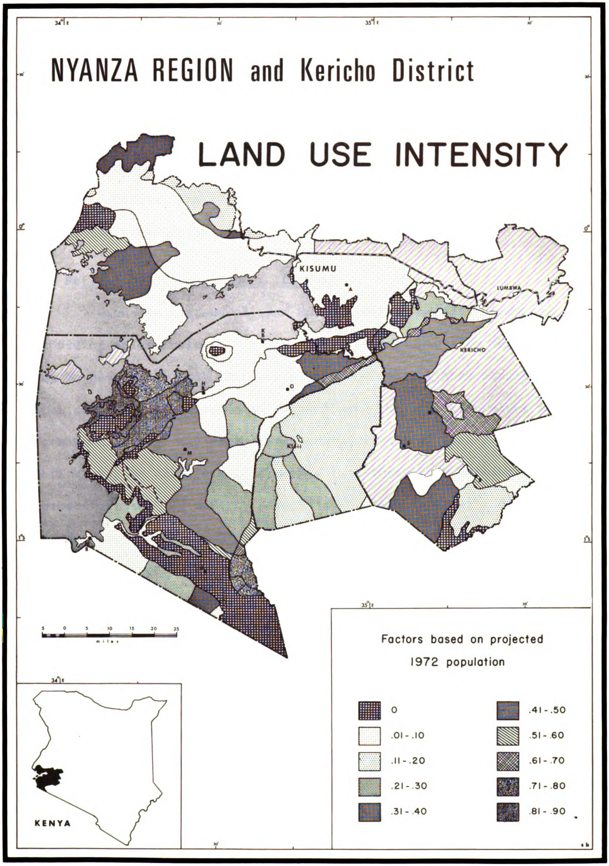

NYANZA REGION and Kericho District
LAND USE INTENSITY
KISUMU
LUMBWA
KERICHO
KENYA
miles
Factors based on projected
1972 population
0
.01-.10
.11-.20
.21-.30
.31-.40
.41-.50
.51-.60
.61-.70
.71-.80
.81-.90

FIGURE 8-11

course, be proper in a real application, for their use would mask those areas unlikely (or unable) to produce significant quantities of cash crops from smallhold farms. Well over half of Central Nyanza, perhaps one-third of South Nyanza, and fully 70 per cent of Kisii District are expected to be subjected to this level of population pressure by 1972.

The Pattern of Maximum Profit Increase

With the pattern of Land Use Intensity Factors determined, providing an estimate of the proportion of any unit area which may be devoted to cash crop production considering both population density and environmental conditions, the shilling values per acre which can be expected from improved levels of farm profitability may be calculated and mapped in a relatively straightforward manner. As a first step in this final mapping, the patterns of potential profitability improvement for each of the crops must be combined. Under conditions of adequate information and motivation, the cash crop grown on any farm in the study region should be that which will yield the farmer the greatest return for his efforts. Although these conditions may not be met in a real situation, the goal will invariably be maximization of individual well-being.

The optimum pattern of potential improvement in cash crop profitability, therefore, is comprised of a combination of those portions of each crop's potential improvement (Figures 8-5 through 8-8) which can be expected to yield the greatest profit per acre (see Figure 8-12). The resources of Kisii and Kericho Districts stand out again in this pattern. The very high potential improvement in Kisii District, with only a small portion of the productive land capable of as little profit improvement as Shs. 500/- per acre, reflects the high expected return gains from coffee (western Kisii) and white potatoes (eastern Kisii). It is a bit surprising that this portion of the study region, already producing the highest value-yielding cash crops, also has the greatest average potential improvement in crop profitability of any district here. The generally high potential in Kericho District is brought about primarily from the expected yield gains, and possible acreage increases, for potatoes, although pyrethrum, groundnuts, and some tea zones are also represented. The large area of high potential in South Nyanza is due chiefly to possible groundnut yield improvement with some peripheral gains from coffee. The remaining areas in the district indicate expected maximum returns from sugar cane, cotton, and in a very small area, rice. Central Nyanza, productive to a large extent only in cotton (which has a relatively low improvement potential), appears capable of improving maximum crop profitability at the level of the remainder of the study region only in the area to the south and west of Yala and Maseno. This zone of potentially higher gains arises from a complex combination

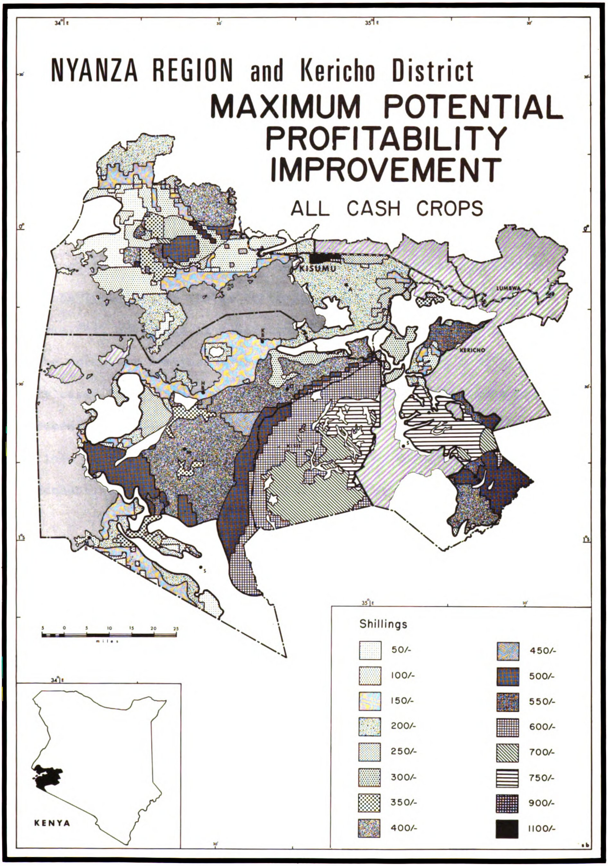

NYANZA REGION and Kericho District
MAXIMUM POTENTIAL PROFITABILITY IMPROVEMENT
ALL CASH CROPS
KISUMU
LUMBWA
KERICHO
Shillings
50/-
100/-
150/-
200/-
250/-
300/-
350/-
400/-
450/-
500/-
550/-
600/-
700/-
750/-
900/-
1100/-
miles
KENYA

FIGURE 8-12

of sugar cane, groundnut, and coffee profitability dominance, a combination that is pleasing in its diversity but disappointing in its areal extent.

Some areas in the study region contain a sufficiently low average population density to have a sizable amount of land capable of some cash crop production available per family. Although it must be remembered that the fact of sparse population probably indicates that farmers in these areas are not likely to take full advantage of conditions of low pressure on the land, the potential remains. The possibility of obtaining a more broadly based family income, through diversifying the cash crops produced, is higher in these low density areas. A series of guidelines were developed to take this additional possibility into account. Figure 8-12 was constructed on the basis of these rules.

1. In any cash crop production area where more than one crop may be grown, the more lucrative crop, A, takes precedence if there is land for only one cash crop.

2. If land is available over and above the minimum holding, the additional land will be used according to #1, above, except that a second crop, B, will be grown if there is more than (an admittedly arbitrary) 10 acres available for cash cropping; annual profit yields may be determined by

$$\text{Yield} = \frac{A\ (10) + B\ (X-10)}{X}$$

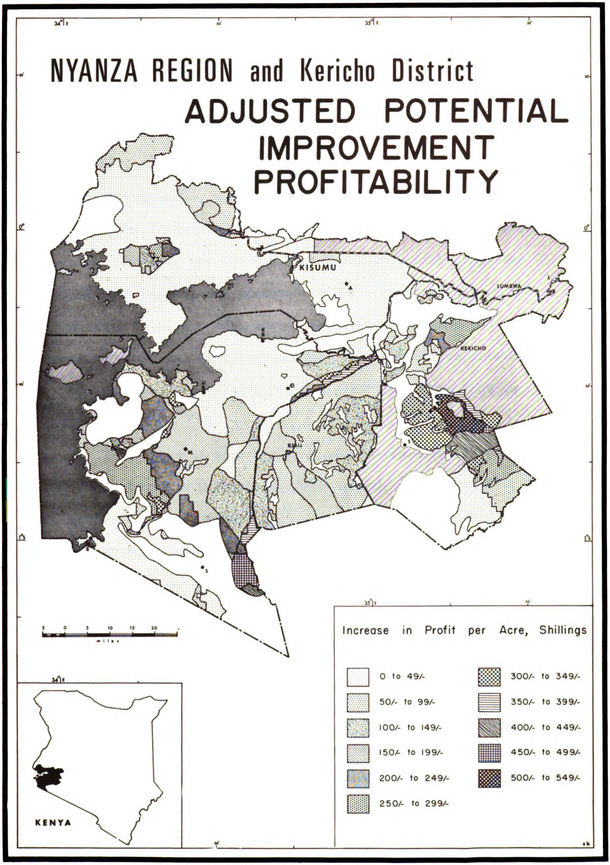
where X is the total acreage which may be devoted to cash crops at that place, with the condition that $10 < X \leq 20$. When more than 20 acres are available for this purpose, both crops A and B are farmed on equal acreages.

3. Rule #2 will not hold if the second cash crop, B, would yield a return improvement less than one-third that of the most lucrative crop, A.

In spite of the fact that in the present work, the requirements for either rules #2 or #3 were absent in almost every case where there was an overlapping of cash cropping capability, some guidelines or rules such as these should be included in future applications of the present methodology.

The final pattern of shilling value per acre, resulting from improved farm profitability, may be constructed directly from Figure 8-12. Multiplying the patterns of Figures 8-12 and 8-11, the maximum profit improvement which can be expected and the proportion of land devotable to such profit improvement, respectively, yields a third pattern which reflects more accurately than any of the previous maps the real levels of cash crop improvement of which the region is capable (Figure 8-13).

Figure 8-13 does not indicate which areas are able to produce the greatest absolute cash crop surplus. The combined returns from Kisii District, for example, may include income from coffee, tea, pyrethrum, and potatoes, all high value-per-acre



NYANZA REGION and Kericho District
ADJUSTED POTENTIAL IMPROVEMENT PROFITABILITY
KISUMU
LUMBWA
KERICHO
KENYA
miles
Increase in Profit per Acre, Shillings
0 to 49/-
50/- to 99/-
100/- to 149/-
150/- to 199/-
200/- to 249/-
250/- to 299/-
300/- to 349/-
350/- to 399/-
400/- to 449/-
450/- to 499/-
500/- to 549/-

FIGURE 8-13

crops. Smallholders in Kisii may take advantage of the low variability in climatic conditions to reduce the proportion of their land devoted to food crops below that possible elsewhere. Because of the very high average population density in Kisii, however, and because, under the assumptions of the farming schemes proposed by Brown, income equity among smallholders is maximized and only one of the several possible cash crops was "counted" in mapping the patterns of optimum profitability gains, the average value per acre increase which can be expected is kept lower than in other regions where the population pressures are much less severe relative to the capacity of the land to produce.

The region of greatest potential improvement in profitability is found in Kericho District around, and to the east and south of Litein (see Figure 8-13). After adjustments are made for the relative carrying capacities of the land and the population pressure which must be "carried," the improvement in profitability in this area reaches levels as high as Shs. 510/- per acre with much of the area capable of profit per acre increases above Shs. 300/-. The fact that this same portion of Kericho District presently contains high-quality smallholder tea indicates it is presently the most flexible <u>and</u> promising of areas for individual African small-farm development in the study region.

Other zones capable of high profit improvement in the region are smaller in size, lower in value of improvement, or both. The small area in southeastern South Nyanza showing fairly high potential profit increase is a zone environmentally capable of coffee production; because of present restrictions on new coffee planting, however, this increase can be expected only if the coffee is already established there. If the coffee factories located there are, for some reason, spatially separated from the areas of current coffee farming, then the estimated profit improvement is much too high. In west-central South Nyanza, a moderately large area of reasonable profit improvement (Shs. 200/- to 300/-) might be expected if the land and climate are, in fact, well suited to groundnut production. The adjacent land in the Lambwe Valley showing slightly lower, but substantial potential may be less accurately assessed. The level of improvement possible (Shs. 162/- to 202/- through most of the middle Valley) is based almost entirely upon the very low projected (1972) population density. Development of this land for agriculture is not likely to proceed rapidly enough to place returns of this level within "the near future"; population pressure will undoubtedly be much greater than that projected for the Valley by the time such land development has taken place.

The most surprising, and disappointing, results obtained from this map pertain to Central Nyanza District. While Kisii District profit gain potential could not be expected to be large considering the tremendous population already supported by the land resources, the real potential is even lower throughout Central Nyanza. With only two moderate exceptions, each having a small areal extent, the average small farm profits can be expected to rise less than Shs. 77/- per acre anywhere in the district. For most of this low increase area, the profit improvement is likely to be less than Shs. 50/- per acre. As this general paucity of improved profit capabilities results from the already high population density per carrying capacity in Central Nyanza, the situation is liable to deteriorate further unless some unforeseeable agricultural (or non-farm employment) possibilities improve the bases upon which these low figures are calculated.

Summary

Investments should be justified on the basis of the returns which can be expected from the investment. If the desired returns are primarily economic, the grounds for their acceptance or rejection should be as objectively determined as data permit. Decisions on the correctness of road investments in agricultural regions are, however, rarely based on a thoroughly objective study of the true potential of the various regions which will benefit from the improved transport facilities. Unprejudiced estimates of this varying potential, it was argued, could well be based upon ecological regionalizing with the relative support for different aspects of agriculture determined for each ecology. Several examples of this procedure conducted in Africa, with one fortunately in Kenya, were briefly discussed.

The true potential of the land, however it is measured, must be treated as spatially variable, i.e., different from place-to-place. This rather obvious observation is too often ignored in preliminary and post-research gathering stages of investment considerations. The described ecological divisions of the study region were delimited cartographically and further subdivided on pedologic and climatic criteria. Using these and other environmental criteria, a series of complex patterns were derived showing the spatial variety of potential agricultural profit for each of the cash crops included in this study. When the concern is with road investments, as it is here, priorities should be based on the potential increment in profit levels rather than the absolute maximum profit totals. After combining the patterns of potential profitability improvement for the several cash crops, these patterns were adjusted to account for the relative availability of land for such production vis-a-vis land needed for foodstuffs. The resultant distribution of profit potential indicated sizable areas of high and moderately high improvement levels in portions of Kericho and South Nyanza Districts, respectively, with rather low profit per acre improvements likely in Kisii District and minima

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minimal profit gain capabilities throughout Central Nyanza.

Road investment priorities cannot be determined, of course, solely on the basis of possible agricultural production improvements. The characteristics of the roads, the regions through which they are to pass, and the network changes which will result must all be examined. It is to this task that attention is now turned.

CHAPTER IX

THE RELATIVE INVESTMENT PRIORITY INDEX

Where to invest in road improvements in agricultural areas is a decision that must be based on a consideration of both the support to be gained from the land's output and the costs of improving the efficiency of movement to and from the land. Derivation of the former factor has been outlined in detail in the preceding chapters. Several facets of the second consideration must now be examined. The importance of improvement costs and annual maintenance costs must be shown in light of the need to provide access to areas of high potential farm profitability improvement. The sources of variation in both construction and maintenance costs should be discussed. The applied pattern of the sum of these costs, taking into account the sources of variability where they apply to the region concerned, must also be derived. It is only after these steps are completed that a decision may be made on the relative investment priorities for road projects in the agricultural region under study.

The Pattern of Investment Costs

Just as proper justification for road investments must be based upon the true potential improvement in agricultural output, some consideration must be given to costs which will have to be borne in order to facilitate this rise in farm productivity. Obviously, it may not be feasible to encourage output increases by improving the means of transportation, even from land which is extremely well-endowed with agricultural resources, if this land is also very distant from the major markets. Similarly, a road which requires frequent and expensive maintenance in order to keep its running surface at a given quality level will be a less attractive investment than one which does not, unless the expected benefits are proportionately higher on the former road. Investment in transportation projects should not be undertaken, non-economic factors aside, if costs exceed benefits over a given period. The decision to invest in one road improvement rather than another should be based on the relative excess of potential gain over probable cost for the two investments.

In applying this elementary economic principle to the situation with which this volume is concerned, the variations are numerous but the theme remains. As has already been shown, it is reasonable to expect a considerable spatial variety of farming profitability improvement in the near future. To say the same thing in another way, there are wide differences from place to place in the quantity of returns which can be expected from improved produce movement facilities. By the same token, the heterogeneity of nature and the different levels of existing road surface, present in spatial as well as qualitative variety, results in a very complex pattern of investment costs. As it is necessary to examine a region as a whole in order to determine investment priorities, for roads examined in isolation are unrealistically removed from the spatial context in which they _do_ exist on the earth's surface, the combined pattern of costs and that of returns are both required in this priority determination.

The Variable Costs of Road Improvement

The costs which must be borne for annual maintenance and for the initial construction or quality improvement of the road surface are extremely varied and in some cases, rather difficult to determine. This variation is in large part a result of the spatial heterogeneity of the earth's surface features. Road construction and improvement costs will be different for every unit distance of a single road. The sum of these units will vary so that average construction cost per mile will not be the same for different routes and different roads. Spatial variations in relief, climate, drainage pattern, and soils are usually sufficient to cause these different costs. In addition, however, there are numerous human decisions which inject cost variation into any road improvement considerations.[1] For example, problems of traffic

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[1]For a discussion of these and related problems, see, William W. Hay, _An Introduction to Transportation_ . . . , _op. cit._, pp. 377-393.

allocation must be decided. Where will traffic demand be greatest in the near future and by what mode of transport should this traffic move? An estimate must be made concerning the proper level of demand to be accepted as having the most efficient cost results. To what traffic level between mean and peak flows should the road capacity be adjusted in order to avoid both the high costs resulting from congestion and the waste of excessive investment? Furthermore, to what economic degree is time spent on the road an important factor in operation costs? And in detailed routing of the road, to what standard grade and alignment will the construction be designed? Are there "works of man" to be avoided or approached by the route? With this variety of cost differences, it is easy to accept the individuality of a road's initial or improvement construction costs.

There are severe difficulties for the present work resulting from this characteristic of transport engineering economics. In order to provide a balanced accounting of costs throughout the study region, it would be necessary to survey each major length of road between junctions to determine the initial cost of upgrading the road in question from its existing quality to the next highest road grade. Some estimate would also be required of construction costs for roads into areas now sparsely settled but containing land of high agricultural potential. These surveys need not be in great detail, for the preliminary nature of the methodology outlined in this volume does not justify this. It would be necessary, however, for a team of trained highway engineers, familiar with the environment and costing situation of East Africa, to calculate roughly the financial requirements for every significant road in the study region.[2]

Although it is not possible at this stage of research, for the reasons discussed, to present detailed estimates of improvement costs for all roads in the study region, general levels of cost may be used here as preliminary guidelines. Detailed surveys of several parts of the study region have been carried out and the improvement costs were calculated for the major routes in the area. Thus, figures are available for the cost of upgrading roads in flat to rolling terrain,[3] and in rolling to quite hilly topography.[4] The stages through which road improvements are

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[2]While this author traveled extensively in the study region over most of the main roads and many of the minor ones, he had neither the training nor the time to provide realistic cost estimates on the scale needed.

[3]Sir Alexander Gibb and Partners, Report on Agricultural Roads . . . , op. cit.

[4]Republic of Kenya, Ministry of Works, Loan Application for Trunk Road Development 1967-1970, "Preliminary Project Report on the Wanjare - Suna Road B4/3," (Item A2) and "Preliminary Project Report on the Ahero - Nyakoe Road B4/1 & B4/2," (Item A3), August, 1966; and the large table compiled by Eduard Irgens which was enclosed in this application, "Proposed I.D.A. Trunk Road Programme 1967/1970 : Discounted Cash Flow Analysis," Ministry of Works, Roads Branch, drawing number MPR/105, August, 1966.

measured are more numerous than the three quality levels used in Chapter IV when assigning vehicle operating costs. Although there is a difference in terminology used to refer to these road grades in the several reports, the actual levels of road quality are similar in corresponding categories. A "Type II gravel road" in one report,[5] for example, is apparently the same as a "Grade 4 road" in another.[6] The quality differences between roads are best described by Irgens (see Table 9-1), and it is with these general grade categories in mind that average improvement costs are offered for use here.

TABLE 9-1

ROAD GRADE CLASSIFICATION

Grade 0	-	Unimproved track
Grade 1	-	Slightly improved track
Grade 2	-	Improved track
Grade 3	-	Gravel Road, slightly improved
Grade 4	-	Improved Gravel Road, or low standard tarmac road
Bitumen Road		(paved)

In addition to the paucity of data concerning road improvement costs in the study region, the individualized character of such costs makes the process of deriving _average_ costs difficult. The Gibb and Partners report, for example, cautions

[5]Kenya, Ministry of Works, _Loan Application_ . . . , _op_. _cit_.

[6]Irgens, "Proposed I.D.A. Trunk . . . ," _op_. _cit_.

> . . . that the soil conditions prevailing [on the Kano Plain] together with the lack of suitable surfacing materials within reasonable haul distance have contributed significantly to the high overall cost. The average cost per mile of road cannot therefore be directly compared with the cost of similar roads constructed elsewhere in more favourable conditions.[7]

Further questions are raised when the same road is assigned two widely divergent cost per mile estimates in different portions of the same report! Thus, the bitumenizing of the road from Wanjare to Kamagambo (south of Kisii town toward Suna) is estimated to cost £19,000 per mile in the text of the loan application,[8] while the same improvement for the same road is set at £26,400 by Irgens.[9] The cost per mile figures used in the present volume, then, are obviously no more than indications of the real costs of improving any road in the study region. The calculated average grade-to-grade road improvement costs per mile which will be used in this volume, rounded to facilitate computations and to avoid any mistaken impression of detailed accuracy, are shown in Table 9-2.

The Variable Costs of Road Maintenance

The sources of variation in road maintenance costs have fortunately been grouped into more clearly defined categories than

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[7] *Report on Agricultural Roads* . . . , *op. cit.*, p. 40.

[8] Kenya, *Loan Application* . . . , (Item A2), *op. cit.*, Appendix A.2 (IV).

[9] Irgens, "Proposed I.D.A. Trunk . . . ," *op. cit.*, column 7, line A.2A.

TABLE 9-2

CALCULATED AVERAGE IMPROVEMENT COSTS PER MILE, BY ROAD GRADE

Road Grade:	from	to	rounded cost/mile	calculated cost/mile
	gravel (4)	bitumen	£10,000.	£9,990.
	gravel (3)	gravel (4)	£ 9,000.	£8,936.
	earth (2)	gravel (3)	£ 4,000.	£4,130
	earth (1)	gravel (3)	£ 5,000.	£4,754.
	earth (1)	earth (2)	£ 3,000.	£2,888.

have the sources of improvement costs. Because the administration of regular annual maintenance grants has been under the jurisdiction of official agencies--first the Road Authority, and since July 1, 1964, the Ministry of Works' Road Branch--justification for regional variation in demand for these grants has been carefully scrutinized. In a recent examination of Kenya's road maintenance costs, it is reported that since 1952, "the allocation of maintenance grants was calculated as a certain rate/mile from a formula based on traffic density with modifying factors for local climatic conditions and the availability of materials."[10] From the basic rate, governed by the traffic to be borne, an addition or subtraction of funds may be made if the rainfall and the relative availa-

[10] British Road Research Laboratory, "A Study of Road Maintenance Costs in Kenya," East African Transport Planning Research Unit (Kenya), KN/2 (unpublished), p. 2.

bility of suitable surfacing material warrant this modification. The schedule of reported incremental factors is shown in Table 9-3.

TABLE 9-3

MODIFICATIONS TO THE BASIC ANNUAL ROAD MAINTENANCE GRANT

Condition	Increment
Average Annual Rainfall	
0 - 20 inches	- 5%
21 - 40 inches	0%
41 - 60 inches	+ 5%
above 60 inches	+10%
Surfacing Materials	
Location requiring haul over 5 miles	+ 5%
Hard (vis-a-vis soft) material	+ 5%

Source: British Road Research Laboratory, "A Study . . . ," *op. cit.*, p. 2.

In addition to the basic road maintenance grant, variable in the manner described, two further factors are applied toward total maintenance costs. A small sum is paid to local authorities throughout Kenya for the administration of local road maintenance. This figure varies with the daily traffic density of the roads and is one-quarter of the sum of the basic and the re-gravelling grants. A much larger factor in total costs is this re-gravelling grant. As is noted in the Road Research Laboratory report:

> Engineers have found from experience that the loss of gravel from the surface of the road is of the order of 1" per year for every 100 vehicles using the road per day. The cost of replacing gravel is not likely to be less than £600/mile for a 4" compacted thickness, two lanes wide.[11]

The total cost of maintenance, then, is the total of these three elements plus any modifications based on climatic or materials characteristics. Table 9-4 summarizes these total costs by road "class," where the class is determined by the traffic density.

TABLE 9-4

TOTAL COST OF ROAD MAINTENANCE FOR ROADS EARNING THE BASIC GRANT, 1964/65
(POUNDS STERLING PER MILE PER YEAR)

Class of Road	Vehicles per Day	Basic Grant	Re-gravelling Grant	Administrative Grant	Total Cost
I	25-50	43	50	23	116
II	51-100	66	100	42	208
III	101-200	89	150	60	299
IV	201-300	150	200	88	438
V	over 300	270	250	130	650
bitumen:					
1-lane		200*	-	50	250
2-lane		265*	-	66	331

*The rates quoted for bitumen roads include periodic resealing and resurfacing at about 5-year intervals.

Source: British Road Research Laboratory, "A Study . . . ," *op. cit.*, p. 9.

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11 *Ibid.*, pp. 6-7.

Using the data presented here in Table 9-4, the author of the Road Research Laboratory note on maintenance costs derived an equation describing the relationship between the total cost of maintenance for gravel roads and the traffic flow in vehicles per day. The linear equation is T.M.C. = 95 + 1.37Q using the mid-flow values, where T.M.C. is total maintenance cost and Q is the average daily traffic flow.[12] The equation states that the total maintenance cost, in pounds sterling, increases 1.37 times for every unit increase in vehicle flow, over the initial £95. of fixed costs (in this case representing maintenance of non-surface portions of the road, e.g., ditches and culverts). By adding the climatic and material availability increments, where suitable, to the T.M.C. derived from this equation for each road in the study region, it should be possible to cartographically represent the pattern of road improvement costs.

Some of the most important, and typically some of the least available, data needed in order to construct the map of total road maintenance costs are the complete traffic flows for all roads in the study region. Several surveys of traffic volume have been made in selected portions of the study region or include the Nyanza Region and Kericho District within a larger survey

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[12] _Ibid._, p. 11.

area.[13] The data resulting from these surveys are not wholly satisfactory, however, for not only are the data reserved to the few main roads in the study region, but they are also widely divergent in the level of average daily traffic reported for the same locations on several roads.[14] Later applications of the present methodology should include traffic counts on all roads in the region, from Grade 2, which is generally a packed earth road, through bitumen. Grade 1 roads, or motorable tracks, may be checked in the areas containing top priority investment possibilities (as determined below) but will generally have fewer than 25 vehicles per day.[15] With suitable traffic data, total

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[13]Kenya, *Loan Application* . . . , (Item A2) and (Item A3), *op. cit.*; Sir Alexander Gibb and Partners, *Report on Agricultural Roads* . . . , *op. cit.*; and, British Road Research Laboratory, "Preliminary Note on the Origin and Destination Survey of Road Traffic in Kenya 1964/65," East African Transport Planning Research Unit (Kenya), KN/4 (unpublished), p. 35.

[14]Although unusual circumstances might cause a considerable variation in traffic counted during different surveys, the variation reported is disturbingly large. The Road Research Laboratory survey counted 175 vehicles per day just outside Kisii town on the road to Oyugis, while the Ministry of Works loan application reports 381 vehicles per day as the average. - British Road Research Laboratory, "Preliminary Note . . . ," *op. cit.*, p. 35; and, Kenya, *Loan Application* . . . , "Preliminary Report on the Ahero - Nyakoe Road . . . ," *op. cit.*, Appendix A.3 (II).

[15]Roads of similar quality used for tea collection have traffic generally less than ten vehicles per day. See, John A. King, Jr., *Economic Development Projects and their Appraisal* (Baltimore: The Johns Hopkins Press, 1967), p. 302.

maintenance costs may be determined for each road in the region being studied. Proper increments would, of course, be added to or subtracted from the basic grants because of climatic or material availability variations.

For present purposes, as a means of deriving a pattern of road costs reflecting both construction and maintenance costs, a series of assumptions will be made regarding road traffic patterns. Although not strictly an assumption,[16] the study region's roads are re-classified into five categories, rather than the three shown on Figure 4-2. A distinction is made here between one-lane and two-lane bitumen roads. The sole one-lane bitumen road in the study region connects Sotik with a short two-lane bitumen road extending south from Kericho town. The only gravel roads realistically called "all weather" roads are (excluding short bitumen sections): Kisumu through Yala, Ahero to Miwani, Ahero to Kisii via Oyugis, Sondu to Sotik, Sotik to Kisii via Keroka, and Kisii to Kamagambo. These roads will be assumed to carry traffic suitable to Classes IV and V (see Table 9-4). The remaining "unpaved" roads shown on Figure 4-2 are generally of mixed quality and seemed more suitable to a combined gravel/earth category. These roads will be assumed to carry Class II and III traffic, or an average 50 to 200 vehicles per day. Those routes

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[16] Some justification for the new categories is provided by qualitative judgements based on the author's personal observations.

connecting major centers will be assumed to carry close to the maximum traffic in this class while roads of less obvious importance may be expected to carry lower traffic volumes. The Oyugis - Kendu Bay road, for example, appeared to the author to be of much higher general quality than, say, that passing through Mirogi to Lake Victoria. The remaining roads, or "vehicular tracks," will be treated as though they carry daily traffic at the level of 25 to 50 vehicles, undoubtedly an excessive estimate in many cases. These traffic volume assignments permit here, at the least, a consistent assessment of relative maintenance costs for each road within the study region.

It is not, however, costs based on existing traffic which are of primary concern here. Because it is the total road costs to be borne *if* road improvements are made that need to be calculated, estimates of future traffic volumes are required. In Kenya, it has been found that road improvement leads to a 40 percent increase in daily traffic during the first year after upgrading and an 8 percent increase thereafter. An average 10 percent increase per year could be assumed when calculating maintenance costs.[17] The pattern of costs based on these maintenance requirement estimates must be added to the varying upgrading costs,

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[17]Republic of Kenya, Ministry of Works, *Loan Application for Trunk Road Development 1967-1970*, "General Information on All Road and Bridge Projects," August, 1966, p. 2.

the latter converted to annual costs by using the appropriate loan interest rate and amortization period. In the present case, a 20 year loan period and a 4 percent rate of interest will be used in calculations.[18]

<u>The Problem of Absolutes</u>

A serious difficulty in the logical development of the present method emerges when consideration is given to the problem of obtaining a meaningful and applicable measure of the variable contribution which can be made by upgrading the study region's roads. It is desirable to make this complication explicit so that it may be treated directly, and more importantly for the future, so that the research necessary to resolve the matter may be conducted.

The road quality to which all roads can be improved, in the end, is the highest quality--two-lane bitumen. It would seem theoretically correct to measure costs and relative well-being derived from the road improvements to this level. It is only by reference to the best movement facilities (based on the costs of reaching these levels and the increased benefits to be derived from the new facilities) that an <u>absolute</u> measure of road improve-

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[18]The factors to use in calculating annual capital recovery for these, and other, rates of payment are shown in tabular form in Hay, <u>An Introduction</u> . . . , <u>op</u>. <u>cit</u>., p. 390.

ment costs and returns may be obtained for comparison with the level of potential agricultural improvements. Without such an absolute measure, it might appear, there can be no consistent reference point to provide a basis for investment decisions.

On the other hand, it is not realistic to expect all roads to be upgraded to bitumen quality. Recent research in southwestern Tanzania under Robert Bonney has indicated that the move to bitumen road quality may be justified, ". . . where the proportion of medium/heavy traffic is especially high . . . at a traffic volume as low as 60 vehicles/day - depending on the standard of maintenance."[19] It is not likely, however, that the funds for such extensive road improvements will be available when they are needed. Furthermore, it is more meaningful to devise a method of investment priority determination which allows comparison between, say, improvement from track to earth/gravel quality and improvement from gravel to bitumen, both in terms of the facilities required to reap the possible returns from improved agricultural production and the relative levels of these possibilities. What is needed, more specifically, is a justifiable

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[19] R. S. P. Bonney, M. N. Daniel, and A. T. Noorani, "Traffic and Road Characteristics in South Western Tanzania," E.A.T.P.R.U. Research Note No. 5, British Road Research Laboratory, Ministry of Transport, East African Transport Planning Research Unit, Tanzania Branch, May, 1966, (unpublished), p. 35.

method for choosing the optimum location and degree of road upgrading with regard to expectable returns. But *if only the potential returns are used as a basis for comparison, the differences in returns from transport improvement are ignored, for regardless of the amount of transport route upgrading, the potential returns from agriculture are the same*. This is a formidable dilemma. To resolve it, it is necessary to return from theoretical considerations to the reality presented by meager research results.

There are no known guidelines for correctly calculating the actual returns resulting from road investments. This has been emphasized before (Chapters I and IV). Cost-benefit studies do attempt to estimate these future returns, but with very few exceptions, even the direct returns from increased productivity in areas adjacent to the new or improved road have been "estimated" with no more than a cursory regard for empirical justification. In less developed regions, these studies have been hindered by a lack of long-term, detailed statistical records. Although increased production has been observed in a number of cases (see Chapter I), only in the study by Smith in Uganda,[20] and possibly Hawkins' later research in the same country,[21] are

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[20] N. D. S. Smith, "A Pilot Study in Uganda . . . ," *op. cit*.

[21] E. K. Hawkins, *Roads and Road Development* . . . , *op. cit*.

there cases in Africa which lend quantitative indications of possible production increases.[22] Other secondary benefits are even more difficult to measure.

The only immediate benefits which deal with individual movement costs[23] and can be used with reasonable assurance of accuracy are the reduced operating costs that follow from improved road surfaces. Considering this limited source of dependable return data and the objectives of the present methodological offering (i.e., that a system or priorities be established concerning the best alternative among numerous investment possibilities), it is more meaningful to measure comparative investment possibilities with respect to the maximum returns that can be obtained from the land.

The Priority Index

There are three primary variables involved in the present problem--agricultural potential, existing road quality, and the priority for investments. It is only by fixing two of these factors that the third may be explained. By dealing with maximum

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[22]Robert Bonney, who had worked on this problem on Sabah in the East Indies, was engaged in research during the latter part of 1966 in southwestern Tanzania on the relationship between agricultural production and its proximity to movement facilities. His conclusions may provide a partial solution to the present problem.

[23]Other quantifiable benefits, such as license fee increases, higher fuel tax income, and the like, are basically a function of increased traffic volume.

agricultural potential, this factor is dealt with in a standardized form even though the level of potential may vary from place to place. In the same sense, although existing road quality is variable from road to road, that aspect of this factor crucial to the present undertaking may be made constant by standardizing the improvement costs to be invested. Thus, by relating the same level of road improvement costs to the known returns which result from these investments (the reduced vehicle operating costs), regardless of the initial road quality, and then by relating the resulting factor, in turn, to a consistent measure of agricultural potential (the maximum potential, as defined by explicit criteria), the variable ratio which results indicates the routes' respective priorities.

This relationship, resulting in the establishment of investment priorities, may be more clearly seen by stating it in another form.

$$\text{Relative Priority Index} = \frac{\text{Potential Improvement in Farm Profitability}}{\dfrac{\text{construction costs} + \text{maintenance costs}}{\text{reduction in vehicle operating costs}}}$$

It is vital that the resulting fraction be seen as a quantitative statement of <u>relative</u> investment justification. These fractions have meaning only with respect to one another and within the system of roads and agricultural regions being examined. The index relating to a given route cannot be compared with some standard value, for none exists, and a large or a small result must be analysed within the context of the complete range of values for all similar routes in the study region.

Careful consideration of the manner in which this relationship is expressed, above, reveals the simple consistency in this statement of any road's relative investment priority level. The denominator is an expression of the relation between road investment costs and the benefits to be derived from these investment expenditures. If returns are large relative to annual output, the denominator is small; it is large when costs are relatively large compared to returns due to the reduction in vehicle operating costs. The larger the returns relative to the costs (i.e., the smaller the denominator), the larger will be the priority index for a given potential profitability improvement. It should be noted that the denominator need not be less than 1.0 (i.e., costs may be greater than benefits) in order that a route achieve a high investment priority rating. If the agricultural potential is sufficiently large relative to the potential elsewhere in the region, a route which might be rejected by cost-benefit analysis may still be justified as the top priority investment project.

Although it has been frequently stated that the present concern is with the setting of priorities, not with the establishment of acceptable or unacceptable grounds for investment, the author should make a related point clear. It is recognized that there is a danger that this methodology may strongly indicate the best of a dozen alternative investment projects, all of which are wasteful, because the region of concern is too small. It is also believed, however, that considering the present stage of agricultural development in most African countries and the funds available for road improvement, there is little danger of over-investment in transport facilities. These nations contain regions which, even on the basis of broad (but informed) subjective judgement, are of high agricultural potential yet lack good internal communications. If the proper statistical records are kept during and after road improvements in these regions, sufficient data should be available to calculate the proper mathematical constant indicating the level at which high agricultural potential is not adequate to overcome an excessively large deficiency of returns relative to costs.

The Application

The major task which remains is to demonstrate the manner in which the measure derived above may be applied to a real situation resulting in the establishment of a series of road investment priorities. As with earlier portions of the present application, a number of assumptions are necessary, but also as before, they are made explicit, are eminently testable given adequate resources and correctable if required, and do not drastically affect the outline of the methodology.

Because of the limitations imposed on the analysis by the requirement of a consistent increment in road improvement costs, the value used should be suitably proportionate to the average improvement costs between road grade categories. By examining Table 9-2, several alternative factor combinations are apparent in the calculated improvement costs per mile. The proportion to be used in this volume is that applicable to the costs required to upgrade roads from Grade (1), basically an earth track, to Grade (3), a mixed earth/gravel road, from Grade (3) to the top quality gravel road, Grade (4), and finally, from Grade (4) to a bitumen surface. This alternative was chosen for several reasons: the proportion of Ł5000 to Ł9000 to Ł10,000, or 1 to 1.8 to 2, is very manageable, and most vehicular tracks in the study region are of a quality that is best described as unimproved, or Grade (1).

This ratio, 1.0 to 1.8 to 2.0, represents the inverse of the relative class improvement by investing similar amounts of capital into each quality of road. That is to say, by spending Ł5000 on every mile of road in the study region, all earth tracks would be improved to the level of Grade (3), or earth/gravel. All Grade (3) roads would be improved, but none would be upgraded sufficiently to place the bettered road in Grade (4). The quantitative improvement in costs of movement and traffic and maintenance costs is only $\frac{1}{1.8}$ (or 0.55) times the Grade (3) to Grade (4) increase in these factors. The £5000 invested in every Grade (4) road results in an increase of half that which would have occurred had the full improvement to two-lane bitumen been possible.

Clearly, several assumptions must be made at this point. The change in traffic and maintenance costs and in operating costs for those investment situations where the full grade increase cannot be made with the investment increment chosen to apply to all roads (the costs of which are indicated in Table 9-2) are assumed to be proportional to the reduction from the total investment required. Although under ordinary circumstances, improvement costs are not reported on projects resulting in less than a full grade increase in road quality, this does not preclude its feasibility and in many cases because of scarce funds, its desirability. That returns will be proportional to inputs is also assumed, but this is consistent with the linear relationship between these factors with respect to maintenance costs and traffic volume.[24]

The second assumption which must be made is related to bitumen roads. Much of the road between Kericho and Sotik is

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[24] British Road Research Laboratory, "A Study of Road . . . ," _op_. _cit_., p. 9.

bitumen but only a single-lane bitumen road with gravel shoulders. Because there are almost no data relating to one-lane paved roads, the costs of improving to or from this level and the effects generated by improvement will be assumed to be half that required to upgrade a Grade (4) gravel road to two-lane bitumen. Although it will be admitted that the empirical foundation for this assumption is weak, firmer knowledge could easily be substituted for the £5000 cost per mile "convenience figure" used in the present work.

It is easiest if the relationship between the investment inputs and outputs (i.e., the denominator in the relative priority factor) is determined in detail before any attempt is made to combine it with the spatially variable agricultural potential. Although any application of the method, when full traffic data are available, would require a more specific set of calculations for each length of road, the limitations of these data on the present, preliminary application allow generalized factors to be determined for each level of road improvement. In this application, the "before investment" levels of daily traffic were set at 35 vehicles per day on regional "tracks," 125 vpd on the mixed earth/gravel roads, an average of 300 vpd on the Grade (4) gravel roads, and 300 vpd also on the only 1-lane bitumen road. The calculations following from these figures are summarized in Table 9-5.

TABLE 9-5

DETERMINATION OF THE ROAD FACTOR FOR THE INVESTMENT PRIORITY INDEX

		track from - earth/gravel to	earth/gravel from - gravel[(a)] to	gravel[(a)] from - 1-lane bit. to	1-lane bit. from - 2-lane bit. to
1	construction cost/mile	Ł5000	Ł9000	Ł5000	Ł5000
2	traffic before improvement	35 vpd	125 vpd	300 vpd	300 vpd
3	traffic after improvement[(b)]	98 vpd	349 vpd	839 vpd	839 vpd
4 = 3 - 2	traffic volume change	63 vpd	224 vpd	539 vpd	539 vpd
5	heavy vehicle traffic[(c)]	42 vpd	149 vpd	359 vpd	359 vpd
	calculated T.M.C.:[(d)]				
6	before road improvement	Ł143/year	Ł266/year	Ł506/year	Ł250/year
7	after road improvement	Ł229/year	Ł573/year	Ł250/year	Ł331/year
8 = 7 - 6	change in T.M.C.	+ Ł86.	+ Ł307.	- Ł256.	+ Ł81.

TABLE 9-5--Continued

		track from - earth/gravel	earth/gravel from - gravel[a]	gravel[a] from - 1-lane bit.	1-lane bit. from - 2-lane bit.
9	annual const. cost/mile[e]	Ⱡ367.9	Ⱡ367.9	Ⱡ367.9	Ⱡ367.9
10 = 9 + 8	ann. cost/mi. after invest.	Ⱡ453.9	Ⱡ674.9	Ⱡ111.9	Ⱡ448.9
11	reduction in vehicle operating cost/mi.[f]	-/24	-/13	-/06	-/06
12 = 11 x 5	ave. daily savings, all heavy traffic	10/08	19/37	21/54	21/54
13	ann. operating cost saving[g]	Ⱡ170.86	Ⱡ328.32	Ⱡ365.10	Ⱡ365.10
$14 = \frac{10}{13}$	$\frac{\text{invest. costs}}{\text{invest. returns}}$	2.66	2.06	0.31	1.23

[a] Because the full construction cost required to improve the earth/gravel roads to full Grade (4) gravel roads (row 1) is greater than the standardized investment used here, for that partial improvement which can be supported by the investment, the reduction in vehicle operating costs (row 11) is proportionately smaller. See note (f).

[b] Calculations are based on a 40 percent traffic increase in the first year after improvement and an 8 percent increase each year thereafter. Figures shown are estimated traffic 10 years after investment.

TABLE 9-5--Continued

(c) Heavy vehicular traffic is assumed to be two-thirds of the total traffic.

(d) T.M.C. is the total maintenance cost, where T.M.C. = 95 + 1.37Q, and Q is the average daily traffic flow. See the earlier discussion related to Table 9-4, and the data in this table. These figures do not include increments justified on the basis of local climatic or material availability variations.

(e) This value represents the £5000 input applied to each road quality, amortized over a 20 year period at 4 percent annual interest.

(f) These figures are based on the ratio 2.0 : 1.6 : 1.2 : 1.1 : 1.0 for the relation between operating costs on the grades of road, track:earth/gravel:gravel: 1-lane bitumen: 2-lane bitumen. In shillings per mile for 3-5 ton trucks, this ratio is 1/20 : -/96 : -/72 : -/66 : -/60.

(g) One-half of the normal daily traffic volume is assumed to exist on Sundays.

The calculations necessary to determine the transport element of the relative investment priority factor are not difficult once the preliminary cost and return information has been gathered. From a beginning traffic volume and a known rate of traffic change, given road improvements, the actual change in volume of traffic may be determined. The difference between pre-improvement and post-improvement traffic yields the altered maintenance costs which must be borne annually because the road quality was upgraded. The sum of these generally larger maintenance costs and the construction costs required to allow this increased traffic (in the present case, a constant £5000 reduced to a realistic annual cost) yields the total costs which must be borne because of the improved infrastructure. By then calculating the annual benefits received because of the better road surface, here limited to the reduction in vehicle operating costs, a benefit level is derived comparable to the total cost level. This, of course, allows calculation of the denominator of the investment priority index for each road in the study region.

Several observations may be made concerning the figures shown in Table 9-5. It should be remembered that the ratios of costs to returns cannot be taken as absolute cost-benefit ratios. Aside from the restraining assumptions, the ratios derived in the manner indicated tend to be very pessimistic because the only benefit counted in the calculation is that resulting from lower movement costs. Keeping in mind the many data qualifications, it would appear that the top-grade gravel roads in the study region should be upgraded to at least one-lane bitumen quality. The low figure of 0.31 leading to this conclusion is, of course, a function of the existing high traffic volume on these roads[25] and the sharp decrease in annual maintenance requirements after a road surface has been paved.[26] These conclusions are supported by the construction work already begun on the Ahero-Kisii road in late 1966 preliminary to applying a bitumen surface. In any case, it is these ratios between improvement costs and the change in vehicle operating costs that are one half of the information needed to calculate the roads' relative investment priority indices.

The index which will provide an indication of a road's relative position among a short priority sequence for investment is calculated, as discussed above, by determining a quantitative measure of the relation between potential improvement in farm

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[25]Reported in, British Road Research Laboratory, "Preliminary Note on the Origin . . . ," _op_. _cit_., Figure 4.

[26]See Table 9-4. Furthermore, Klein has reported that Kenya's policy has been to bitumenize road with traffic exceeding 300 vehicles per day, judged very conservative in contrast with Tanzania's general policy to bitumenize at 150 vehicles per day. - Martin S. Klein, _Economic Feasibility_ . . . , _op_. _cit_., p. II-27.

profitability and the relative costs of road upgrading. In other words, this measure describes the relation between the expense of improving a given length of road and the economic quality of the land through which this length of road passes. There is no assumption that the land will yield to its full potential because of easier and cheaper transportation, but it is believed that this is highly probable.

As a guide in carrying out the calculations necessary to complete the choice of top priority investment projects among the roads in the study region, a set of "rules" were drawn up. These rules (together with some explanatory argument) follows:

1. The relative investment priority index is defined by the relationship between the land's potential and the road or roads passing across this land, as was stated earlier. For a given length of road, the index equals

$$\frac{\text{Potential Improvement in Farm Profitability}}{\dfrac{\text{costs resulting from road improvement}}{\text{returns received from road improvement}}}$$

2. The land for which the agricultural potential is considered responsive to changes in road quality is limited to one mile distant from the road adjacent on each side. This distance is considered here (subjectively and arbitrarily) the no-profit margin for walking large quantities of produce to the road. Land lying at a distance greater than one mile from the

nearest road, or track suitable for wheeled vehicle, is taken to have a sufficiently reduced profitability to be deemed non-productive for present purposes. It is recognized that this margin is probably located too close to the road to accurately represent conditions in the study region. There is, however, no known function, applicable in Africa, expressing the decline in profitability, productivity, or attraction to the farmer with distance from the nearest motorable route.

3. The important factor in priority determination is the ratio between agricultural potential and road returns for the costs incurred. The index resulting for <u>each mile</u> of road (based on Table 9-5 and on Rules #1 and #2) indicates the relative priority which should be given that length of existing road.

4. In order to deal with realistic road lengths, the priority index will be determined on the basis of road lengths longer than the one mile units of Rule #3. The indices for each mile will be summed over the length of the connected road. The <u>maximum resulting index of combined, one mile units</u> will be taken to represent the best investment possibility among the various composite routes.

5. Each route whose index is to be compared with others must have at least one direct connection (not through another route) with a non-improvable (i.e., a two-lane bitumen) road which, in turn, connects with one or the other of the primary regional market outlets, Kisumu or Lumbwa. Of course, this rule limits to some degree the flexibility of the present application, for there may be areas of high agricultural potential proximate to non-bitumen truck routes, but having no good connection with a major bitumen road. This may be shown in future applications if desired; it is within the scope of the method. Here, however, improvement priorities will be shown in light of the development of the region as a whole. This procedure, combining the economics of improving a (non-bitumen) trunk road with those of the feeder roads, is justified by reference to a more complete examination of the relations involved. It is only by considering the entire road length, as long as the priority index remains large, that the true relationship may be shown between the rural profitability potential and the means of moving the products of these rural areas the entire distance to the market.
6. Routes not presently in existence extending into re-

gions of high, but as yet undeveloped agricultural potential will not be considered. (Suggested areas requiring such a road net may be seen by implication from the combined patterns of Figures 4-2 and 8-13.)

Using these broad guidelines, the calculations may be made which yield the pattern of road investment priorities.

Before proceeding, a final objection might be made. The resulting priority indices, it could be argued, do not accurately represent the desired priorities because they do not include a measure of trip movement costs. Such indices would contain operating costs over bitumen sections of the total routes as well as over those roads capable of improvement. This, however, is a reversion to the old cost-benefit approach. If agricultural output is increased sufficiently to result in income greater than the costs of moving the goods to market, then the road construction is justified. As has been argued before, this is not the issue. A variable level of output will reach the market without better routes; this is the existing level of product sales. The problem solved by the present method is: Given the desire to improve transport facilities, what agricultural pattern justifies, through the potential improvement in cash crop profitability and the existing road connections with the market, the decision to upgrade the roads connecting this area with the market? The costs of operating vehicles on the paved roads are not directly relevant because there is no change in these costs with a change in the condition of other roads--assuming maintenance remains adequate--until congestion becomes a serious cost burden. The agricultural areas through which the bitumen roads pass will not be assisted toward a closer approximation of full potential output by better road conditions. The road conditions, obviously, will not be better in this instance.

The Regional Priorities

By applying the rules set down above to the data for the present study region, a series of priority lines are established. The successive sums of relative priority indices, drawn from the points where unpaved roads contact paved roads, show very clearly a stong dominance in encouragement for investment along a few routes. Those routes having the greatest concentration of justification are shown in the form of a flow map (Figure 9-1). Although the calculations resulted in numerical conclusions, the flow map offers better visual support for the road investment priorities.

That road for which the relative investment priority index remains the largest for the greatest distance is the road which should take investment precedence over all others in the region. In a situation where a decision must be made between a short road with a high priority and a completely separate long road with only a moderately high index, the shorter road should be upgraded first.

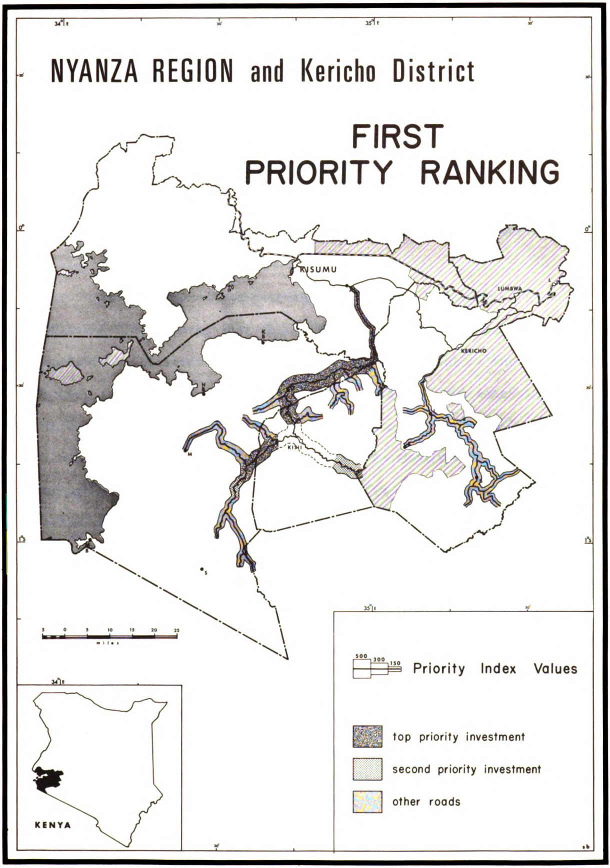
NYANZA REGION and Kericho District
FIRST
PRIORITY RANKING
KISUMU
LUMBWA
KERICHO
KISII
miles
KENYA
Priority Index Values
500
300
150
top priority investment
second priority investment
other roads

FIGURE 9- 1

The larger index for the short road indicates that investment in this route will make better movement facilities available to land with greater potential gains in profitability than would an improvement in the longer route. The leading statement in this paragraph explicitly states the guide which should be used when choosing the optimum route among the many which may be connected to a single base.

Examination of the pattern of investment indices (Figure 9-1) indicates that the route with the greatest justification to be classified "top priority" for investment is the road between Ahero and Kisii via Oyugis. Beyond Kisii, the extension of top priority may not be clear from the map but the calculations show it to be the extension passing southwest from Kisii through Kamagambo. The road toward Sotik is deceptively longer with almost exactly the same index (382.4) just before reaching the Kericho District border, as the southwestern road's index (382.6) at Kamagambo. The choice between these two roads is clear when it is pointed out that much of the apparently longer distance southeastward is over the bitumen section of this road from Kisii. Adjacent to the town, a portion of each of these three roads entering Kisii has been paved and cannot, therefore, be included in calculations yielding the relative investment indices.

The explanation for this road's high index is not difficult to make. The primary cause lies in the fact that this road has a top quality gravel surface. The class into which the road would be raised upon investment of the unit improvement decided upon (i.e., £5000 per mile) is one-lane bitumen. Because of the sharply diminished maintenance costs required by paved roads relative to gravel surfaces, especially when the latter must bear a high traffic volume, the change would cost less relative to that of other roads. Thus, even the moderately high potential improvement (Shs. 300/- to 400/-) of the small area through which the road passes after Sondu is sufficient to raise the index sharply. The low denominator and the occasionally moderate numerator values, supplied by the land through which the route passes, are adequate to maintain this large index as far as Kamagambo. Beyond this point, the quality of the road changes with the result that the index diminishes rather quickly. Nonetheless, the top priority investment rating is justified ten miles byond Kamagambo along the road toward Suna.

The length of the first investment priority route is limited by the index size of the next best route for investment. As the top priority route is followed from its base, it eventually reaches a level equivalent to the investment index which is next largest after that associated with this primary route. At that point, the road classified as having the greatest relative justification for investment ends and a second, slightly lower priority index road is followed to its termination, and so forth.

The setting of priorities, however, is not simply a matter of choosing, in a step-by-step fashion, the next smaller index among a map of these indices for the entire region. It is important to remember that a change in one section of this network of indices may result in an altered importance for other portions of the net. The upgrading of the Ahero-Kisii-Kamagambo road will alter the index of every road and track connected with this route. The eventual road improvement may only be to a one-lane bitumen quality or to a two-lane, 20 foot roadway; the determination of first priority does not limit the improvement to the standard level used in the calculation. This decision should be made after the setting of priorities. In the present case the high traffic volume already carried in 1964 and 1965[27] would seem to justify two-lane pavement unless funds simply cannot be allocated. In either case, the cost of further improvement, maintenance, and the reduction in operating costs will be different for roads associated with this route, and the pattern of priority indices will also be different.

Assume, for example, that the road from Ahero to Kisii, and also the unpaved section of the road from Kisii to Kamagambo, have been bitumenized to a width of two lanes. Furthermore, ten

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[27]British Road Research Laboratory, "Preliminary Note . . . ," *op. cit.*, Figure 4.

miles of the road beyond Kamagambo toward Suna have been upgraded to a Grade (4) gravel surface. In addition, there exist the desire and the funds to further facilitate the process of moving goods to market outlets by improving the quality of other road surfaces. It is appropriate to ask what new top priority road investment may be seen.

Following these assumptions and demands, a new pattern of indices was calculated. It was clear that the major priorities remained with those roads of gravel quality which passed through areas of moderate agricultural potential. The reduction in annual maintenance costs which can be expected after reconstructing these roads to bitumen surfaces was again a sufficient benefit in its own respect to justify early upgrading. Thus, the investment required to improve the 10 miles beyond Kamagambo raised to gravel quality under the top priority investment and that required to extend the bitumen portion of the road between Kisii and Sotik to at least the District boundary are the next priority investments. In order that undue importance not be put on the assumed investment desirability of upgrading <u>all</u> gravel roads, it should be pointed out that the index calculated for the Kisii District portion of the Sondu - Sotik gravel road does <u>not</u> justify an investment before several other roads' upgrading. In spite of the sharp drop in annual costs after paving, the land in this corner of Kisii District is apparently not capable of enough profitability improvement to result in a high priority index for this road.

The route which would justify a third priority rank for upgrading is discovered in the same manner as previous priorities. This route, as shown on Figure 9-2, is obviously in Kericho District between the end of two-lane pavement just south of Kericho town and a few miles beyond Bomet. In the case of this route, it is the land's extremely high potential profitability improvement that is the predominant source contributing to the resulting large priority index.

It is interesting to note that improvements to the roads included in the first two priority determinations are already under way, or are at least to a stage where requests for the necessary funds have been formally submitted.[28] In contrast to this, only the widening of the one-land bitumen section of the third priority route has been included in the published program of road development.[29] A major portion of the route remaining in this priority, between Litein and Bomet, is partially included within the improvement plan for tea roads in this area, but this inclusion is obviously coincidental.[30] This reflects one advantage

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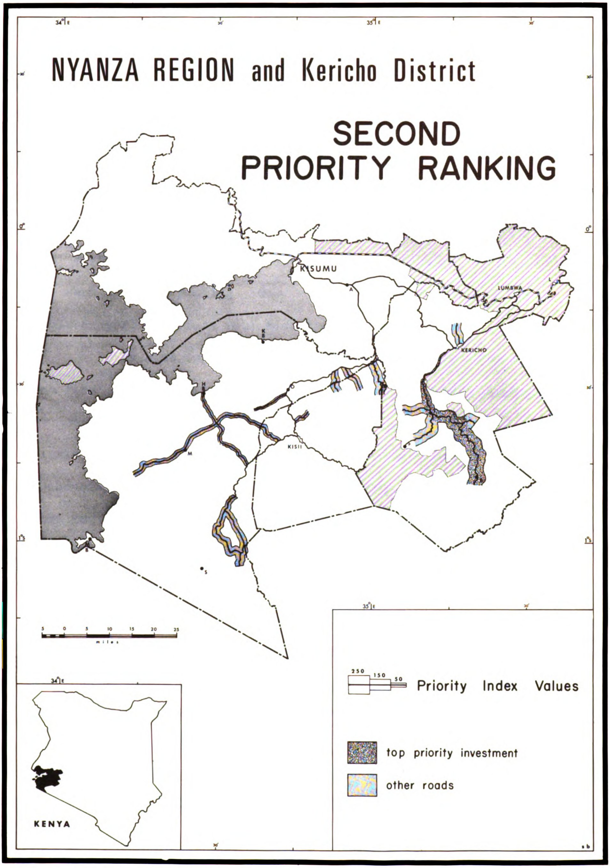
[28]Kenya, Development Plan 1966-1970, *op. cit.*, pp. 281-82.

[29]*Ibid.*, p. 283.

[30]See the maps accompanying, Edwards and Burrow, "Preliminary Report to the Permanent Secretary . . . ," *op. cit.*



NYANZA REGION and Kericho District
SECOND PRIORITY RANKING
KISUMU
LUMBWA
KERICHO
KISII
miles
KENYA
250
150
50
Priority Index Values
top priority investment
other roads

FIGURE 9- 2

of the objective determination of road investment priorities as demonstrated in the present work; projects of potentially high return are not by-passed in favor of programs of more obvious, but shorter term remuneration. It should be remembered, however, that there are a great many data limitations in the present application of this procedure. The agricultural potential might possibly have been exaggerated sufficiently to distort the real priority ranking. Only more complete data collection could support or refute this reservation.

It is also important to keep in mind the basis upon which the final determination is made. If there are reasons, economic or not, which justify road improvements through an area with little or no potential profitability improvement, the present methodology will not indicate this. The road connecting Kisii and Homa Bay, for example, would obviously be very low on the priority scale using the method outlined in this volume (see Figure 9-2), and yet it is slated for upgrading as soon as funds are available.[31] The purpose may be an attempt to encourage traffic now moving from Kisii to Kisumu entirely by land transport to return to the cheaper route using E.A.R. & H. lake services from Homa Bay to Kisumu. Even here, however, the method is useful, for it does indicate the relative level of support which can be expected from the agricul-

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[31]Kenya, Development Plan 1966-1970, op. cit., p. 283.

tural producers among whom the road passes.

Summary

In sum, the method by which an objective decision may be reached concerning road improvements in agricultural areas is based upon the costs of improving the efficiency of movement and the potential returns from the land which might be reaped if better transport existed. Annual road costs, variable from place to place, may be calculated for each road. The spatial differences of such costs will follow from a great many environmental factors as well as the variable character of the roads' surfaces at the present time. An application of the method was carried through several stages of priority determination for the roads within the study region. To proceed much further would be an injustice to the assumptions made necessary by sparse data. Nonetheless, it is clear that the method is workable and could be of great assistance in reducing the waste of sparse funds that follows from less-than-optimum investments.

PART IV

CONCLUSIONS

CHAPTER X

SUMMARY AND CONCLUSIONS

The Context and the Orientation

The method outlined in this volume offers an answer to the question: How can the decision to invest in one road project rather than another be made more rational, more realistic, and with greater empirical justification? Granted that subjective investment decisions may result in less than optimal allocation of funds, in what manner can the knowledge required for a decision based on the relevant characteristics of the region be brought together and translated into an outline for choosing the best among many alternatives? The problem is not whether to invest or not to invest. The concern here is discovering which of several investment possibilities promises the greatest returns. Decisions concerning road investments, especially investments dealing with an improvement in road quality, vis-a-vis the construction of a new road, are usually founded on essentially subjective factors. What is needed, it is believed, is an objective method for determining the priorities of road investment projects in agricultural areas.

This problem has been treated within the context offered by an "underdeveloped" country. Even aside from the possible sensitivities bruised by the term "underdeveloped," it is important that the author's concept of this word be made explicit. Underdevelopment, as used throughout this volume, does not relate in any way to the intelligence, capabilities, or character of the people living in the countries commonly so designated. Nor does the term refer to the intensity with which the land is used, in spite of the recently fashionable view that Canada, Australia, and the United States are truly underdeveloped. The concept is here used to refer to the relative position of a country along a difficult-to-define continuum of economic nature, the position being determined primarily by the <u>attitudes</u> of the dominant portion of the population toward participation in a commercial economy and the <u>acceptance</u> of the changed mode of economic behavior required by such participation. This, of course, is reflected in such trends as rising per capita income, a rising proportion of non-agricultural employment, increasing urbanization, and often a re-orientation of the political structure. It is important to the development process, then, that all possible encouragement be given to the population to break with subsistence activities and contribute to a growing national market economy.

It is clear that agriculture and transportation are among the most important facets of a country's development efforts. The majority of the population in each newly independent state in Africa are engaged in agriculture. With several notable exceptions, these countries will have to depend in large part upon revenue gained from the agricultural sector. Agricultural products, however, are an unstable source of foreign exchange because of the wide fluctuations in world supplies, world demand, and world market prices. This instability, plus the factor of an apparent long-term decline in the competitive position of most such products, has led development planners to place at least a balanced emphasis on industrial, as well as agricultural, development. Nonetheless, agricultural development will remain crucial to national development within the foreseeable future.

Because of the source of most internally generated development funds and the fluctuations in the availability of these funds, there is an added urgency to use such funds in the most efficient manner possible. It would be important that development funds not be wasted in any case, because of the tremendous need for project financing throughout the national economy of a low income country. The choice between one investment project and another, therefore, should be made on the basis of a thorough investigation of the alternatives so that the project offering the best expectation of returns may be clearly seen.

Increased transport efficiency obviously contributes to a nation's development. An operational economic specialization in a <u>regional</u> framework, in addition to the customary occupational sense, is allowed and encouraged only with low-cost movement facilities. Agricultural production appears to increase sharply in areas in which the means of transportation are improved. A more controlled marketing procedure is possible for the small farm producer when transportation of goods is frequent, rapid, and proximate to his farm. Transportation is also important in encouraging the broader outlook that is necessary for a revolution in farming (and marketing) methods, to say nothing of the contribution to national political integration. This last point, in turn, is vital to the maintenance of stability and unified effort required in countries which have few development resources.

Investment in transportation is necessary to development. Investment projects should be undertaken only in light of the returns to the total economy available from alternative projects. Decisions concerning the importance of rural roads in underdeveloped countries, therefore, should be based upon an empirically determined list of investment priorities. Commitment to such a procedure, if it is correctly conceived, will reduce the possibility of inefficient resource allocation caused by decisions founded on subjectivity.

An argument was presented in this work that the formulation of a procedure for investment priority determination is a problem that might best be considered from a geographic perspective.

Reality is complex and does not lend itself to compartmentalized analysis along the lines of academic disciplines. Geography examines reality from a spatial perspective and is distinguished from other disciplines by this approach rather than any of the specific types of subject matter studied. That few geographers have concerned themselves with economic development in this way vis-a-vis the "case study" approach and the building of world scale descriptive models does not invalidate the applicability of a spatial perspective to detailed, practical problems in development.

The Existing Pattern of Agriculture

The procedure by which the priorities can be determined for investment in agricultural roads has been discussed in detail during its application to a region in an underdeveloped country. The method described here is, in the abstract, to determine the improvement which can reasonably be made in the profitability of agricultural production and then compare the costs and advantages of improving one road rather than another with the agricultural potential of both. This is done in order to discover which roads will assist the greatest agricultural change for the least investment in facilities. Crucial to the method is treatment of these costs, returns, profitability, and so forth, as *patterns containing spatially variable functions of each economic element*.

The pattern of existing crop profitability in the study region, Nyanza Region and Kericho District in Kenya, is seen as the difference in patterns of costs per acre of production and those of value per acre. The costs to the farmer for production of the cash crops included for analysis is also divided into the cost of producing the crop on the farm and the cost of moving the crop to market. Both of these costs are variable from place to place. Transport costs are smaller for farmers located near the market centers. Furthermore, these costs will be less for farmers whose land is close to existing roads of high quality, for vehicle operating costs are lower on paved roads than on gravel roads or earth tracks. Although costs of production are also undoubtedly spatially variable, it was believed that such qualitative factors as farmer motivation and knowledge were strict deterrents to a full understanding of this variability. In any case, the non-human sources of cost variability are included in treatment of differences in value per acre of production; inclusion of these factors in both aspects of the method would multiply their true effect on the resulting patterns. Total costs of production are taken to be the sum of the uniform cost of production inputs for each crop plus the cost of moving that crop from the land on which it is grown to the major market centers.

With adequate data, the pattern of existing profitability of cash crop production could be easily obtained. Because these data are not available at the present time, it was necessary to simulate the patterns of farm income. Due to the difficulties associated with an assignment of quantitative indices to the variable quality of human inputs, it was argued that place-to-place variations in the environmental suitability for the production of each of the relevant cash crops were the over-riding factors affecting the pattern of value per acre of these crops. Using derived indices of environmental suitability and the patterns of each pertinent environmental characteristic, the spatial variation in crop value per acre was determined. Objections to the method used for this determination were answered. Because of its flexibility, both in terms of easy revision and of applicability to more detailed studies of the same nature, this method is an attractive substitute for the fully detailed data which should be gathered prior to an actual application of the total procedure.

The patterns of existing profitability, determined by subtracting the patterns of total production cost from the respective patterns of crop value per acre, showed coffee and tea to be the most profitable cash crops within the study region. Although there were areas of highly profitable farming elsewhere, these two crops, with support from pyrethrum and white potatoes, give Kisii and Kericho Districts the zones of greatest profitability of production.

The Potential Pattern of Agriculture

One of the most serious problems faced by those concerned with development when attempting to formulate a series of investment priorities is the difficulty of estimating the returns which can be expected from an investment. Even in the present volume, where immediate returns to investment are only of indirect concern, the level of future agricultural profitability is very important. Only by estimating in some consistent manner the potential return per acre from cash crop production can the potential improvement in agricultural profitability be calculated. It was argued here that a dependable, and more meaningful, approach to this problem of determining agricultural potential can be made through use of ecological regions.

The use of environmental characteristics in combination, as ecological areas, in estimating agricultural production potentialities is not common. William Allan and Colin Trapnell surveyed a good deal of Northern Rhodesia in order to classify the land devoted to African agriculture into areas of varying suitability for different crops. Allan was later able to utilize the patterns of vegetation-soil associations in determining the variable pressure of population on the land resources. A detailed survey of Southern Rhodesia during the 1950's was made explicitly to provide development planners there with the information required by them concerning the optimum agricultural use to which the land could be put. In Kenya, L. H. Brown formulated preliminary agricultural policies for the two most productive farming regions in the country. It is the report by Brown on the ecology and agricultural potential of Nyanza Province that provides the beginnings for a detailed determination of potential profitability in this region.

Some modifications of the description of ecological zones offered by Brown were made on the basis of the patterns of other environmental elements. Climatic influences in the form of potential evapotranspiration and water surplus and deficit were also used to modify this delimitation. The resulting ecological regions were found to correspond to the patterns of production for those crops which can be expected to produce well in each region.

Using the extent of each ecological region as a guide, the portion of the study region capable of supporting each cash crop was indicated. These areas of potential production were refined using the previously stated environmental growing limits. It was then possible to translate this pattern into one showing the potential levels of farming value per acre in the not-too-distant future for each cash crop. Future value per acre patterns were based on reasonable estimates of the yields per acre and prices per unit output, and on the crops' patterns of environmental suitability. The patterns of improvement in profit per acre, i.e., the difference between existing and potential profitability configurations, were then drawn. These patterns illustrate the variable gain of which each crop is capable given the proper inputs, one of these inputs being better transportation.

As was pointed out, the pressure of the population upon the land forces modification of potential production levels. Under systems of land use designed to give each farm family a moderate annual income regardless of the ecological region in which the farm is located, it was apparent that population pressure was a crucial variable in any estimate of crop production per acre. If the population per square mile exceeds the productive capacity of the land for even moderate subsistence requirements, then little dependable cash crop surplus can be expected. The greater the surplus of land per family above that required for each family's subsistence, the larger is the proportion of the total average farm acreage which may be devoted to the appropriately lucrative cash crop. A severe pressure of population on the agricultural resources was shown to be imminent throughout a large portion of the study region, even under reasonable estimates of population growth.

By combining those portions of each cash crop's potential improvement which can be expected to yield the greatest profit increase per acre for each separate square mile in the study region, the optimum pattern of potential improvement in profitability was determined. This pattern, however, does not account for population pressure. The map of profit increase per acre, adjusted for the variable demands placed on the land resources by population, was drawn as a product of a land use intensity map (reflecting population and land carrying capacity) and the absolute pattern of likely profitability improvement (reflecting costs, yields, and prices of the best crop for each unit of land). This product illustrates the place-to-place variation in the increased returns from the land which are possible in the near future given appropriate stimulus to the development.

The Pattern of Road Investment

The justification for investment in one road rather than another is based partly upon the costs of upgrading the roads' quality and the immediate benefits which will be derived by transporters from the better roads. Construction costs are variable with environmental conditions in the area through which the road passes, traffic demands, deviations from the least-cost route because of human settlement patterns, and the like. Annual maintenance costs, both before and after upgrading, are variable with the quality of road surface, the demands placed on the surface by traffic, environmental conditions, and the availability of materials required in road maintenance. Although there are many benefits, both direct and indirect, which undoubtedly result from road improvements, the difficulties of obtaining empirical measures of these benefits applicable to the region of concern here were seen as justification for restricting the direct returns from investment to a measurable element of the transport factor. This direct return was the reduction in vehicle operating costs resulting from the change in road surface.

The ratio between the incremental costs of road investment and the reduction in operating costs following this investment is the denominator of an index of relative priorities for road upgrading, the numerator, of course, being the adjusted pattern of agricultural profitability improvement. For a given level of agro-potential, the smaller the denominator, because of a better relationship between returns and costs from investment, the larger is the priority index, and vice versa.

It was found that because of the existing high traffic volume on major non-bitumen roads in Nyanza Region and Kericho District and the decrease in annual maintenance costs when a road is paved, those roads which would be improved to bitumen quality with any reasonable investment were clearly the top priority road projects in the region if even moderately high agricultural improvement is possible along their route. Of those existing roads not this near to bitumen quality, those within the high potential improvement areas of Kericho District had the next greatest justification for early investment.

The Method's Potential and its Limits

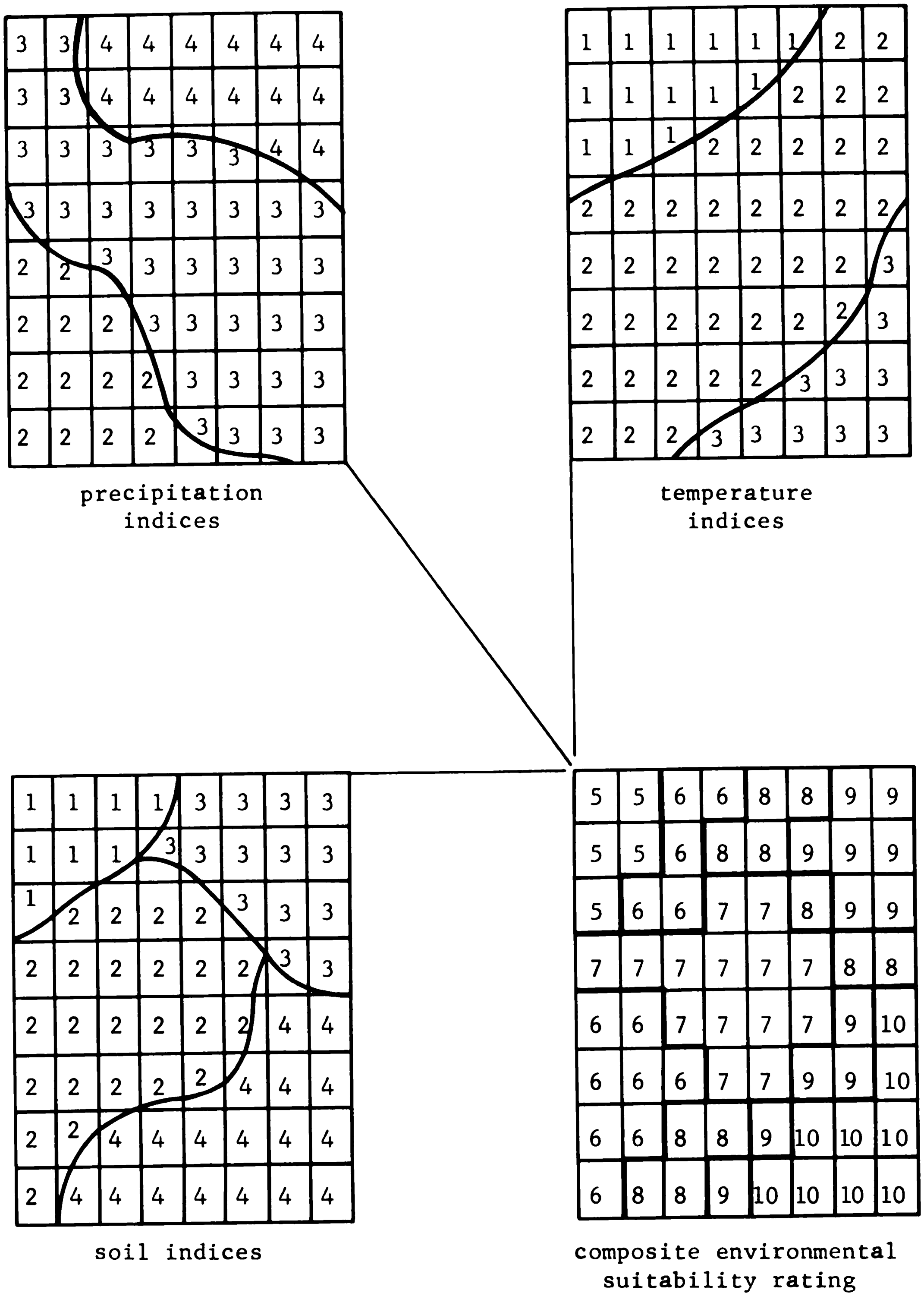
There are numerous assumptions made throughout the volume. These assumptions are almost entirely limited to the application of the proposed methodology rather than to the method itself. The assumptions should be tested thoroughly in any application which is to lead to real investment decisions. This cannot be emphasized too often. An attempt has been made to consider the implications of each assumption in as clear a manner as possible to facilitate their later examination. The procedure itself, however, stands without bolstering assumptions. Given the results of the necessary research, this model for investment priority determination within a spatial framework should be a valuable addition to development methodology.

The procedure is especially attractive because of its flexibility and inclusiveness. Although designed explicitly for road investment problems, numerous other questions are answered in the process of its application. The locations for agricultural investment which must accompany any road investment in rural areas are clearly indicated by the pattern used in the index fraction's numerator. The locations of extreme population pressure are also made plain by the land use intensity factor. The implications from this map of the real ability of the land to carry existing and projected populations are many. The origins of rural emigration, and local, small town unemployment, may be implied from this pattern as can the areas able to support much larger populations, and how much larger. The procedure may also take on a dynamic character if it can be determined that a given investment in a certain level of agricultural production will result in changes in both investment priorities after some time period. Perhaps the most attractive feature to harried development planners, in Kenya and elsewhere, should be the fact that once the data has been gathered, the updating and revision necessary to continue the model through several time periods do not require much additional data that is not already gathered under existing procedures.

This volume relates a preliminary application of a method for determining road investment priorities in agricultural areas There are many aspects which could be modified with more specialized knowledge and more complete survey data. It should make clear, however, to those interested in economic development that the spatial perspective is an important element in many of the real problems facing underdeveloped countries. It is hoped that this methodology will be of assistance in the solution of some of these problems.

APPENDICES

Appendix I The Method of Deriving Indices of Environmental Suitability for Crop Production



Appendix II   Farming System for Ecological Zones
from: L. H. Brown, "Draft Agricultural Policy: Nyanza Province," Appendix I.

Farming System for Zone I.   Star - Kikuyu - Grass Zone

(1) ½ acre. House and vegetable and banana garden
Surplus eggs poultry etc. 100/-

(2) 2½ acres. Arable Land. Production as follows -

LR.	Maize 1 ac.	Mtama or Wimbi 1 ac.	Potatoes ½ ac.
	15 bags	8 - 4 bags	20 bags

SR.	Beans or other Legume 1½ ac.	Grain 1 ac.
	6 bags	4 bags

Family requirements:- 12 bags Grams
4 bags Legumes
10 bags Potatoes

Surplus	9 bags Maize @ 30/-	= 270/-	
	2-6 bags Grain	180/-	
	2 bags Legumes @ 40/-	= 80/-	
	6 bags Potatoes @ 10/-	= 60/-	
		Shs.590/-	590/-

(3) 2½ acres. Grass (including some fodder grass)
carrying 3-3½ stock units
= 2 Adult cows & followers 2 - 2½ years
2 Adult cows produce 200 gallons surplus/annun
= 400 gallons @ 1/50 600/-
Surplus stock (calculated on 5 yr. basis with 20% loss) 250/-
Shs.850/- 850/-

(4) 1 acre. Cash crop. Either ½ ac.Coffee & ½ ac. mulch for same. 8 cwt.Coffee @ £300 per ton 1,200/-
or ½ ac. Pyrethrum: if rotated with an extra ½ ac.fodder grass this will enable another cow to be kept
Value of Pyrethrum 350/-)
Cattle Products 425/-) 775/-
or 1 ac.Tea producing 3,000 lb. green leaf per acre. 1,000/-

<u>or</u> 1 ac.Sugar Cane yielding @ 130 tons cane/cycle or 26 tons cane/year @ 30/-/ton of cane, 780/-
This also enables another cow to be kept on tops 425/- 1,205/-

(5) ½ acre Trees

<u>Total 7 acres. producing an income of Shs.2,195 - Shs.2,745/-</u>

Note: (1) Sugar cane yield above is based on recent experimental results, Coffee on actual practice. Milk surplus is based on a cow producing 500 gallons/lactation of which 100 is required for the calf & the family.

(2) Wimbi has been included as a grain crop for beer making etc; its superior feeding value in other respects would not be necessary if the family got adequate eggs, milk etc.

<u>Farming System for Zone II.</u> High Rainfall Savannah.

(1) 1½ Ac. House. Vegetables, Bananas & Cassava
Surplus products eggs etc. Cassava in some years 300/-

(2) 3½ Ac. Arable, Producing as follows -

LR.	2 Ac. Maize 20 bags	1½ Ac.Wimbi & Sorghum 10 bags
SR.	2½ Ac. Legumes 10 bags	1 Ac. Sweet potatoes 10 bags

(TOTAL 30 bags Grain: 10 bags Legumes and 10 bags roots)

Family Requirements 12 bags Grain
4 bags Legumes
6 bags roots

Surplus	18 bags Grain @ 30/-	540/-	
	6 bags Legumes @ 40/-	240/-	
	4 bags Roots @ 10/-	<u>40/-</u>	
			820/-

(3) 4½ Ac.Grass of which 1 ac. will be fodder grass.
Will keep at least 6 stock units i.e. 4 Adult animals & followers. Of the adults 2 will be cows and 2 oxen.

2 Cows producing @ 150 gallons surplus/annum 300 gallons @ 1/50 per gallon	450/-	
Surplus stock (on 5 year basis with 25% loss)	200/-	650/-

(4) 1 Ac.Cash Crop Either Sugar Cane @ 3/4 Zone I yield 800/-

or 1 Ac. of cotton	400/-	
1 Ac. Rice in a swamp	400/-	800/-

½ acre extra to allow for more grass in rotation with cash crops

(5) 1 Ac.Trees. (Planted on boundaries as shelter belts)
Value of surplus timber, token figure 100/-

Total 12 acres. Producing a Cash Income of Shs.2,470 - 2,870/-

Note: (1) In this zone it is envisaged that Cash Crops may have to be grown outside the holding in areas of swamp etc. which are particularly suitable to them.

(2) Practically no account is taken of the value of the large area of bananas possible in the homestead plot; this would almost certainly enable a greater proportion of surplus grain etc. to be sold.

Farming System for Zone III. Less favourable dry land areas.

(1) 1 Ac. House and vegetable garden.
Surplus poultry etc. 200/-

(2) 4 Ac. Arable Land producing as follows -

LR.	3 Ac. Sorghum 18 bags	1 Ac. cotton	
SR.	2 Ac. Legumes; 6 bags	1 Ac. Cotton, 600 lbs	1 Ac. Sweet Potatoes 10 bags

Family requirements	12 bags Grain		
	4 bags Legumes		
	8 bags Sweet Potatoes		

Surplus -

6 bags Grain @ 20/-	120/-	
2 " Legumes @ 40/-	80/-	
2 " Sweet Potatoes @ 10/-	20/-	230/-

(3) 6 Ac. Grass ley started with arable		
1 Ac. Fodder rotated with Cassava		
Will keep 6 cattle units (2 oxen & 2 cows)		
annum each	300/-	
Surplus stock (on 10 year basis with 40% loss)	300/-	600/-
(4) 1 Ac. Cassava rotated with Fodder grass In a good year produces 400/- extra in cash; in a bad required for food. If one year in two is good this gives a mean income per annum of		200/-
(5) Cash Crop (a) Internal Sisal Hedges, ½ ton fibre @ £80 per ton		800/-
(b) Cotton in Arable rotation		300/-
(6) 1 Ac. Trees, for fuel, windbreaks etc.		
Total 14 acres producing an income of	Shs.	2,330/-

N.B. Many families in this zone will derive additional income from fishing, which appears to affect people living up to 5 miles from the Lake Shore.

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