THE SPATIAL DIFFUSION OF AGRICULTURAL INNOVATIONS IN KISII DISTRICT, KENYA

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

RONALD D. GARST

1972

This is to certify that the

thesis entitled

The Spatial Diffusion of Agricultural Innovations in Kisii District, Kenya.

presented by

Mr. Ronald Garst

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Geography

John M. Hunter.

Major professor

Date June 2, 1972

ABSTRACT

THE SPATIAL DIFFUSION OF AGRICULTURAL INNOVATIONS IN KISII DISTRICT, KENYA

By

Ronald D. Garst

Due to the failure of the modern sector of the economy to generate sufficient employment opportunities and the rapid growth of its cities, particularly Nairobi, the Kenya government has placed greater emphasis on rural development. It is hoped that greater attention to agriculture and to the rural areas will increase the production of food, create more jobs in the rural areas and thus slow down rural to urban migration. Previous plans for employment and food production expansion based on opening new lands have been abandoned primarily because of the high cost. Instead, intensification of production on presently used land will be the focus of efforts by the Kenya government.

In order to intensify production it is necessary, of course, to change current practices and change will require the farmer to accept new techniques, technical inputs or crops, all of which can be classified as

innovations. Therefore, the study of innovation diffusion is intimately related to the problem of agricultural intensification. Geographers have generally confined their spatial diffusion research to the developed countries, to the neglect of the developing countries. A gap therefore exists in the literature concerning the developing countries.

This study is an empirical investigation of the spatial diffusion of five new crops and grade cattle in a densely populated, high agricultural potential area of Kisii District, Kenya. The innovations investigated are coffee, pyrethrum, tea, passion fruit, hybrid maize and grade cattle. The data consist of 1935 short interviews conducted in 93 different sampling areas to determine when farmers first adopted the innovations in question and 485 long interviews ascertaining socio-economic and demographic characteristics of the farmers. A total of 55 computer maps, using the SYMAP technique, were produced to depict the spatial diffusion pattern for each innovation over time. These maps show the distribution of adoption percentage levels every two years from the time of original introduction to 1970, plus a final map for 1971.

The general diffusion pattern is as follows: (1) initially low levels of adoption are found at scattered locations, (2) an outward spread at low levels of adoption occurs, (3) the emergence of peaks of higher

levels of adoption, and finally (4) the coalescence of these peaks into broad areas of high percentages of adoption. The forward edge of the diffusion wave moves very rapidly outward to encompass much of the final area of adoption in about half the time period. After the initial spread, the gradient between no adoption and the highest levels becomes progressively steeper.

Factor analysis of 57 geographic, socio-economic, demographic and innovation-measuring variables reveals little relationship between the innovation measures and the non-innovation variables as the latter primarily factor out by themselves or with the geographic variables. The principal determinant influencing the location of greatest intensity of adoption and use is the place of original introduction. Thus, the mass media communication channels and extension services are of minimal importance while person-to-person communication, as exemplified by the Personal Information Field, is the major moving force behind the spatial diffusion process. Recommendations for policy planners and suggestions for further research are also given.

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A THESIS

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

DOCTOR OF PHILOSOPHY

Department of Geography

1972

ACKNOWLEDGMENTS

The field investigation upon which this study is based was made possible by a Fulbright-Hays graduate fellowship, supplemented by a grant from the Michigan State University office of International Studies and Programs. The Institute for Development Studies, University of Nairobi, provided part of the field operation expenses. Computer costs were met in part by a grant from the National Science Foundation.

As is typical of any dissertation involving foreign field work, numerous persons were involved. Mr. Malcolm N. H. Milne, Planning Officer, Nyanza Province, provided valuable assistance in securing approval for the field investigation. Dr. E. S. Ole-Mperre and Mr. S. M. Wambua, Kisii District Agricultural Officers, were most cooperative and helpful in providing assistance while in Kisii. Numerous other government officials gave freely of their scarce time to provide background information. Dr. Joseph R. Ascroft, of the Institute for Development Studies, who was instrumental in getting the field investigation underway, assisted greatly in problems of

field sampling, questionnaire design and data compilation. My colleague on the field investigation, Miss Carolyn Barnes, endured the many physical and emotional hardships of field work with unfailing dedication and determination.

The Kisii Department of Agriculture provided three agricultural extension agents to serve as interviewers: Mr. Andrew Atone, Mr. Fred Nyagwaya and Mr. Mathew Onsomu. Without them this study would have been impossible. Mr. Timothy Ahoda, Data Processing Unit, Institute for Development Studies, supervised the data punching and preliminary computer analysis in Nairobi.

My graduate guidance committee provided greatly appreciated stimulation, advice and guidance on this dissertation. Dr. John M. Hunter, chairman of the guidance committee, sparked my interest in the problems of developing areas in an excellent seminar that eventually saw five of its participants do foreign area field work. My greatest vote of thanks goes to Dr. Hunter for his unfailing confidence in me; the value of which cannot be overestimated. Dr. Stanley D. Brunn, through his ememplary teaching, rekindled my dormant interest in the quantatitive techniques that are so evident in this dissertation. Dr. Ronald J. Horvath, through personal conversations, helped me to clarify many of my own thoughts about the diffusion process. Dr. Carl K. Eicher brought to life the role of rural development in Africa. Dr. Everett M. Rogers, a

very exciting teacher, got me more involved with innovation diffusion than either of us would have expected back in 1969. Each of these men, in his own way, has been instrumental in formulating my academic interests and this research.

Dr. Lawrence M. Sommers, Chairman of the Department of Geography, Michigan State University, helped finance my graduate program with a Graduate Assistantship, an NDEA Fellowship, a National Science Foundation Traineeship and, during the final year, a half-time position as Instructor of Geography.

Dr. Robert I. Wittick and Mr. Brian P. Holly assisted greatly with computer mapping techniques. Mr. Sherman Hollander and Mr. Mark Sullivan, respectively, are responsible for the cartography and photographic work. Their skill speaks for itself.

Each of the abovementioned people have been involved in some way with the preparation of this dissertation. However, there is one group of individuals who must go unnamed. They are the nearly 2,000 Gusii farmers who kindly provided the raw material out of which this document was produced. My hope is that the information they provided will help, in some small way, others like them by furthering our understanding of the spatial diffusion process.

My final expression of appreciation goes to my wife for persevering through two very difficult years. She accompanied me to Kenya, gave birth to our daughter while there, and after returning to East Lansing managed to complete her own Ph.D. dissertation in music as well as perform the duties of wife and mother. A lesser person could never have accomplished so much.

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INTRODUCTION

This study is an empirical investigation of the spatial diffusion process in a densely populated, high agricultural potential, African small-holder agricultural area in Kisii District of western Kenya. The principal objectives are: (1) to determine and map the spatial diffusion for coffee, pyrethrum, tea, passion fruit, grade cattle and hybrid maize; (2) to determine if the spatial diffusion pattern found in Kisii District corresponds to the pattern found in the more developed countries; (3) to determine, with the use of factor analysis, the internal structure of a series of socio-economic, demographic, locational and innovation-measuring variables; and (4) to determine via multiple regression and correlation the direction and degree of relationship between the spatial distribution of the above-mentioned variables and the spatial diffusion pattern.

In addition to the primary objectives mentioned above the following will be undertaken. First, the role of rural development in the overall economic structure of Kenya will be evaluated to determine why planners have

generally reduced their emphasis on industrialization in favor of agricultural development and why they now favor agricultural intensification over new extensive land settlement schemes. Second, the growth of the Kenya economy from 1963 to 1971 will be examined to determine the contribution of each of the major sectors toward foreign exchange earnings and employment generation. A brief examination of the agricultural sector will evaluate the role of each of the six abovementioned innovations towards the foreign exchange and employment problems. Finally, the basic objectives of the 1969-1974 Kenya Development Plan will be discussed. Third, the literature on aspatial diffusion and spatial diffusion will be reviewed and an attempt made to integrate the basic concepts of both into an explanatory model. Fourth, recommendations for policy planners and suggestions for further research will be offered.

It is normally assumed that the adoption of innovations is ipso facto beneficial to the adopter. By beneficial it is meant that the welfare of the farmer and his family is improved. However, this is not always the case. If, for example, a farmer removes a sizable portion of his land from food production and uses it for commercial crop production the overall quality of the family diet may deteriorate. Cash earned from the sale of commercial crops could be used to purchase an adequate

diet, but normally an inferior quality diet is purchased. Clearly, the adoption of commercial crops may not always lead to an improvement in living standards. However, this dissertation is concerned with the spatial diffusion of agricultural innovations and not the consequences of those innovations.

CHAPTER I

GROWTH OF THE KENYA ECONOMY: 1963 TO 1971

Introduction

An investigation of the spatial diffusion of six agricultural innovations may, at first glance, seem to be far removed from the more generalized problem of economic development. Spatial diffusion is, however, closely linked to the efforts to achieve a higher level of economic development.

Due to problems of population growth, rural to urban migration, inadequate employment generation and insufficient foreign exchange earnings the 1970-74 Kenya Development Plan has focused greater attention on rural development. The commitment of the Government of Kenya to rural development is no longer questioned. Instead, the questions revolve around the ways to most effectively improve rural levels of living. To help achieve that end the government has established a Special Rural Development Program (SRDP). Fourteen areas, representing differing ecological, agricultural potential and population density conditions were selected in which to

develop programs that will raise rural living standards with a minimum of outside capital or personnel inputs. Techniques devised for implementing change in the SRDP areas must be replicable in other parts of Kenya using only normal government staff and financial resources. Therefore, capital or personnel intensive projects will not suffice. To help develop, test and evaluate the techniques for affecting change the government invited the Institute for Development Studies of the University of Nairobi to establish an SRDP Research and Evaluation Unit (Heyer, 1969, pp. 1-5; and Kenya, 1969a, pp. 174-178).

The process by which change is accepted has both a temporal and a spatial dimension. The temporal dimension has been researched rather thoroughly, but research on the spatial dimension of change in the developing countries is lacking. Therefore, this study focuses on the spatial dimensions of change in a rural area.

The six innovations used in this study will serve as vehicles for searching out the influences on the spatial diffusion process. The underlying purpose is to investigate the processes involved rather than the geography of six innovations. For it is only by understanding the spatial diffusion process that an optimal spatial structure of a change program can be designed. Thus spatial diffusion research that seeks universals can contribute to the more efficient use of scarce developmental resources.

Population Growth and Rural to Urban Migration

Until recently East Africa has not been considered as a population problem area. Past rates of annual population increase are as follows: Tanzania 1.8 percent (1948 to 1957), Uganda 2.5 percent (1948 to 1959), and Kenya 3.1 percent (1948 to 1962). Newer figures indicate that the rate of increase has increased. Tanzania (1957 to 1967) is growing at 3.1 percent per year, Uganda (1959 to 1969) at an annual rate of 3.9 percent and Kenya (1962 to 1969) at 3.3 percent annually. Growth rates of this magnitude will cause the populations of these countries to double in 18 to 23 years (United Nations, 1971, pp. 408-409).

Annual rates of increase of this size have often made it difficult to provide sufficient food for the growing numbers of people. However, the demand for food is much easier to meet than is the demand for employment. Increased food demand first became a problem in the developing countries after World War II, so it has existed for some time, and has been met with reasonable success via the use of new technological inputs that allow greater yields and via the expansion of acreage.

There is approximately a 15-year grace period between the birth of a child and the time he enters the labor force. Thus, the current growth of the labor force is a reflection of the birth rate of 15 years ago, and

today's birth rate will determine the growth of the labor force 15 years hence. Unfortunately, an expanding body of unemployed poses a greater threat to peace and stability than does famine (Brown, 1970, pp. 121-126).

The initial thrust of development activity during the 1950's and the early 1960's was an effort to transform the economic structure of developing countries, that is, to change from a rural-agricultural economy to an urban-industrial economy. Development based on economic transformation was abandoned when it became apparent that the industrial sector would be unable to absorb adequate numbers of workers. This failure is most evident in the place that epitomizes the modern sector, the city: for it is here that high urban growth rates converge with the lack of employment generation provided by the industrial sector. Employment generation will be considered below, but first rural to urban migration will be examined.

Nairobi, for example, expanded between 1962 and 1969 at an annual rate of 9.5 percent. However, this figure includes all nationality groups; African, Asian, Arab and European. The non-African population in Nairobi actually declined by about (24 percent) 21,000 during this time period. So it seems appropriate to consider the growth of the African population as an indication of future growth trends for the city. During the time in question the African population expanded from

156,246 to 407,736, or at an annual rate of approximately 14.5 percent (Kenya, 1966a, V. III, p. 21; Kenya, 1966c, V. IV, pp. 7, 41, 58, and 70; Kenya, 1970, V. I, pp. 1 and 70).

Theoretically it is possible to slow the migration of job seekers to the urban areas by lowering wage rates and by decreasing urban amenities. This would have the dual effect of making labor an attractive alternative to machinery and would probably reduce the rural to urban migration rate. The latter might not be true, because if more jobs are offered it could in fact attract even more workers, in spite of low pay and poor amenities. Unfortunately, policies that would tend to restrict wages in any portion of the economy, particularly in urban areas, are politically impractical (Harbison, 1967, pp. 174-193).

Rural to urban migration in most developing countries has been going on for several years at a very high rate. The result is that urban areas, and in particular the largest cities, are growing at two to three times the national rate, as in Kenya. In an effort to better understand why this migration has continued unabated in spite of high urban unemployment rates, Todaro has developed a migration model that involves three basic elements. They are: (1) the urban-rural income differential, (2) the expected probability of getting

a job, and (3) the differences in urban vs. rural amenities that will effect one's "real" income.

Urban wage levels are normally several times as high as rural wages, therefore even poor odds of getting a job become favorable considering the potential income if a job is secured. Thus the key element in the Todaro model is a consideration of the probability of finding employment. The probability of getting a job during time period "t" is equal to the ratio of new modern sector employment openings in period "t" relative to the number of accumulated job seekers in the urban traditional sector at time "t" (Todaro, 1969, pp. 138-148).

The real probabilities of finding employment are not as important as perceived probabilities, for that is what primarily influences the movement of people into the city. For example, the 1964 tripartite agreement in Kenya between government, management and labor unions to increase the number of jobs by 15 percent was a failure, because it had the effect of attracting numerous new workers into the urban labor market. A few months later employee attrition, not offset by new hiring, brought the total employment back to the old levels, while total numerical unemployment increased as a result of the migration induced by the prospect of new jobs. Thus the erroneously perceived probabilities of employment were largely responsible for the increased migration (Todaro, 1969, pp. 138-148).

The migration process generally involves two steps. First, the unskilled rural worker moves into the urban area and spends a certain amount of time in the urban traditional sector. That is, he is not regularly employed in the modern wage-earning sector, but instead is either overtly unemployed, underemployed, sporadically employed, or earns a minimal existence in petty retail trade and services. The second step is the attainment of a permanent job in the modern sector (Todaro, 1969, pp. 138-148).

The urban bias in social services that attracts migrants to the city can easily be seen in Kenya. Local government operations are divided essentially into two groups, the seven municipalities consisting of those cities with over 10,000 people, and the 33 county councils that are largely responsible for services in the rest of the country. Lower levels of government, urban and area councils, are under the authority of the county councils for both budgetary and administrative matters. During the period 1964-68 the expenditures of the municipalities and the county councils were about equal, but the county councils served about 12 times as many people, with a resultant per capita expenditure of about 12 times as great. Per capita expenditures in 1968 were K£ 16 (U.S. $38.65) in the municipalities and only K£ 1.30 (U.S. $3.30) for the county councils. If social services only (education, health, housing and community development)

are considered, then the municipalities averaged about 27 times the per capita rate of expenditure for these services (Kenya, 1969, pp. 179-180).

The Employment Problem

The structural transformation view of development was based on the fact that most rich countries have only a very small portion of their labor forces in agriculture, and therefore the way to modernize was to withdraw labor from agriculture and move it into the industrial sector as rapidly as possible. A corollary reason for this action was the widespread assumption of extensive disguised unemployment in agriculture. That is, a significant portion of the labor force has a marginal product of labor that is either very low, zero, or even negative. Therefore it would be possible to remove large numbers of workers from agriculture with no decrease in agricultural output and utilize that labor in the modern sector (Kao, 1964, pp. 129-144).

This assumed redundant labor was seen as a free form of capital that needed only to be organized. The free aspect took on two forms; first, the removal of workers from agriculture would not adversely effect agricultural output (in fact, if the marginal product of labor was negative the removal of excess labor would actually increase output) and second, the excess labor could supposedly be organized at little or no cost. It

later became apparent that the removal of anymore than a few percent of the labor force would reduce the level of agricultural output, for the marginal product of labor was low, but positive (Kao, 1964, pp. 129-144).

The main problem was the gross underestimate of the time, effort and amount of resources necessary for a structural transformation of the economy to take place. It also assumes that the developing countries will be able to industrialize on a massive scale, and that the only way to improve living standards is to duplicate the economic histories of the western developed countries. The basic fact is that the poor countries of today are starting with large populations, high population growth rates and generally limited resources; problems with which most of today's industrialized countries did not have to contend (Nicholls, 1964, pp. 11-44).

The very process of transformation from a traditionally oriented economy to a modern economy seems to be a generator of unemployment. Rather than responding to supply and demand, wages increase due to government policies, trade union pressure and the desire of multinational companies to make the wages of local employees comparable to those of expatriate employees. As the rate of production increases the poorer workers are weeded out and those remaining become more experienced, skilled and effective at their jobs, so the number of workers

per unit of production decreases. Thus it is not uncommon in the less developed countries to find production increasing more than ten times the rate of employment (Eicher, et al., 1970, pp. 8-9; Harbison, 1967, pp. 174-193).

It is becoming all too obvious to planners that in the modern sector of the less developed countries, increased production per unit of investment is the goal, the same as in the more developed countries. Workers become more skilled and effective, and the investment per worker increases. Today, for example, a factory of a given level of output employs fewer people than a factory of the same output would have ten years ago. Therefore, as the modern sector of the urban economy grows in output, but not in the size of the labor force, the size of the urban traditional labor force grows. This leads to increasing numbers of shoe shine boys, petty sidewalk traders, hand-cart operators, and hangers-on at the small shop owned by family or friends.

In an effort to stem the tide of urban migration planners now are looking to the rural areas with the hope of controlling migration. In order to keep people out of the cities, they argue, it will be necessary to create more jobs in agriculture and increase rural living standards to a level where it no longer becomes profitable to try the odds for an urban job. This calls for both increased rural incomes and additional rural amenities.

Increased agricultural production can be achieved by clearing new land or by increasing the productivity of presently cultivated land. Opening new land for settlement has not been overly successful for a variety of reasons. In a country of already dense population in relation to the carrying capacity of the land, all of the good land will usually be occupied, leaving only marginal land to be opened by the settler. Most of the people who move to settlement schemes are very poor, thus are unable to make capital investments in the land, and are often short on skills. The most common result is for the government to invest much more in the settlement scheme than could ever be justified on purely economic criteria (Lewis, 1964, pp. 299-310).

Ruthenberg summarizes problems of the Kenya agricultural schemes as follows: (1) There is seldom a cash crop capable of providing sufficient income to meet expenses. (2) Unjustifiably large expenditures go to housing, feeder roads, water supplies, etc. (3) Settlers are usually either the poorest farmers, uninterested in farming, or the formerly landless who possess few management skills. (4) Economic returns are not sufficient to attract the better farmers. (5) Squatters, one group for whom the settlements were designed, often prefer to remain where they are rather than move to a new area and subject themselves to new rules. (6) The agency responsible for

the scheme often tries to do more than is technically, economically and administratively possible. (7) When settlers fail to practice good husbandry and agriculture there is rarely any consistent policy of reprimand or correction. (8) The number and quality of staff the scheme could afford is generally insufficient to meet the needs, while an adequate staff is prohibitively expensive. (9) Little or no continuity of policy is detrimental to good operations. (10) The average cost for thirteen schemes has been about K£ 312 (U.S. $800) per family, but that figure does not include the cost of Settlement Officers' salaries (likely to be the most expensive item), overhead costs of associated government units and the interest charges on the money invested (Ruthenberg, 1966, pp. 55-56).

The repeated failures of settlement schemes in other African countries such as Ghana (Miracle and Seidman, 1968, p. 2), Nigeria (Baldwin, 1957, pp. 166-171), and Tanzania (de Wilde, 1967, pp. 419-420) has led planners to abandon this method of development. The degree of success seldom justifies the level of expenditure. Given a limited amount of money it seems more expedient to spend it on intensification of presently occupied land.

Consideration will now be given specifically to the Kenya economy based on the problems of employment

generation in both rural and urban areas, and the generation of foreign exchange.

The Kenya Economy: An Overview

The purpose of this section is to examine the main sectors of the Kenya economy in order to evaluate their contribution toward reducing the problems of employment and foreign exchange. A three-fold breakdown of (1) the modern sector, with special emphasis on the role of industrialization; (2) tourism; and (3) agriculture, will be used. Discussion will also be included on the principal exports as well as the principal objectives of the 1970-74 Kenya Development Plan.

The Modern Sector

In 1964 the modern sector of the Kenya economy accounted for about 64 percent of all wage employment. The remainder consisted of employees on small-holder farms outside the settlement schemes, employees of the settlement schemes and rural non-agricultural activities. In the rural areas the distinction between wage employment and self-employment is not always clear-cut. A farm owner may work occasionally for someone else, for the government, or perhaps in a nearby town. Thus a fair number of people probably are counted twice, as wage employees and as self-employeed. Altogether there were about 4,200,000 persons in Kenya engaged in economic

activities in 1968, including those counted twice. All wage employees accounted for roughly one-fourth of that total (Kenya, 1968, pp. 119-120).

Employment (see Table 1) in the private modern sector (wage employment in privately owned enterprises) has actually been declining in recent years. Between 1965 and 1968 there was an overall decrease in employment of 3.7 percent. The decline in agricultural employment can be attributed to the transfer of ownership from the large-scale European farms to private smallholder status, with the former wage employees becoming self-employed. The steady decline in commercial employment is probably due to the departure of non-citizen Asians and Europeans. Also the departure of these high-income people and their purchasing power would have the effect of depressing this industry. The only classifications accounting for a significant increase in number of employees are manufacturing and repairs, and building and construction (Kenya, 1969, p. 121).

Had it not been for a steady rise in government employment, the overall modern sector would have declined in employment between 1965 and 1968. The public sector, which in 1968 accounted for about 36 percent of the modern sector grew by 14.9 percent between 1965 and 1968. About three-fourths of the public sector employment is accounted for the Kenya Government and local governments. When the

TABLE 1.--Employment in the "Modern" Sector, 1965-1968.

Private Sector	Number of Employees ('000)				Percent Change, 1965-68
	1965	1966	1967	1968	
Agriculture & Forest	202.4	188.1	172.7	173.0	-14.5
Mining & Quarrying	2.3	2.3	2.4	2.9	26.0
Manufacture & Repair	52.1	52.4	56.8	58.2	11.7
Building & Construction	8.7	10.3	17.4	18.1	108.0
Electricity & Water	2.5	2.7	2.8	2.7	8.0
Commerce	46.5	46.1	43.5	40.1	-13.7
Transport & Communication	12.0	14.8	18.1	18.0	50.0
Other Services	75.8	79.3	75.2	73.6	- 2.9
Total Private Sector	402.0	396.0	388.6	386.8	- 3.7
Public Sector	188.2	200.4	212.2	221.9	17.9
Total	590.2	596.4	600.8	608.7	3.0

Source: Kenya Economic Survey, 1969, pp. 120-121.

entire modern sector, both public and private, is considered, the increase in employment between 1965 and 1968 amounted to 3.2 percent, or about 1 percent per year. Considering that the modern sector is primarily urban, and that it employs only 14.5 percent of all people engaged in economic activity, the growth rates mentioned above are unimpressive. Indeed, the contribution to total employment provided by this sector is minimal (Kenya, 1969, pp. 119-122). It should be noted in examining Table 1 that while most categories showed large percentage increases in employment for the 1965-1968 period, their contribution to employment expansion is

not large due to the small base. The two categories showing the greatest decline in employment, agriculture and forestry, and commerce, were also the largest employers. Therefore employment in the private sector declined by over 1 percent per year.

Industrialization

The potential for manufacturing expansion in Kenya is limited by a small natural resource base that does not show much promise for future expansion, by a limited domestic market, and by rising unit costs that make Kenya products less competitive in the world market. There is no single natural resource in Kenya, such as petroleum, that could serve to support a major industrial complex. The national market, limited in size and purchasing power, could be expanded to include all of East Africa; but the worsening political climate between Kenya, Uganda and Tanzania precludes basing large-scale industrialization on such a market. In spite of the fact that Kenya has a vast reservoir of cheap labor the unit costs of manufactured items are high. This is due largely to lack of worker training and skill, caused by the utter newness of the factory discipline and rules. Unfortunately, the net result is a per unit-cost that matches or surpasses that of the developed countries. And considering transport costs and tariff barriers, the overseas market is quite limited (IBRD, 1963, pp. 153-154).

The Kenya government remains committed to the process of industrialization primarily because of the need for foreign exchange earnings. The country has not yet exhausted the opportunities for import substitution industries. An additional national goal is to increase the degree of processing on raw materials produced in the country and gradually move to the exportation of processed goods rather than raw materials (Kenya, 1969, pp. 304-305).

As regards the annual increase in manufacturing output, Kenya has been doing rather well. Overall manufacturing production rose from a 1964 base of 100 to 105 in 1965, to 112 in 1966, to 116 in 1967, and to 125 in 1968. The average growth was 6.2 percent per year (Kenya, 1969b, p. 83). These figures suggest that while manufacturing output is increasing enough to make it important as a factor in import substitution aimed at saving foreign exchange, it is not nearly as successful at employment generation.

The 1970-1974 Kenya Development Plan calls for an 8.9 percent annual increase in manufacturing production between 1967 and 1974. Given past performance of manufacturing output an increase of this order of magnitude does not seem unreasonable. It also calls for an annual increase of 3.7 percent in manufacturing employment, exactly the same as the 1965 to 1968 mean (Kenya, 1969, p. 314).

No mineral wealth of great consequence has been discovered in Kenya to date, nor are any great discoveries anticipated in the near future. Oil exploration that began in 1960 has almost completely been abandoned. Almost half of the mineral production is accounted for by soda ash. Salt makes up about one-fourth of the total production and gold about one-sixth. Overall, employment in mining and quarrying amounts to less than three thousand people, and in 1967 it accounted for only 1.3 percent of the total exports (IBRD, 1963, pp. 146-150; Kenya, 1969, pp. 153-156; Kenya, 1969a, pp. 93-95).

Tourism

Tourism is the fastest growing segment of the Kenya economy. In 1963 the International Bank for Reconstruction and Development mission to Kenya suggested that because of its important contribution to foreign exchange earnings, tourism be given the highest investment priority (IBRD, 1963, pp. 170-175). Importantly, the annual increase in the number of foreign visitors is currently on the order of 25 percent. The total number of foreign visitors rose from 50,000 in 1962 to 257,000 in 1968 (Kenya, 1967a, p. 66; Kenya, 1969a, p. 101). In terms of foreign exchange earnings tourism ranks third to the general categories of primary agricultural products and manufactured products. It is larger than any single agricultural or manufacturing export. In 1968

foreign exchange earnings from tourism amounted to K£ 15 million (U.S. $38 million) and is expected to increase to K£ 37 million (U.S. $95 million) in 1974. The figure for 1974 represents about 75 percent of the total income derived from tourism, the other 25 percent will go for the cost of imported goods used by the industry and repatriation of profits (Kenya, 1969, pp. 427-428).

In terms of employment the tourist industry is not important to the Kenya economy, for the current employment amounts to about 20,000 people and the projected employment for 1974 is roughly 40,000. This amounts to slightly less than 1 percent of the economically active population (Kenya, 1969a, p. 452). Thus tourism justifiably ranks very high on the investment priority list because of the foreign exchange it generates, but unfortunately the same argument cannot be used for employment generation.

Agriculture

Agriculture has been and will continue to be the major sector of the Kenya economy. In terms of export production for the earning of foreign exchange it is currently the leader. In the realm of employment generation agriculture is also the most important. Largely because of the latter reason agriculture has been given the highest priority in the allocation of financial and technical resources (IBRD, 1963, p. 63).

Agriculture's contribution to the Gross Domestic Product of Kenya is the obvious reason for its high priority position. In 1967 non-monetary agriculture made up about 21 percent of total output and in the monetary sector about 13 percent. About one-third of the GDP consisted of agricultural products and about 60 percent of the value of commodity exports are raw or processed agricultural products. Of utmost importance is the fact that about three-quarters of the population derives its livelihood from the land (Kenya, 1969, p. 191).

The following is a brief evaluation of each of the major cash crops and grade cattle treated in this dissertation in terms of the contribution to export earnings, and employment and the prospects for future growth.

Coffee, the leading export cash crop, faces at best an uncertain future. The 1962 International Coffee Agreement set export quotas for producing countries because of a tendency for world production to amount to about 130 percent of annual consumption. Therefore, in 1964 Kenya imposed a ban on further plantings of coffee trees. Old trees could be replaced and new growers could enter the market via the division of old plantings among new farmers. As will be seen later, the ban on further coffee plantings has not been enforced rigorously in

Kisii District. Fortunately, the Kenya-grown aribica coffee commands premium prices on the world market, and with a quality improvement campaign underway, it should be possible to increase export earnings while remaining within the quota (IBRD, 1963, pp. 116-120; Kenya, 1969a, p. 44).

Recently an increasing percentage of coffee production has come from small-holder plots as opposed to estates. In 1964 small-holders produced about 40 percent of the total compared to about 60 percent in 1967. This was primarily due to the breakup of European-owned estates that were convered to small-holder African agriculture. While it does not represent any significant increase in the number of Africans working on coffee production, it does show an increase in coffee-tree ownership by African farmers (Kenya, 1969, p. 70).

Tea acreage has increased in recent years and plans are to continue the expansion. In 1968 a total of about 33,000 hectares (81,500 acres) of tea was divided two-thirds on large-scale estates and one-third on small-holder farms. By 1974 about 52 percent of the total acreage should be on small farms. This amounts to a 12 percent increase in acreage on the tea estates and a 120 percent increase in small-holder acreage (Kenya, 1969, pp. 245-246).

The international price for tea fell somewhat when the British devalued the pound sterling, but increased production in Kenya caused foreign exchange earnings to increase. However, the reduction in price may discourage others from planting. Tea ranks second only to coffee on the list of major exports, with K£ 10 million (U.S. $26 million) worth exported in 1968 (Kenya, 1969b, p. 43). The Kenya Tea Development Authority does not want to expand the area of tea production but instead to intensify production in those areas where it is already grown. This will allow a reduction in the unit cost of transport and other overhead costs (Kenya, 1969, p. 246).

Expanded pyrethrum* production will probably be very dependent on two international developments. First is the great demand from the developed countries that want to discontinue the use of synthetic insecticides such as DDT. Second is the marketing of an inexpensive synthetic for pyrethrum that is acceptable to these same countries. If more countries ban the use of DDT the demand could skyrocket, but if an effective and cheap synthetic is marketed it could spell disaster to Kenya pyrethrum producers. In anticipation of future market uncertainties the Pyrethrum Marketing Board is working to increase the efficiency of production and processing,

*Pyrethrins, the extract of the pyrethrum flower, is in great demand as it is a non-toxic, biodegradable additive for insecticides.

for as prices decline that is the only way the industry can survive. New varities of pyrethrum are being developed that will yield more flowers per acre and a higher content of pyrethrins. The higher content will greatly reduce the cost of extracting the pyrethrins from the dried flowers. The higher yields and content will allow a reduction of about 40 percent in the pyrethrum area. So while exports have increased in the last year or two the Pyrethrum Marketing Board is not overly optimistic about the future, as it plans for declining prices and an uncertain market (IBRD, 1963, pp. 125-126; Kenya, 1969, p. 249; Kenya, 1969a, pp. 67-68).

In terms of foreign exchange earnings pyrethrum extract (pyrethrins) lost ground between 1966 and 1969 when the amount exported was worth K£ 2.4 million (U.S. $6.1 million) and K£ 2.2 million (U.S. $5.6 million), respectively. By 1974 the contribution of pyrethrum to foreign exchange earnings is expected to decrease by about 1/2 percent (Standard Bank, 1970, p. 2). The labor intensive nature of pyrethrum production is borne out by the fact that 75 percent of the production comes from small-scale farms (Kenya, 1969, p. 249).

Passion fruit production is concentrated in the Kisii and Sotik area, but a new area of production is opening up in Thika, north of Nairobi, where a new processing plant is under construction. In 1965 the

passion fruit industry was nearly wiped out by the brown spot disease, and only in 1970 did production reach previous levels. If the North American market opens up, production could be tripled immediately (Interview No. 5). However, in anticipation of a slowly expanding market production is not scheduled to triple until 1974. Even then the total amount of foreign exchange earned will be on the order of K£ 210,000 (U.S. $540,000), a rather small figure when compared to the other principal export crops. Almost all production will continue to be on small farms. In the Kisii area it is anticipated that passion fruit will replace pyrethrum as the relative price structure begins to favor the former (Kenya, 1969, pp. 250-251; Kenya, 1969a, p. 69, and Interview No. 4).

Maize production has increased tremendously in recent years, largely due to the introduction of hybrid varieties. In 1965, for example, some 80,000 metric tons of maize were imported from the United States, and during the first few months of 1966 another 140,000 metric tons were imported (Kenya, 1967a, p. 32). By 1968 production had increased to the point where the government, through the Maize and Produce Board, was able to export 250,000 metric tons, worth K£ 4.8 million (U.S. $12.3 million) (Kenya, 1969b, p. 65). But in order to do this the government subsidized the Maize and Produce Board about KSh.0.14 (U.S. $0.02) per kilogram. In the future the farmer will be paid less for his product as the

efficiencies brought about by the introduction of hybrid varieties lower costs. Also, more efficient bulk handling facilities will lower the cost of transporting the maize from farm to dockside by about KSh. 0.07 (U.S. $0.01) per kilogram. The amount of maise exported is expected to rise to 430,000 metric tons, wroth K£ 7.6 million (U.S. $19.5 million) by 1974. However, at that time there will be no government subsidy, thus the value to export earnings will be much greater than before. Currently most farmers grow some maize and in a few years nearly all of them will be growing hybrid varieties. Some use will have to be found for excess production. In anticipation of this, maize will increasingly be used for stockfeed (Kenya, 1969, pp. 237-238).

Approximately four-fifths of Kenya is too dry for cultivation so the government is looking to cattle as a way to intensify the utliization of this land. Of the estimated 7 to 7.5 million cattle in the country, only a small portion are being raised for commercial purposes. Most are owned by semi-nomadic herders who do not raise the animals specifically to be sold or to produce milk. Currently most of the cattle are not of a sufficient quality to be sold on either the Kenya urban or the international market. Also, they do not produce enough milk to be of great value to the owner. Today, throughout the country, efforts are underway to increase the quality of the cattle. This is done either through the

introduction of grade cattle to replace the local cattle or through a program of upgrading via artificial insemination (Kenya, 1969, pp. 251-268).

About 25 percent of the total cattle slaughterings are marketed through the Kenya Meat Commission and about half of this es exported while the remainder is sold in the urban areas. There is a ready market, both local and international, for beef, so the limitations on the growth of the industry are on the supply side. As for the dairy industry, there are two trends. One is an effort to increase the amount of milk available for the urban areas and for the Kenya Cooperative Creamery, Ltd. to process into cheese and dry milk. The other is to expand the availability of milk for consumption by the rural African population. In order to accomplish these goals grade cows are replacing the zebu cows that produce only about one-tenth as much milk. With higher production per cow the number of animals in the more densely populated areas should go down. In this way, with virtually no change in land requirements, milk could be made available to the local people (IBRD, 1963, pp. 126-132; Kenya, 1969, pp. 251-268; Kenya, 1969a, pp. 74-78).

Principal Exports

The respective roles of agriculture, manufacturing and tourism in the export economy of Kenya can be ascertained from Table 2. As far as commodity exports are

TABLE 2.--Exports of Commodities and Services, 1967 and 1974.

	Share of Total, %	
	1967	1974
Agricultural Primary Products		
Coffee	12.0	4.7
Tea	6.0	7.7
Maize	1.1	3.7
Wheat	1.2	0.8
Rice	0.1	0.3
Sisal	1.6	0.8
Cotton	0.5	0.4
Other Agricultural Products	3.8	3.2
1. Total Agricultural Products	26.4	26.7
Processed Agricultural Products		
Meat Products	2.6	1.9
Dairy Products	1.7	0.5
Canned Fruits & Vegetables	0.9	1.5
Pyrethrum Products	2.2	1.8
Wattle Products	0.7	0.3
Animal & Vegetable Oils & Fats	0.3	0.3
Other Processed Agricultural Products	1.2	1.1
2. Total Processed Agricultural Products	9.6	7.5
3. Total Primary & Processed Agricultural Products (1&2)	35.9	34.1
4. Forestry, Hunting & Forestry	0.5	0.4
5. Minerals	1.3	0.8
Other Manufactured Products		
Beverages and Tobacco	0.7	0.4
Textiles	1.8	1.5
Clothing & Footwear	1.6	2.0
Wood Products	1.0	0.9
Paper and Printing	1.7	1.5
Leather Products	0.2	0.5
Rubber Products	0.3	1.1
Chemical Products	2.8	4.3
Petroleum Products	9.0	7.0
Other Mineral Products	1.5	1.6
Metal Products & Machinery	2.3	1.6
Miscellaneous Products	0.4	0.5
6. Total "Other" Manufactured Products	23.4	22.9

TABLE 2.--Continued.

	Share of Total, %	
	1967	1974
7. Total All Manufactured Products (2+6)	33.0	30.3
8. Total Commodity Exports (1+4+5+7)	61.2	58.2
Exports of Services		
Freight and Insurance	7.4	7.3
Other Transportation	12.3	11.4
Foreign Travel (Tourism)	11.3	18.0
Other Services	7.9	5.1
9. Total Services	38.8	41.8
10. Total Exports of Commodities & Services (8+9)	100.0	100.0

Source: 1970-74 Kenya Development Plan, pp. 153 and 157.

concerned, the relationships between the various categories will remain substantially the same. Primary and processed agricultural products will continue to dominate with about 35 percent of total exports for the period 1967 to 1974. Coffee and tea will continue to dominate agricultural exports, but tea will gain and coffee will decline in relative position. Maize will climb to 3.7 percent of all exports by 1974. Manufactured products will decline slightly from 23.4 percent of total exports in 1967 to 22.9 percent in 1974. This seeming stagnation is largely due to more of the products being kept in Kenya as import substitutes. By far the biggest gain in the balance of payments account will be made by tourism. With an anticipated annual gain of 14.1 percent this category will bring in fully 18.0 of all foreign exchange in 1974, or K£ 37 million (U.S. $95 million). This compares with 9.7 percent and 7.7 percent, respectively, for coffee and tea. Another service category, simply labeled "Other transportation" is expected to bring in K£ 23.5 million (U.S. $60.2 million) in 1974 or 11.4 percent of total exports (Kenya, 1969, pp. 153-156).

Principal Objectives of the Kenya Development Plan, 1970-74

The basic objective of the 1970-74 Kenya Development Plan can be summed up in the following quote:

"
. . . rural development should not be seen as a special

programme but as the underlying strategy of the whole Plan" (Kenya, 1969, p. 2). The reasons for the emphasis on rural development are three. First, is the desire to attain a more uniform and equitable distribution of the national income between economic sectors, individuals and areas of the country. Second, by creating better living conditions, higher incomes and more employment opportunities in the rural areas it is hoped that the massive movement to the urban areas will be reduced. Third, it is recognized that the modern sector, and particularly the industrial sector, will not be able to generate sufficient employment opportunities, so efforts are now directed to the rural areas to achieve that end (Kenya, 1969a, pp. 1-4, 11-12, 15-16).

Due to its small portion of the total economy, wage employment in industry and commerce will not be a significant generator of employment, even at the highest conceivable growth rates. Therefore the Plan is geared toward the creation of self-employment opportunities in the rural areas on large-scale farms, small-holder farms and in rural non-agricultural activities.

An important goal of the Plan is free and universal primary education. But the very achievement of that goal can exacerbate problems. An urban, or at least a non-agricultural bias in education is a large cause of urban migration. Curriculum changes could do much to

lessen urban and wage employment aspirations and strengthen a rural orientation.

Rural development is more than just agricultural development. It is also the improvement of rural amenities such as health care, housing and water supplies. These improvements will not take place in the rural areas themselves during the plan period, but will be located in numerous small urban centers and what are classified as major rural centers. Efforts are being made to increase the attractiveness of major urban areas other than Nairobi and Mombasa. The principal method will involve the placing of new factories and other enterprises in designated urban growth centers to act as a stimulus to concomitant growth. Over the Plan period K£ 43 million (U.S. $111 million) will be spent on improving the secondary feeder road system to tie into the already adequate primary road network. This will help to alleviate the rural-urban disparity in living conditions.

Import substitution industries and controls on the importation of luxury items will help to keep the balance of payments deficit to a minimum. A major component of the future foreign exchange picture will be tourism, for it significantly lowers the country's dependence on foreign capital for development. To meet development needs not met by domestic savings, foreign investment will be encouraged. The government has

provided guarantees on the repatriation of profits and capital, and on compensation in the event of nationalization (Kenya, 1969, pp. 1-19).

Conclusion

The above examination of the Kenya economy should make clear the reasons why the government is turning more towards rural development rather than towards accelerated urban development. Problems engendered by urban growth are simply exacerbated by attempts to solve them by the application of resources to the urban areas. New urban jobs often increase, rather than decrease, urban unemployment as they may attract a greater number of migrants. If the ability of a city to adequately accommodate more people is increased that new-found ability is frequently overwhelmed by masses of new migrants. The shift in emphasis towards rural development is an attempt to solve some of the problems of production, employment and the provision of social amenities at their source and reduce the concentration of these problems in the cities of Kenya.

CHAPTER II

SPATIAL AND TEMPORAL DIFFUSION PROCESSES: A REVIEW AND INTEGRATION

Introduction

The purpose of this chapter is to (1) review the relevant literature on the diffusion of agricultural innovations as it pertains to social characteristics of adopters, innovation characteristics, and sources and types of information; (2) review recent spatial diffusion literature commenting specifically on the relationships between spatial and temporal diffusion; and (3) attempt to integrate the basic concepts of temporal and spatial diffusion into an explanatory model.

Temporal Diffusion

The social system in which innovation diffusion takes place is a collection of interacting and functionally differentiated units. The intensity of interaction and the distance over which it takes place are directly related to the degree of functional differentiation because each spatial unit may tend to perform functions considerably different from neighboring spatial units.

Thus, in a more modernized society individual spatial units have more functional differentiation so there will be more interaction over space. Increased functional and spatial differentiation will cause a lessening in intensity of local interactions and an increase in wide-ranging relations. In a more traditional society where each spatial unit performs the same basic functions the intensity of interaction will be most intense with those units in close propinquity and less intense with non-adjacent units. For example, in a densely populated agricultural area of 100 square miles where any single square mile is nearly identical in character to any other [square mile] there will be little need for interaction between non-adjacent units since they all perform the same basic functions. So the character of the local milieu strongly influences the process of diffusion (Timms, 1971, pp. 138-140; and Wilson and Wilson, 1945, pp. 24-44).

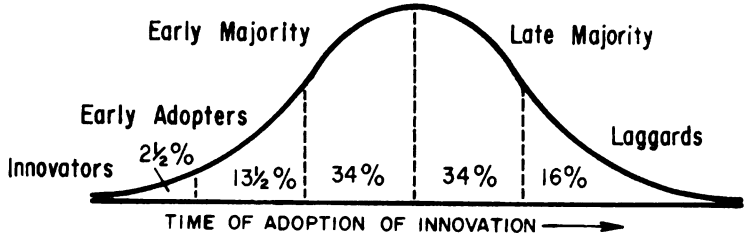
Adopter Categories

Most diffusion research on agricultural innovations starts with the readily observed notion that improved farm practices are not uniformly accepted within a population. The basic hypothesis posited is that differing personal characteristics lead some people to adopt innovations more readily than others. Considerable research has been directed toward dividing a population into groups according to the relative date of adoption as

compared to others in their social system. The most common set of adopter categories is that postulated by Rogers (Robers, 1971, pp. 183-185). They are: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards.

Figure 1

ADOPTER CATEGORIES



Through the use of field surveys and data analysis it was determined that earlier adopters in India belonged to higher casts (Bose, 1961), were more literate (Rahudkar, 1962; Savale, 1966), had more education, were of a higher social status, had larger farms, and were more wealthy (Shetty, 1966). While most studies seem to indicate that young people are more prone to adopt something new, Chaudhari and others (Chaudhari, 1967) found the opposite tendency (see also, Marsh and Coleman, 1955; Gross, 1949; Graham, 1956).

Earlier adopters have greater exposure to both interpersonal and mass media communication channels than later adopters. Thus, earlier adopters will have a wider

spatial range of personal contacts, whereas later adopters tend to have highly localized personal contact patterns. Also, earlier adopters rely more heavily on mass media communication channels than later adopters, and later adopters require more interpersonal communication before they will adopt an innovation. The communication pattern of earlier adopters is thus characterized as being more cosmopolite while the later adopter is more localite (Rogers, 1971, pp. 188-191).

Characteristics of Innovations

Simple logic would suggest that the overt characteristics of an innovation should have an influence on the rate of adoption, and indeed, such is the case. Most characteristics of innovations can be categorized according to the system suggested by Rogers. The five categories are: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability and (5) observability (Rogers, 1971, pp. 137-157).

Even though different researchers have generally agreed on the major characteristics, there is not agreement on the relative influence of each. As regards farm practices, one of the most important controversies started when Griliches (Griliches, 1957, pp. 501-522) examined regional differences in the rates of adoption and use of hybrid seed corn in the United States. He argued that the delay in the development of hybrids suitable for a

particular area and the delay of seed producers in providing seed for those areas was explained by varying profitability. Profitability here was defined as the density of the potential adoption market, costs of the innovation and marketing costs. Differences in the maximum potential rate of adoption and the rate of adoption over time were explained, in part at least, by differences in profitability between hybrid and open pollenated varieties.

Later Havens and Rogers (Havens and Rogers, 1961, pp. 409-414) stated that an innovation must be economically profitable even to be considered by most farmers, but the interaction effect (defined as the informal pressure to adopt caused when those who have adopted an innovation influence those who have not yet adopted) was the most important variable in explaining the rate of adoption over time. Every acceptance of the innovation served as a stimulus for the non-adopters to accept. They maintained that if the only variable were profitability, the rate of adoption would be as rapid as profitability could be demonstrated.

Griliches responded (Griliches, 1962, pp. 327-330) with a comment critical of the Havens and Rogers article on the interaction effect because, he claimed, rather than ignoring the interaction effect, his model was based on it, and that the differences in the average rate of

adoption between different situations could not be explained by interaction. Finally, Rogers and Havens (Rogers and Havens, 1962, pp. 330-332) wrote a rejoinder to Griliches explaining that the argument was over the relative importance of profitability versus interaction. Griliches contended that profitability was the most important factor while Rogers and Havens contended that profitability was necessary for adoption to take place at all, but interaction explained the rate of adoption from year to year, and perhaps even spatially.

Unless the innovation in question provides a significant increase in return, (Desai and Sharma, 1966, pp. 141-154), no matter what the initial cost, it will not be adopted. Desai agrees with Rogers and Havens in that regard but not with Fliegel and Kivlin, and Jones (Fliegel and Kivlin, 1962, pp. 364-370; Jones, 1967, pp. 1-34). In separate statements they contend that high-cost practices are adopted at least as fast as low-cost innovations. However, four years later Fliegel and Kivlin (Fliegel and Kivlin, 1966, pp. 197-206) reversed themselves on the basis of new evidence and maintained that cost was a factor. Cost effects the adoption rate according to the size of the farm in question primarily because the medium- and large-scale farmers perceive expensive items as investments whereas the small-scale farmer sees only the cost.

Day (Day, 1971, pp. 68-76) has further postulated a series of economic factors that will influence the adoption of new techniques. These could be subsumed under the rubric of relative advantage of the innovation in the Rogers schema. Briefly, they are as follows: (1) The magnitude of the capital investment necessary for adoption is directly related to the economic return expected. Often a gradual decline in further adoption is caused by the lowered expected profitability of additional investment because new techniques may lead to increased output which can saturate the market. (2) Uncertainty of economic return may reduce the adoption rate or the extent to which an individual firm or person adopts. Also, there may be the desire to save capital to invest in new and improved techniques as they come along, thus reducing the adoption rate for the old innovation. (3) The availability of the innovation may not be sufficient to allow all who want to adopt to do so. (4) The supply of financial capital may not be sufficient to allow all desired adoptions to take place. (5) Given the fact that managerial skills tend to be normally distributed there will be laggards who refuse to adopt until almost everyone else has done so. (6) A social system in a state of change induced disequilibrium may lead to a decline in enthusiasm for a new product or process. (7) Newer technologies may replace the old before the old is fully adopted.

Innovations that are highly compatible with existing practices tend to be adopted more rapidly (Fliegel and Kivlin, 1962, pp. 346-370). A change that requires a complete reversal from the current practice has a lower probability of adoption than one that requires only a minor change. For example, the replacement of local maize with hybrid maize requires a minimum of change on the part of the farmer and therefore hybrid maize usually has a high rate of adoption. However, if the new maize has a taste or consistency that is incompatible with established preferences it will very likely have a slow rate of adoption, have a high rate of discontinuance, or it may even be rejected outright (Rogers, 1971, pp. 117-118).

The social system through which the innovation is diffusing is related to the impact of innovation complexity (Fliegel and Kivlin, 1966, pp. 235-248). Thus, if the society is western and highly mechanized a new practice can be quite complex with no reduction in the adoption rate, but in a non-western non-mechanical society the innovation could not be very complex before the rate of adoption was reduced.

The possibility of trying an innovation on a small scale generally has the effect of improving the possibilities of adoption, but occasionally such is not the case, as Fliegel and Kivlin found no relationship

between the two (Fliegel and Kivlin, 1962, pp. 364-370). An important variable in the adoption rate is the observation of good results obtained by neighbors. Seeing others succeed with the innovation apparently is an incentive to adopt (Lindstrom, 1958, pp. 171-183). Therefore, it is logical to assume that physical objects will be more readily adopted because of their readily observed attributes. A visible physical innovation leaves little doubt as to its use or potential; however, non-material innovations, such as a new farm practice, may not have this favorable characteristic (Burnett, 1967, pp. 351-363).

An individual's overall perception of an innovation is the sum of each of these categories of innovation characteristics. Total innovation perception ranges on a continuum from highly positive to highly negative. The way an individual perceives an innovation will determine the character of the message he passes by interpersonal channels. It is hypothesized that the more positive the composite of innovation characteristics the more likely an adopter will communicate that message to a non-adopter. Thus, the overall character of an adopter's experience with an innovation is directly related to the type of message he relays via interpersonal communication channels.

Sources of Information

Information sources on innovations can be divided into two groups: (1) informal, consisting of friends and neighbors; and (2) formal, consisting of mass media sources and agents of formal organizations, such as agricultural extension services. As would be expected, farmers in the United States and Europe learn more about innovations from formal sources than do farmers in developing countries. In Iowa (Smith, 1958, pp. 51-57), for example, 21 percent of the farmers learned of hybrid seed corn from radio and farm journals, while 15 percent learned from neighbors. All formal sources, such as newspapers, agricultural extension agents, and salesmen, would push this figure towards 85 percent. By way of contrast, in India 76 percent of all farmers used informal sources to learn about farm innovations while 24 percent used formal sources. Also, in the Indian case fully 87 percent of the laggards used informal information sources, illuminating the great importance of local sources of information for the laggard group (Dasgupta, 1965, pp. 330-337).

In a related study of information sources that illustrates differential media exposure Belcher found there was no relationship, contrary to expectations, between the acceptance of Salk polio vaccine and socio-cultural factors considered important in the acceptance of farm practices. The finding that rural blacks, who

are almost always low on socio-economic measurements, exhibited a high rate of adoption of Salk polio vaccine seemed surprising. In retrospect the reasons are clear as there was widespread publicity about the vaccine using all media sources and ample time for word-of-mouth communication to be fully operative. A controversy arose about the safety and effectiveness of the Salk vaccine, but as blacks did not have a high level of newspaper readership they were less aware of the controversy and thus presented themselves for innoculations at a higher rate (Becher, 1958, pp. 158-170). Similarly, studies have revealed that among physicians information diffused via friendship networks that allow word-of-mouth communication (Coleman, 1957, pp. 253-270). This illustrates that in virtually all situations information transmitted by direct contact is a very important influence on the adoption rate, even though exposure to mass media sources might suggest otherwise.

It appears that as farmers approach a decision about whether or not to adopt an innovation they seek out more authoritative sources such as an agricultural extension agent or a neighbor with a reputation as a good farmer. The important consideration is that these more authoritative sources are all interpersonal. Thus, the location of the information source in relation to the farmer becomes important. If a perceived authoritative

information source is in close propinquity to the indecisive farmer the probability is high that he will decide to adopt. On the other hand, if an authoritative source is not readily available the skeptical farmer probably will not adopt (Mason, 1967, pp. 40-52; Rogers and Beal, 1958, pp. 329-335).

Knowledge can be divided into three types: (1) awareness, that an innovation exists; (2) "how-to" knowledge; and (3) principles knowledge. "How-to" knowledge refers to the information needed to acquire and utilize an innovation. Principles knowledge deals with the underlying principles of the innovation. Awareness knowledge must exist first, and principles knowledge is not necessary for successful adoption. That leaves "how-to" knowledge as the most important when the decision to adopt is made. Two generalizations hold as regards "how-to" knowledge. First, the more complex the innovation the more "how-to" knowledge required for a person to adopt. Second, earlier adopters require less "how-to" knowledge at the time of the adoption decision than later adopters. At the time an innovator acquires an innovation there is virtually no "how-to" knowledge available from other than mass media sources because few other local adoptions exist. And mass media sources generally will not carry a great deal of highly localized "how-to" knowledge. Later adopters secure most of their information from

interpersonal sources, which at the time they adopt would possess abundant "how-to" knowledge because of the high level of adoption nearby. Thus, the types of information sources available at different times in the adoption process provides a clue as to the degree of "how-to" knowledge required by earlier or later adopters (Rogers, 1971, pp. 106-107).

In summary, a combination of the four basic components of the diffusion process discussed here, acting in concert, appear to have a major impact on the spatial aspects of diffusion. The interlocking interrelationships are as follows: (1) Areas with a minimum of functional differentiation between spatial sub-units require little horizontal interaction, therefore short distance communication about an innovation results. (2) Earlier adopters utilize more mass media information sources whereas later adopters make more use of interpersonal communication channels. (3) Earlier adopters will adopt with a minimum of "how-to" knowledge, but later adopters require considerable "how-to" knowledge. (4) Earlier adopters therefore will adopt with very few local information sources while later adopters require a higher level of information from propinquitous sources. The nature of information channels and the type of information required thus effects the spatial diffusion process. (5) The sum total of all innovation characteristics determines the

positive or negative nature of the messages communicated about the innovation.

Spatial Diffusion

Spatial diffusion seeks to add a spatial dimension to temporal diffusion in an effort to complete the heretofore partial picture of the diffusion process. Until Hagerstrand published his initial work on spatial diffusion in 1952 (Hagerstrand, 1952), geographers generally considered only the particular item being diffused and not the process involved, nor the degree to which the item was found in an area. It was only with the introduction of quantitative techniques and behavioral interests that the rate of diffusion and the degree of intensity of occurrence could be considered. Hagerstrand argued that changes in the spatial distribution of cultural elements were not random events, but followed certain identifiable patterns. He also insisted that the principles controlling changes could be discovered. In the search for those principles it becomes necessary to use certain selected surrogates for measurement, but the surrogates are not the subject of the investigation. The subject is the process of spatial change and the influencing cultural processes. Thus, geographic research on spatial diffusion has less to do with the selected objects than with the geography of cultural behavior (see also Brown and Moore, 1969, pp. 119-157).

Spatial Diffusion Research by Non-Geographers

One of the most important forerunners of modern spatial diffusion research was Pemberton, a sociologist, who attempted to explain the effects of culture contacts on the rate of culture diffusion within a spatial framework. He found that the probability of contacts resulting in the transfer of a culture trait are highest near the center of diffusion (Pemberton, 1938, pp. 246-251).

Even earlier, in 1932, Bossard analyzed five thousand consecutive marriage licenses where one of the partners was a resident of Philadelphia to determine if there was a relationship between a person's place of residence and the residence of the marriage partner (Bossard, 1932, pp. 219-224). This study, and other marriage studies that followed (Davie, 1939, pp. 510-517; Abrams, 1943, pp. 288-294; Ellsworth, 1948, pp. 444-448; Clarke, 1952, pp. 17-22) showed that at least one-third of the couples lived within five blocks of each other. The two principle factors associated with propinquity in marriage within the urban area were distance and social segregation. All other things being equal a person was most likely to select a person living nearby for marriage. With variations in socio-economic characteristics being less within a neighborhood than between neighborhoods, it was most likely that marriage would involve a person from one's own neighborhood. However, there is a slight

tendency for an increase in marriage partner selection from greater distances simply because of the increase in the numbers of potential partners.

Rural sociologists have been concerned with neighborhood norms rather than the effects of distance in the diffusion of farm practices (see, for example, Lionberger and Hassinger, 1954, pp. 378-385; Marsh and Coleman, 1954, pp. 385-389). The basic assumption is that long-term personal associations among farmers will affect their decision making. Farmers tend to be less mobile than urban members of the population so they will therefore interact with their neighbors for an extended period of time; thus mutual expectations and norms develop that influence the behavior of the persons involved, and the individual does not act independently of these norms and expectations. Young and Coleman have suggested that neighborhoods differ in the degree to which they use advanced agricultural practices, the influence of neighbors and in the use of information sources (Young and Coleman, 1959, pp. 372-380). It is apparent that the interface between the spatial distribution of socio-economic characteristics and the spatial diffusion process has so far not been investigated to any great extent.

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have more cultural traits, experiences, values, opinions in common and contacts with each other than with more distant individuals. Thus, for persons living in a given area the mechanisms that would tend to define for them a personal contact field of limited range are as follows: (1) the probability of unintentional contact declines with distance, (2) opportunities for intentional contact declines with distance, (3) knowledge about contact opportunities declines with distance, (4) group and area homogeneity declines with distance, and (5) possibly there are norms against distant personal contacts (Young and Coleman, 1959, pp. 372-380).

Biologists and medical researchers have been involved with spatial communications through their research on the spread of disease (Rapaport, 1951, pp. 85-92; Landahl, 1953, pp. 367-383). The prime effort has been to construct a spatially structured predictive model of epidemic spread where the probability of contact depends on the distance between individuals. Every individual is considered a point in a random network with the probability that there exists a communication route between any given point in the network and any other point a function of both point density and the distance between the points. Using models, it is possible to predict the spread of a disease on the basis of its virility, point density and the probability of contact between points.

Types of Spatial Diffusion

Geographers have generally considered spatial diffusion from two viewpoints. First, differences in cultural traits from place to place and the generalized movements that have caused a particular distribution (Stanislawski, 1946, pp. 105-140; Kniffen, 1946, pp. 549-577; Deshler, 1965, p. 612). Second, the processes involved in the movement are investigated, with the item diffused being relatively unimportant.

Later, expansion diffusion will be discussed in detail, but first the other types of spatial diffusion will be briefly introduced.

Relocation Diffusion.--The most obvious example of relocation diffusion is migration, where the item being diffused actually transfers location (see, for example, Demko and Cassetti, 1970, pp. 533-539; Carol, 1971, pp. 369-373; Villeneuve, 1970, pp. 369-375). Migration research concentrates primarily on the source regions, destination regions, migration routes, incentives to migration, communication channels between source and destination regions, and the characteristics of persons migrating. Diffusion of this type does not lead to an increase in the number of items being diffused, but movement to a new set of locations.

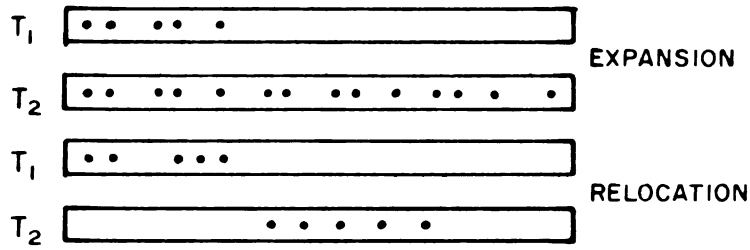
Hierarchical Diffusion.--Bowers in 1937 described the movement of inventions from city to city. Even

though his approach was descriptive rather than analytical, he was in fact dealing with diffusion downward through a central place hierarchy. In contrast to other types of spatial diffusion, straight line distance is not always the most important consideration in hierarchical diffusion. Instead the most important variable is the movement downward from the highest level in the central place hierarchy to the second highest level, and so on to the lowest level (Hagerstrand, 1966, pp. 27-43; Hudson, 1969, pp. 45-58; Brown, 1969, pp. 189-211). Most hierarchical diffusion research has been confined to one country, but Pederson gave his research an international scope by analyzing the movement of innovations between capital or leading cities of separate nations and between cities within the nations (Pederson, 1970, pp. 203-254).

Linear Diffusion.--In certain instances the item being spread by the expansion diffusion process is confined to a linear corridor, such as a highway, and cannot expand at right angles from that corridor for any appreciable distance (Colenutt, 1969, pp. 106-114). Linear diffusion can be a combination of relocation and expansion diffusion in a highly confined environment, for some items will actually move to a different location on the corridor and in other cases there is an expansion in the number of items along the corridor, as shown in Figure 2.

Figure 2

LINEAR DIFFUSION



Basic Concepts of Expansion Diffusion

Also referred to as contagious spread because of its similarity to disease diffusion, this type is the most thoroughly investigated. Hagerstrand was the first researcher to systematically investigate the way innovations spread across the landscape (Hagerstrand, 1953). The diffusion pattern is generated principally by the spread of information from one person to another by interpersonal or word-of-mouth communication channels. It is assumed that a person will adopt the innovation after learning about it, with the exact time of adoption being a function of his resistance to change. Due to the limited spatial range of personal contacts, caused by the friction of distance, a person adopting an innovation will tend to be located close to a previous adopter. Therefore, expansion diffusion causes the innovation to move gradually across the landscape, modified by differences in population density, ecological conditions,

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receptivity to innovation, infrastructural variations, and political, ethnic, linguistic and physical barriers.

Hagerstrand was able to identify four stages in the expansion diffusion process in southern Sweden (Hagerstrand, 1952). The four stages described the differences found in the process as the innovation went from introduction to saturation. Stage I, the Primary Stage, a few isolated centers of innovation acceptance develop. None of these innovation centers, or diffusion nodes, has reached more than a moderate number of adoptions. Stage II, the Diffusion Stage, there is a reduction in the relative difference between the diffusion nodes and the rest of the area as the increase in outlying areas gain on the diffusion nodes and as new diffusion nodes appear. The differences between the adopting and non-adopting areas found in the first stage are reduced as adoption has taken place to at least a limited intensity in nearly all areas. Stage III, the Condensing Stage, the innovation has spread to the entire area and all potential adopters know about it. The rate of intensification is about equal in all areas. Stage IV, the Saturation Stage, is a slow but general increase in the percent of the population that has adopted the innovation, moving toward the maximum possible.

The spatial diffusion pattern found in southern Sweden is exemplified by an outward spread at low

intensity of adoption, followed by an increase in intensity up to the maximum possible percent of adoption. Assuming that the spatial pattern of innovation diffusion is largely determined by the spatial arrangement of communication channels and modified by the physical and cultural environment, it is logical to assume that differences in these factors will produce a different spatial diffusion pattern. The analytical portion of this dissertation will investigate that proposition.

The work of Pyle points up some of the interconnections between the contagion diffusion spread and diffusion within an urban hierarchy. Because of a virtually nonexistent transportation system and no urban hierarchy, the first United States cholera epidemic of 1832 spread across the country in the contagious fashion. However, by 1849 when the second epidemic struck, the transport system and the urban hierarchy system were both better developed, thus the spread was different. First, the disease filtered down the United States urban hierarchy, beginning with the largest cities first, and later, the smaller cities adjacent to the larger cities contacted the disease after the primary centers. The 1866 epidemic moved even more clearly down the urban hierarchy (see also, Bowden, 1965; Brown, L. A., 1967, p. 783; Redlich, 1953, pp. 301-322; Witthuhn, 1968, pp. 5-20).

Personal Information Field

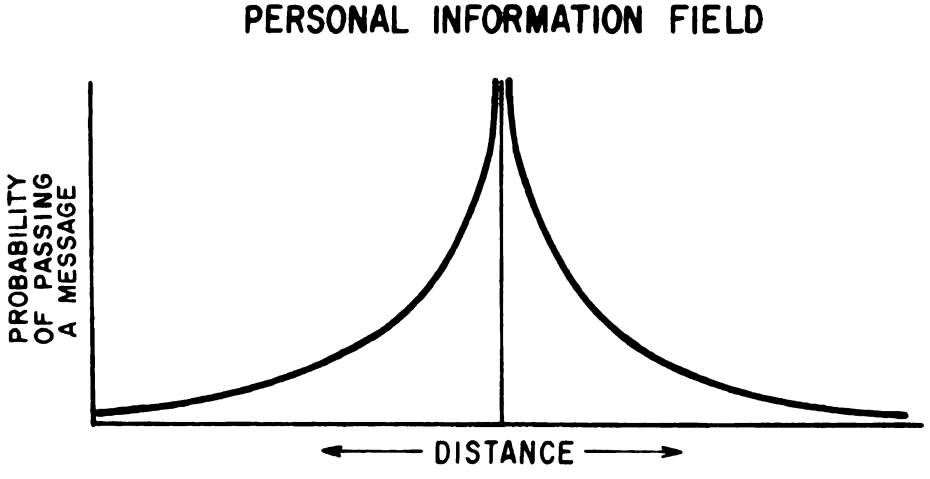
Even though early sociological researchers dealt with marriage partner selection they were in fact using the concept of the personal information field, that is, the probability of contact with another person will decline with increasing distance (Gould, 1969). Later, others began to deal more directly with the phenomenon of distance (Boalt, 1957, pp. 73-97; Miller, 1947, pp. 276-284). They have defined the probability of contact as that of a "J" shaped curve. The probability of selecting a person for contact declines with distance from the chooser, while the distance decay gradient varies with personal characteristics, the communication and transportation system available, and the density of population. The curve was described as having a "J" shape because the probability of contact increases at long distances due to the greater numbers of potential contacts resulting from the expanded area. In places with high population density the distance decay gradient is steeper as the number of propinquitous potential contacts increases.

Geographers have taken the "J" curve concept and made it omnidirectional as opposed to unidirectional. The concept has been set into a stochastic framework and labeled either the Mean Information Field (MIF) or the Personal Information Field (PIF). Mean Information Field refers to the mean probability of contact as distance

increases and does not allow for different probabilities of contact according to different personal characteristics. The Personal Information Field is more versatile because it allows for more cosmopolite persons to have a wider contact field than more localite individuals.

The Personal Information Field graphically depicts (see Figure 3) the declining probability of communication, in all directions, as distance increases. The magnitude of the distance-decay function for any given area can be determined by empirical investigation (see, for example, Hagerstrand, 1953, pp. 165-241; Marble and Nystuen, 1963, pp. 99-109; Morrill, 1963, pp. 75-84; Morrill and Pitts, 1967, pp. 401-422; Warntz, 1966, pp. 47-64).

Figure 3

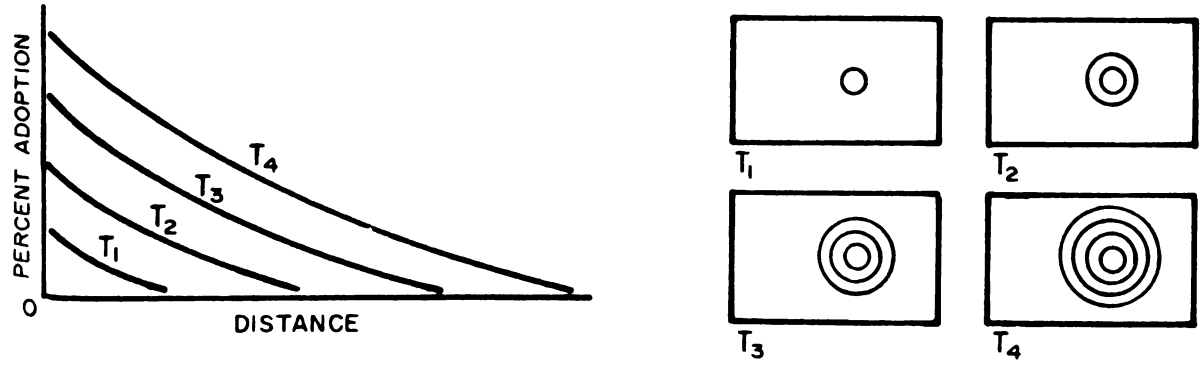


Innovation Waves

Morrill, while recognizing that the use of the wave analogy to describe human spatial phenomena is less than completely accurate, considers it an effective tool in the interpretation of the diffusion process (Morrill, 1968, pp. 1-18). The basic idea is that an innovation is introduced in some location by either chance or design, after which the diffusion process causes an outward movement in a wave-like pattern such that over a series of time periods places farther away will begin to adopt the innovation at the same time close-in places are increasing the rate of use. Depending on a variety of circumstances the impulse of the wave will diminish with increasing distance, and will eventually disappear entirely (Hagerstrand, 1952). Figure 4 illustrates how the waves decrease in intensity over increasing distance and increase in intensity with time.

Figure 4

INNOVATION WAVES I



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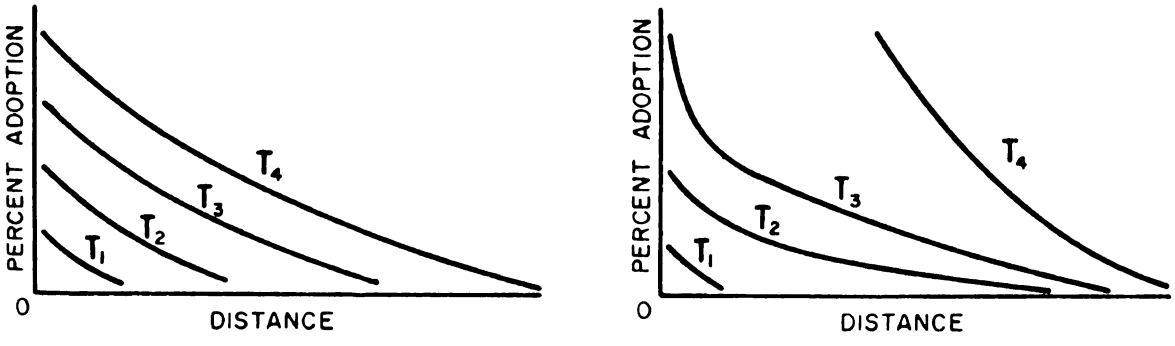
The structure of the innovation waves suggested by Morrill are based on two assumptions. First, a Mean Information Field as opposed to a Personal Information Field is assumed so that no differences in the areal extent of personal contacts are allowed for. The Morrill model of innovation waves is based on every person having the same distance-decay function of personal contact probabilities. Second, this model assumes that all individuals require the same type and amount of information before deciding to adopt. The combination of these two assumptions will produce an innovation wave that moves outward and upward (as in Figure 4) at a uniform rate.

Morrill's implicit assumptions will now be modified. First, Personal Information Fields are used to provide for a wider range of contacts for earlier adopters and a more narrow range for later adopters. Second, differential receptivity is introduced such that earlier adopters will accept an innovation with fewer tellings than later adopters. These assumptions will produce innovation waves characterized by non-uniform outward and upward movement (see Figure 5). The new wave will tend to move outward rapidly at low levels of adoption as earlier adopters throughout the entire area rapidly acquire the innovation. Then a localized intensification will occur at the locations of original introduction as the later adopters accept in those places where a

sufficient number of tellings are generated. Additional tellings are required because later adopters require more interpersonal communication and more "how-to" knowledge than earlier adopters. The conditions required by later adopters are only met in locals with a high intensity of adoption. Finally, the more intensive levels of adoption will move outward from the original areas of introduction. At this time the gradient of the forward edge of the diffusion wave will be rather steep.

Figure 5

INNOVATION WAVES II



From Morrill

Generalized from Kisii data

The "S" Shaped Growth Curve

The "S" shaped growth curve can be seen in the context of both time and space. In the temporal sense the original phase of the curve is associated with earlier adopters, the middle phase with the majority of adopters, and the final phase with the later adopters.

When an innovation is initially introduced into an area the first adopter will tell a few non-adopters about the innovation, they will tell a few others, and so on, with the result being exponential growth. When half of the potential adopters have adquired the innovation, the "S" shaped curve begins to level off because each new adopter finds it increasingly more difficult to find a non-adopter to tell about the innovation (Rogers, 1971, pp. 176-179).

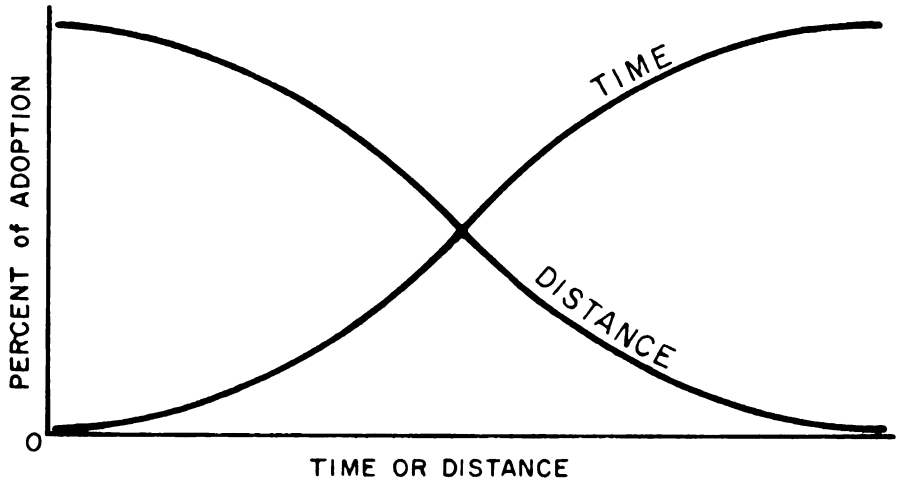
In the spatial context the first phase of the growth curve is represented by a few scattered adoptions, the second phase is a period of rapid adoption and the third phase is a slow and gradual increase leading to the maximum possible level of adoption (Brown and Cox, 1971, pp. 551-559; Dodd, 1955, pp. 392-401; Hagerstrand, 1966, pp. 27-43).

Figure 6 illustrates the "S" shaped growth curve in time and space. The curves are reversed here to allow both the time and distance zero point to be in the same location.

The percent of the population who have adopted, increases from the time of introduction. Two things happen simultaneously in the spatial sense: the percent of persons adopting at the original point of introduction increases and the percent of adoption decreases as distance from the innovation center increases.

Figure 6

"S" CURVE IN TIME AND SPACE



If the "S" shaped growth curve plotted over time represents earlier adopters in the first phase and later adopters in the final phase, then it should be logical to assume that when plotted over distance it represents a similar distribution of adopter categories. Therefore, at a long distance from the point of introduction only the earliest of adopters have acquired the innovation while at the point of introduction the latest of adopters have it. An anamolous situation is revealed here. Persons with the personal characteristics of early adopters, located far from the innovation center, will adopt the innovation at the same time as individuals near the innovation center but with the personal characteristics of late adopters. The seeming anamoly can be resolved by dividing the area into numerous sub-units. Each sub-unit, if there is a normal distribution of adopter

characteristics, will tend to operate as a separate entity, such that the movement of a diffusion wave into the sub-unit acts much like the original introduction. So the determining factor is the relationship between the location of the innovation wave and the location of the sub-unit.

As regards the spatial distribution of adopters, Cassetti has suggested the following postulates: (1) persons adopt when they are brought under the influence of previous adopters in the course of direct personal contacts, (2) potential adopters exhibit different levels of resistance to adoption, and (3) resistance to change breaks down only when there are a sufficient number of messages about the innovation (Cassetti, 1969, pp. 101-105). These postulates would suggest that those adopters at the outer edge of a diffusion wave are innovators and early adopters (i.e., persons fitting the socio-economic characteristics associated with innovators and early adopters), and those in the second phase of the growth curve are early and late majority adopters while those in the third phase are the laggards.

Simulation of Diffusion

Computer simulation models, both aspatial and spatial, have generally been of the Monte Carlo type, that is, they are constructed within a probabilistic framework and powered by a random numbers table. The

aspatial models attempt to simulate the cumulative percent of adoption of the innovation within a population, while the spatial models try to simulate the spatial distribution of adopters for a series of time periods, called generations. Both types of models have a certain heuristic value in that the very construction of the model forces the designer to consider the magnitude and direction of a variety of influences affecting the diffusion process.

An example of an aspatial computer simulation model is SINDI 1 and 2 (for Simulation of Innovation Diffusion) developed by Carroll and utilized by Hanneman (Carroll, 1969; Hanneman, 1969, pp. 36-45; Hanneman, 1969). These models incorporate a number of non-spatial constraints and influences such as communication within and between cliques in a social system, social distance, extension agent influence, cosmopolite influence, the impact of print and electronic mass media information flows, word-of-mouth message transfers, community organization meetings, individual resistance to adoption, and the cumulative influence of repeated messages. As would be expected, considering the number of constraints incorporated into the models, they can simulate the real world rather accurately.

Spatial models attempt to simulate both the cumulative rate of adoption and the distribution of

adopters over space. The Hagerstrand model II (Hagerstrand, 1953, p. 246) is based on four assumptions: (1) initially only one person in the population is informed about the innovation, (2) as soon as a person hears about the innovation he accepts, (3) information can only be received by a pair-wise telling, and (4) information is passed on only once per time interval (generation) to another person (see also, Gould, 1969, pp. 28-38; Hagerstrand, 1965, pp. 43-67; Anderson, 1970, pp. 9-14). Obviously such assumptions are unrealistic, but it does have the advantage of simplification, and later, if the assumptions appear to be inadequate they can be modified.

Modifications of the original Hagerstrand models have been made by Hagerstrand and by Pitts (Pitts, 1963, pp. 111-122). These models include new constraints and controls that make the model more sophisticaled and flexible. The most important of the variations is the inclusion of a means for deciding if there is a barrier between the teller and receiver, and if so, to what degree (Yuill, 1964; Misra, 1966, pp. 149-155). Another variation is the inclusion of a psychological resistance factor based on adopter categories. Those highly resistant to the innovation will have to be told a number of times before adopting.

Most empirical studies that have used simulation techniques have investigated agricultural innovations.

Tiedeman and Van Doren (Tiedeman and Van Doren, 1965) studied the spatial diffusion of hybrid seed corn in Iowa and performed several simulation runs, but could not compare their results with reality as they did not have information on the names and addresses of the actual adopters in the study area (Cassetti and Semple, 1969, pp. 254-259).

Bowden and Ramachandran examined the spatial diffusion of irrigation wells in eastern Colorado and southern India, respectively, and were able to simulate the process rather well (Bowden, 1965; Ramachandran, 1969). In fact Bowden's simulation was remarkably similar to the real world in terms of overall patterns, intensities, and distributions. De Temple simulated the diffusion of Harvestore Systems in northeastern Iowa, utilizing contact fields and a central place hierarchy, while Johansen simulated the diffusion of strip cropping in Wisconsin (De Temple, 1970; Johansen, 1971, pp. 671-683). It can be easily seen that the simple model used by Hagerstrand in 1952 has evolved into a series of highly complex spatial simulation models.

An Integration

This section will attempt to integrate some of the basic elements of spatial (expansion) diffusion with those of temporal diffusion. The model developed is general with no specific parameters, so it is explanatory

rather than predictive. It attempts to give an indication of the probability of adoption for a person residing in one cell in a lattice of "n" cells. There are four basic elements in the proposed model: (1) The characteristics of the adopter. The probability of adoption in any time period is minimum at the laggard end of the continuum and maximum at the innovator end. (2) Combined innovation characteristics generate a level of desirability that ranges from a maximum negative for an undesirable innovation through neutral to a maximum positive for a desirable innovation. The five characteristics of relative advantage, compatability, complexity, trialibility and observability combine to form the overall characteristics of the innovation. (3) The intensity of adoption in any lattice cell refers to the percent of potential adopters who have acquired the innovation in the time period in question. (4) The type of interpersonal knowledge generally available varies from awareness knowledge to specific "how-to" knowledge and is positively related to the intensity of adoption.

Positive innovation characteristics will cause favorable messages to be passed that will facilitate adoption. Since the messages will be passed only a short distance, due to the nature of spatial communication as exemplified by the Personal Information Field, adopters will tend to become concentrated in specific locations.

Increased adoption intensity will produce a Regional Information Field, that is defined as the probability of an individual receiving a positive (i.e., favorable) message about an innovation that contains specific "how-to" information. Around each adopter is a Personal Information Field that indicates the declining probability of the adopter passing a message to another person as distance increases. Theoretically every person in the world is a potential contact for the adopter, but after a short distance the probability of contact approaches zero. As the number of adopters in a confined area increases the combined probabilities of contact caused by numerous overlapping Personal Information Fields virtually guarantees that the non-adopter receives a message about the innovation. The number of messages successfully passed from an adopter to a non-adopter may decrease with increased adoption intensity because non-adopters become increasingly scarce, but the probability of a telling remains high. However, high contact probability may not be sufficient for the later adopters require more than one message due to their resistance to innovation. Resistance, more than unsuccessful tellings is the probable cause of the upper inflection of the "S" shaped growth curve.

Another element enters at this juncture. A higher percent of use in an area will insure a high level of

specific knowledge. Non-adopters can easily observe the innovation and have ample opportunity to discuss its use with a person using it. In this way "how-to" knowledge becomes common to all persons in an area. Thus, the three elements (innovation characteristics, adoption intensity and information type) acting together produce an intensified Regional Information Field which in turn increases the probability of adoption. Adopter characteristics will enhance the rate of adoption in the early stages and retard it in the later stages.

To summarize the model, assume that an innovation with desirable characteristics is introduced at a specific location. Those positive features will insure adoption by innovative people, and thus increase the intensity of adoption from zero to a positive value. Slowly the local level of information about the innovation intensifies and changes from general to specific. The increase in "how-to" knowledge in turn causes more adoption, forming a positive feedback loop. A positive feedback loop is defined as a return of the effects of a process (adoption) to its source (here, in the form of a more intense Regional Information Field) so as to reinforce or modify the prior condition (produce more adoption) (Carroll, 1968, p. 3; Meadows, 1972, pp. 31-33). The Regional Information Field could be referred to as spatial variation in the diffusion effect (see Rogers,

1971, pp. 161-164) or a modified version of the neighborhood effect (Hagerstrand, 1953, pp. 158-163).

Assume that each lattice cell contains approximately the same distribution of ideal adopter types. Since innovators are willing to adopt with less specific "how-to" knowledge, then one could assume that these individuals would adopt as soon as practicable. A pattern develops where a few adopters are found over a wide area. Later the intensification of adoption in certain lattice cells and the concomitant intensification of the Regional Information Field results. The reasons for the initial intensification in a given cell may be spatial variations in the advantages of the innovation, specific efforts on the part of a change agency, or random variation. The end result, however, appears to be a varying level of information from one cell to another caused by the generation of a more intense Regional Information Field in that area, resulting in variation in the spatial diffusion of adoption.

CHAPTER III

KISII DISTRICT: BIOPHYSICAL AND SOCIO-ECONOMIC BACKGROUND TO THE DIFFUSION PROCESS

Introduction

In southwestern Kenya, about 400 kilometers (250 miles) west of Nairobi and 50 kilometers (30 miles) east of Lake Victoria is Kisii District (see Figure 7), home of the Gusii. The political unit of Kisii District, which does not correspond perfectly with the physical unit of the Kisii highlands, is 2217 square kilometers (856 square miles) and in 1969 had a population of 675,000. Included is the former European settlement area, now Borabu Location, of 653 square kilometers (252 square miles) (Kenya, 1970, p. 39).

The economy is basically small-holder cash crop and subsistence agriculture. On the small farms are grown a variety of food crops, both for home consumption and sale at the 75 local markets, and cash crops, such as coffee, tea, pyrethrum, and passion fruit. These crops are the mainstay of the Kisii economy for there is little else besides agriculture to bring in money from outside the district.

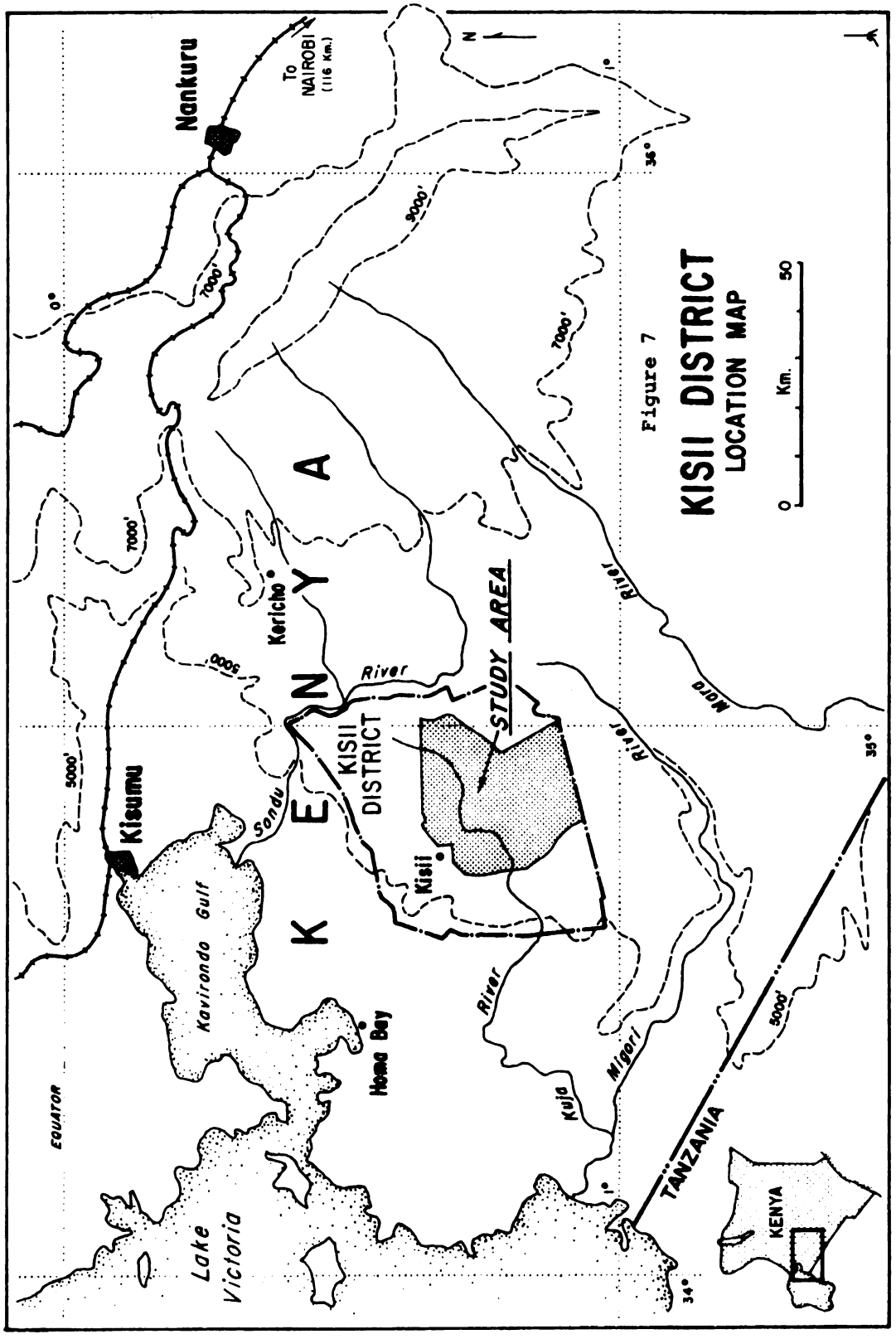

KISII DISTRICT
LOCATION MAP
Km.
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Figure 7
STUDY AREA
KISII DISTRICT
KENYA
Nankuru
To NAIROBI (116 Km.)
Kisumu
Kericho
Kisii
Homa Bay
Kavirondo Gulf
Lake Victoria
Sondu River
Migori River
Kuja River
Mara River
TANZANIA
EQUATOR
0°
1°
34°
35°
36°
N
7000'
9000'
5000'

The district ranges in elevation from about 1525 meters (5,000 feet) to over 2135 meters (7,000 feet) above sea level. The resultant cool temperatures, plus abundant rainfall, give the region an appearance that does not conform to the stereotype of East Africa (see Figures 8 and 9). The verdant green landscape is more reminiscent of what one would expect in Europe or parts of Asia. Population pressure has necessitated the utilization of nearly all suitable land for agriculture. Thus one will find very little of the original forest covering remaining. What is left is confined to small woodlots, watercourses, or along roads. Farms average about six acres in size, with the individual fields separated by hedgerows. The highlands are a dissected uplifted peneplain which now has steep sided valleys with broad flat bottoms that are frequently swampy.

Physical Geography

The physical unit of the Kisii Highlands (see Figure 10) occupies some 3250 square kilometers (1250 square miles) of territory and can be divided into two parts. The eastern two-thirds is a deeply dissected Cretaceous peneplain with steep ridges up to 2160 meters (7,200 feet) separated by deep, often flat-bottomed valleys that are occasionally chocked with swamp grass and papyrus. In this section the main ridges show a westward sloping summit level grading from the previously

Figure 8

Kisii Farmland

In the left foreground is tea and in the right foreground is a passion fruit vine. The light-colored fields in the middleground are planted to pyrethrum. In the background is flat-topped Itumbe Hill, 2,075 meters (6,800 feet elevation, a remnant of the Cretaceous dissected peneplain.

Figure 9

Kisii Hillside

Located near Keroka, this area has over 575 persons per square kilometer (1,500 per square mile). Farms seldom have over one piece of land and extend from the bottom of the hill to the top. Hybrid maize and tea are the main crops.

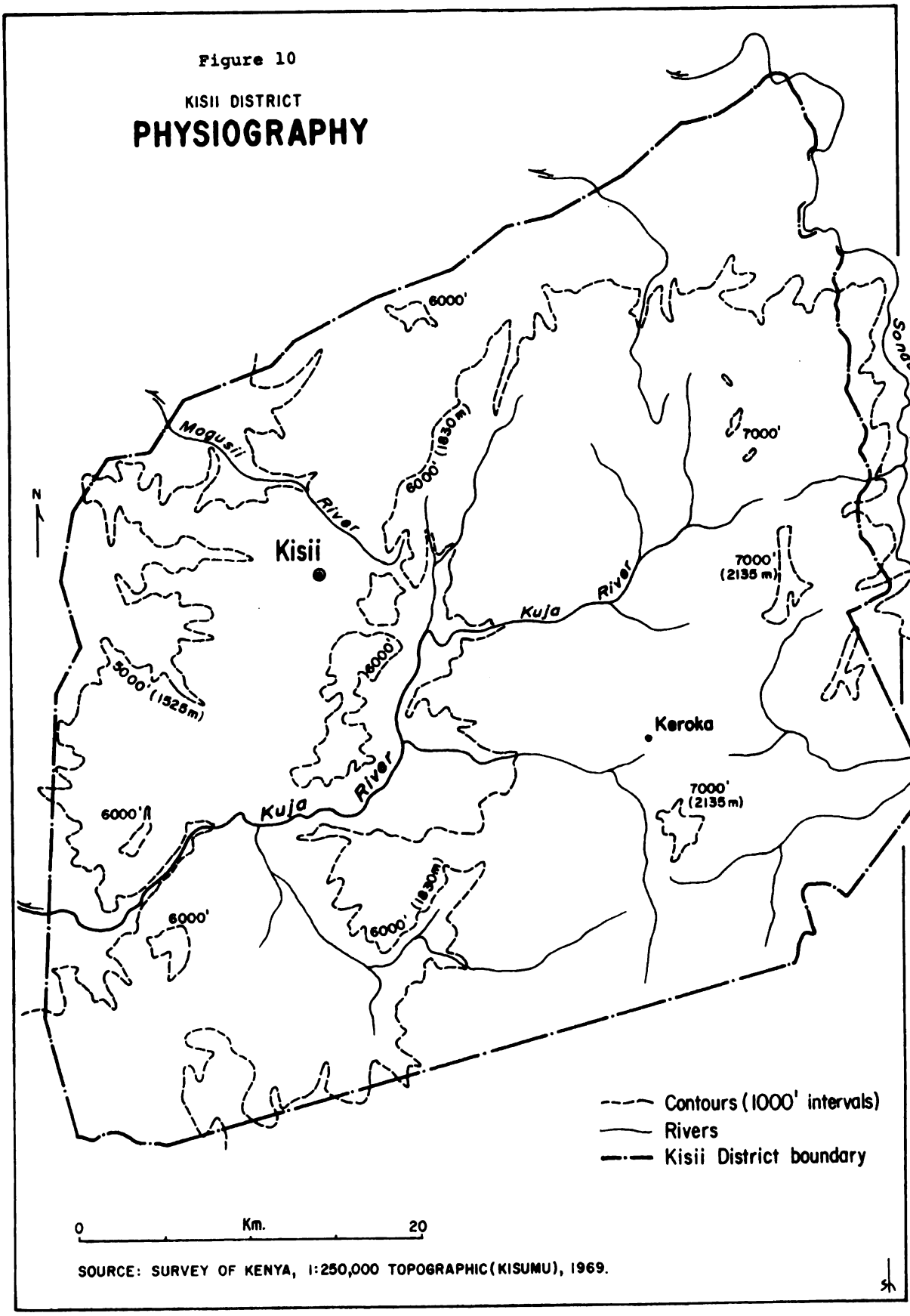


Figure 10
KISII DISTRICT
PHYSIOGRAPHY
Kisii
Keroka
Mogusii River
Kuja River
Sondu River
6000'
6000' (1830m)
7000'
7000' (2135 m)
5000' (1528m)
N
Contours (1000' intervals)
Rivers
Kisii District boundary
0
Km.
20
SOURCE: SURVEY OF KENYA, 1:250,000 TOPOGRAPHIC(KISUMU), 1969.

mentioned maximum of 2160 meters (7,200 feet) in the east to 1950 meters (6,400 feet) in the west. These ridge tops probably represent the remains of an ancient tilted peneplain. The western one-third is lower and more gently undulating country of a sub-Miocene peneplain (Kenya, 1952, pp. 4-5).

There are three primary rock systems that make up the Kisii highlands. They are the Nyanzan System, the Kavirondian System and the Bukoban System. The rocks of the Pre-Cambrian Nyanzan System occur mainly in the western portion of the area. Acid volcanic lava material makes up by far the largest portion of the system, along with a few unweathered outcrops of basalt. The Pre-Cambrian Kavirondian System, made up of massive boulder conglomerates with subordinate sedimentary materials is well developed in several localities in the west-central part of the highlands. Their angular unconformity with the underlying Nyanzan rocks is manifest by strong variations of dip and strike. The thickness of the Kavirondian rocks is unknown but it appears to be greater in the north, where it is estimated to be 1500 meters (5,000 feet) or more thick. In the south the thickness is not more than 1050 meters (3,500 feet).

Most of the district is overlain by the Bukoban System, Kisii Series. Some 1950 square kilometers (about 750 square miles) of the eastern portion of the highlands

is built up of the Kisii Series, a variation of the Bukoban System found in Uganda and Tanzania, which consists of almost flat-lying basalts, quartzites and lavas.

Pleistocene deposits are all of a superficial nature and nowhere do they attain any great thickness. The composition of the material is sparse terrace gravels, lateritic ironstone cappings, semi-consolidated river alluvium, quartz rubble, recent river alluvium and swamp deposits. Many of the valleys of the Kisii highlands are extremely steep-sided but have wide, flat-bottoms filled with decomposed vegetation and silt. The swamp vegetation effectively reduces the speed of the streams and thus assists in arresting erosion (Kenya, 1952, pp. 6-36).

A general east to west drainage pattern of the Kisii highlands is controlled by the westward slope of the ancient tilted peneplain into which the river system is embedded. Most rivers are still actively down-cutting as evidenced, for example, by the rapids that appear in several places on the Kuja River. There is also active cutting back in the headwater areas of most streams. Most streams in the northern part of the district, when debouching from the highlands, swing to a general north-westerly direction towards the Kavirondo Gulf. After leaving the highlands the Kuja River turns south-westward toward Lake Victoria and meanders sluggishly over the gently sloping plains of Luo country.

The drainage of the Kisii highlands is accomplished by three principal river systems: the Sondu River, the Mogusi River, the Kuja (Gucha) River, and their respective tributaries. The drainage of the whole highland area eventually flows into Lake Victoria. The Sondu River, and one of its principal tributaries, the Kibsonoi River, drain much of extreme northeastern and eastern Kisii District. The Kibsonoi is primarily outside the district but its small tributaries reach into the district. The Mogusii, the smallest of the three rivers, and a tributary of the Awach Tende River, drains approximately 20 percent of the northwest portion of the district. Most of central and southern Kisii District is drained by the Kuja River and its minor tributaries; while the extreme southern edge of the district is tapped by a major tributary of the Kuja, the Migori River (Kenya, 1952, pp. 4-5).

Climate

Temperature in an equatorial region such as Kisii District is largely a matter of elevation, whether it is the wet or dry season, and the time of day. The mean daytime temperature in Kisii town is 28.9 degrees C. (84 degrees F.) while the mean night temperature is 12.8 degrees C. (55 degrees F.). The highest temperatures of the year occur during the months of January, February and March; the latter part of the dry season before the long rains. No temperature records are available for any

place in the district outside of Kisii town, and even there the records are scanty. But due to elevation differences it can be assumed that Keroka, at 2040 meters (6,800 feet) above sea level, will average about 2.8 degrees C. (5 degrees F.) cooler (Kenya, 1970b, map).

Precipitation is distributed throughout the year so that no month receives less than 6.4 cm. (2.5 inches). As the rainfall diagram for the Kisii Seed Farm, located at the edge of Kisii town, indicates, there are two distinct wet periods (Figure 11). March, April and May comprise the so-called long rains. July forms a reasonably well-defined break before the short rains of August and September. Following that period is a rather steady dimunition of rainfall from October to January. The amounts of rain falling in a given month will vary within the district, but the pattern of seasonality is everywhere the same.

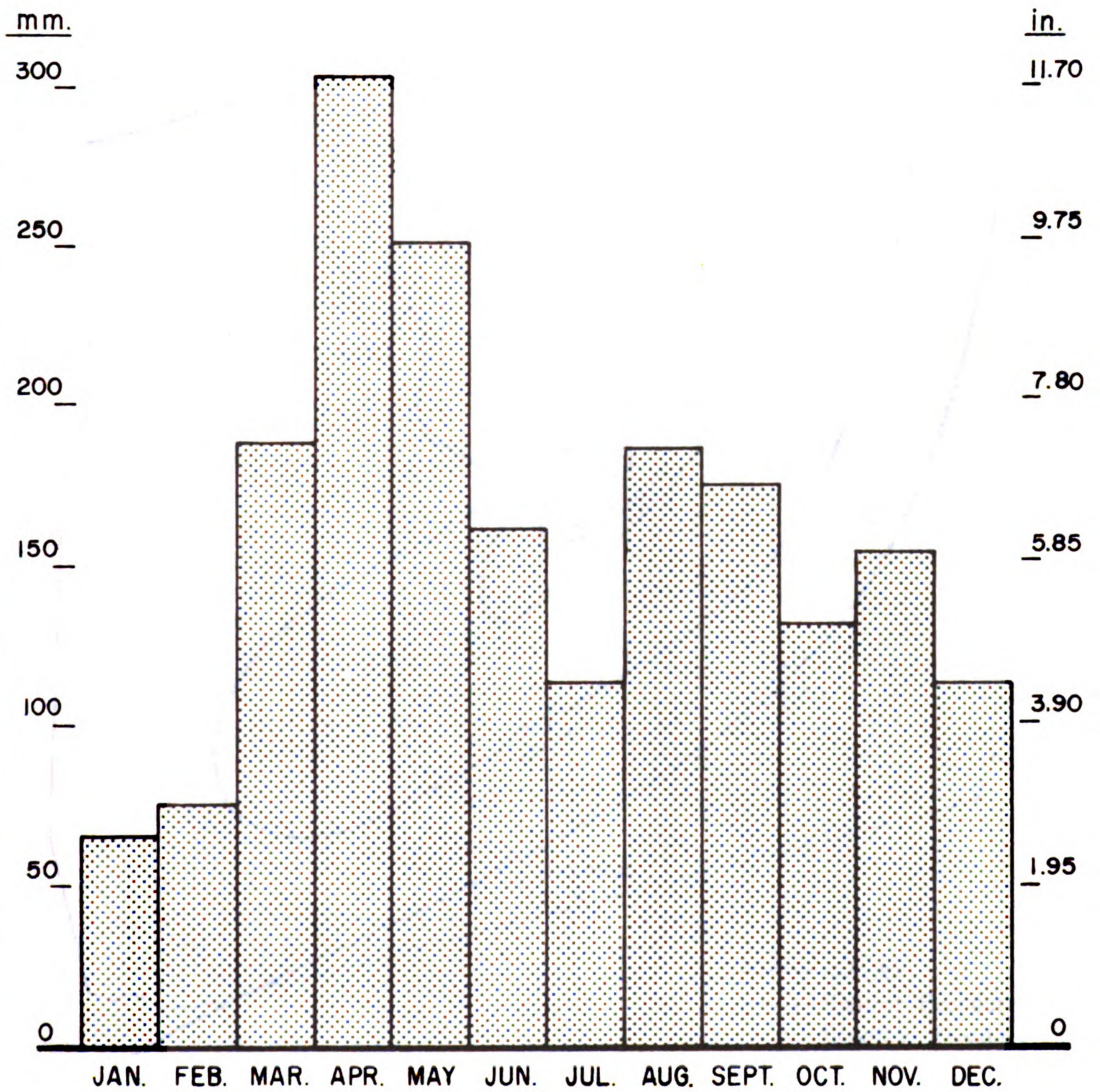
The distribution of precipitation (Figure 12) within the district corresponds very roughly with the occurrence of the highest elevations. The highest rainfall stations are found at about 2000 meters (6,000 feet), at the western edge of the highest section of the district. This is due, in part, to the moisture-laden winds coming from Lake Victoria. Most of the central portion of the district receives in excess of 160 cm. (70 inches) annually. Only the extreme northern and southern portions

Figure 11

ANNUAL PRECIPITATION

KISII SEED FARM

(ANNUAL RAINFALL 73 inches)

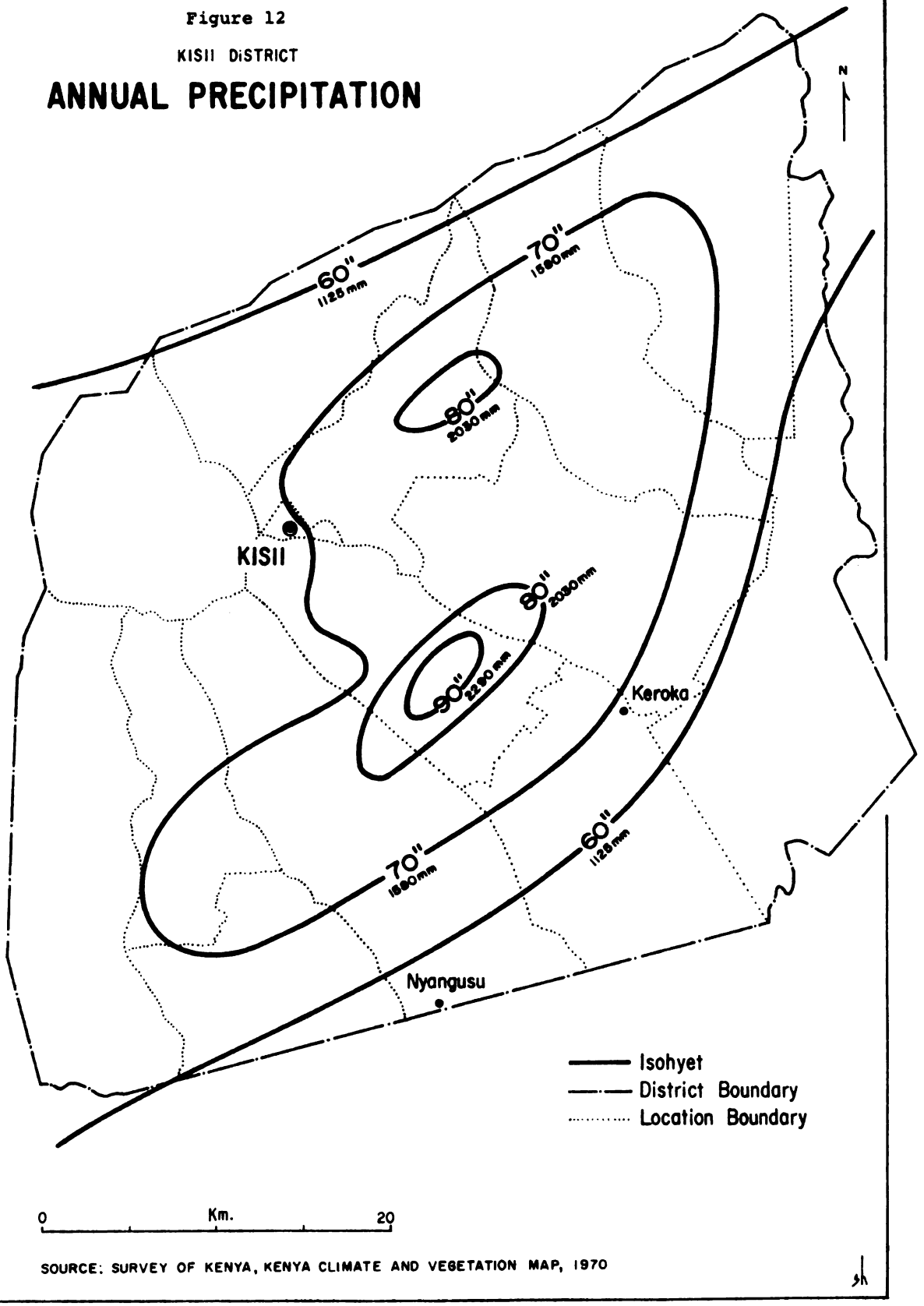


SOURCE: SURVEY OF KENYA, KENYA CLIMATE AND VEGETATION MAP, 1970

Figure 12

KISII DISTRICT

ANNUAL PRECIPITATION



SOURCE: SURVEY OF KENYA, KENYA CLIMATE AND VEGETATION MAP, 1970

of the district receive less than 150 cm. (60 inches) annually.

The predominant influence on the seasonal distribution of rainfall in Kisii District are the two main wind systems; the northeast and the southeast trades. The passage of the intertropical front over the district coincides with the wet seasons. Kisii District has an added advantage in being close to Lake Victoria, for when the prevailing wind is from the southwest it has the opportunity to pick up moisture from the lake which is subsequently received by the highlands (Hichman, 1960, pp. 6-7).

Vegetation and Soils

Due to population pressure and the resultant intense cultivation Kisii long ago lost its original natural vegetation. Nyangweta Forest, in the southern part of South Mugirango Location, indicates that the original vegetative cover was a moist montane forest. Black wattle, along with some cypress and eucalyptus, can be found along watercourses, roads, and in scattered woodlots. The 2000 meter (6,000 feet) contour is the rough dividing line between the highland Kikuyu grass zone and the lowland Star grass zone. Both of these grasses are indicative of good soils, adequate rainfall and moderate temperatures. Of the two zones, the Kikuyu grass area offers the greater potential; not because of the grass,

but due to the coincidence with the better soils and generally heavier rainfall. The Star grass zone, due to its lower elevation, is marginal for pyrethrum and tea but completely adequate for coffee, maize and bananas (Uchendu, 1969, pp. 7-8).

Unfortunately, no detailed soil survey has been undertaken in Kisii District, so only gross generalizations can be made. Three soil types have been identified, each divided by one of the major ridge formations of the district. First are the Kisii Red Loams that are underlain by red loam sub-soils of inferior quality, which occupy most of Borabu Location and parts of the rest of the district slightly to the west of the ridge that generally runs north from Keroka towards Sondu, just north of the northern edge of Kisii District. The second type is the Kisii Highlands Loam, found over much of the district. Two distinct sub-types, dependent on slope, can be distinguished. In the flat valley bottoms the soil is reddish brown to red and is quite deep due to deposition. On the hillsides and hilltops the soil is much more shallow and stoney, with an occasional rock outcrop interspersed. The third soil type, found largely in the lower western part of the district, is the Kisii Savannah Loam. A very rough location guide would be west of the main road entering Kisii from the north, going through Kisii town and then south through Ogembo to

Nayngusu. This soil is usually shallow and variable in color from reddish-brown to gray. Rock outcrops are common, erosion can be severe, and runoff is quick. The best agriculture is confined to pockets of deep soil on the valley bottoms (Uchendu, 1969, pp. 5-6). There is no relationship between the land-use and land-ownership patterns among the different soil types. Population density, however, is related to rainfall and the former settlement area.

The Population of Kisii District

By far the most striking characteristic of Kisii District is the number of people residing there. Within Kenya this district has the second highest level of population density and is growing considerably faster than the country as a whole. The following table gives the estimated annual growth rates from 1900 to 1948 and the calculated growth rates from 1948 to 1969.

TABLE 3.--Kisii District, Population Growth Rates.

1900-1930	0.5	percent	annually	(estimate)
1930-1940	1.2	"	"	"
1940-1948	3.7	"	"	"
1948-1962	5.7	"	"	(author's calculations based on census data)
1962-1969	3.6	"	"	" "

Source: Uchendu, 1969, p. 12; Kenya, 1966, p. 20; and Kenya, 1970, p. 39.

The estimated annual growth rates from 1900 to 1948 seem completely plausible, but the rate of 5.7 percent annually is open to question. If one can assume that the 1962 census is the more accurate, then it appears that the 1948 census undercounted the Gusii people. The more current growth rate of 3.6 percent annually makes Kisii District one of the fastest growing places in Kenya, if not in Africa. Such a growth rate will cause the population to double in twenty years.

But growth rates alone do not present the total picture. Another facet of the population mosaic is age structure. Two main factors emerge; one is the size of the dependent population and the other is an indication of future growth. Table 4 gives a breakdown of the percent of the population in each age group. Fully 55.2 percent of the people are age 14 or under. The dependent population, that is, the percent of the population under 15 years and over 60 years old, is 58.7 percent. Thus the 41.7 percent in the productive years must support the remainder of the population. And not all of the people in the so-called productive years are contributing to output. The size of the population under age 15 indicates a possible increase in the overall growth rate in the near future as these children reach reproductive age.

TABLE 4.--Kisii District, Percent of Population by Age Group.

Age	Male	Female	Cumulative (Male and Female)
0- 4	21.4	20.7	21.0
5- 9	18.9	18.5	39.7
10-14	16.0	15.0	55.2
15-19	11.1	10.5	66.0
20-24	7.2	7.5	73.4
25-29	5.3	6.7	79.4
30-39	7.9	9.2	88.0
40-49	5.2	5.0	93.1
50-59	3.1	3.1	96.2
60 & over	3.7	3.5	99.8*

*Does not total 100% due to rounding.

Source: Kenya, 1970, p. 121.

As one would expect, the distribution of population within Kisii District is far from uniform. In 1969 the mean density for the whole district was 304 per square kilometer (788 per square mile). The range was from 57 per square kilometer (148 per square mile) in Matutu Sub-location of Borabu Location (the former Settlement Area) to 557 per square kilometer (1442 per square mile) in Mwogeto Sub-location of Kitutu Central Location. Table 5 shows the distribution of population by locations for the 1948, 1962 and 1969 censuses. In 1961 Kisii became a district by itself and most of the locations were divided into two or three sections. Borabu Location was added after the 1962 census. Figure 13 shows the distribution of population density by sub-location in 1969.

TABLE 5.--Kisii District, Population, 1948-1962-1969.

	1948	1962	1969	Area, Km^2	1969 Density Km^2
Kisii District	237,800	519,418	675,041	2217	304
Locations					
West Kitutu		31,162	44,796	131	342
Central Kitutu	64,951	62,553	64,368	136	472
East Kitutu		64,118	82,081	198	415
North Mugirango	44,814	50,239	57,825	208	278
West Mugirango		65,255	70,827	193	367
Nyaribari Chache	42,261	34,911	43,192	130	331
Nyaribari Masaba		38,421	50,589	170	297
Wanjare	17,521	27,850	37,446	134	279
Majoge Chache	25,968	55,973	31,577	104	303
Majoge Borabu			36,257	113	320
South Mugirango	19,066	36,672	48,220	201	240
Bassi	21,712	47,464	80,403	242	332
Borabu			21,380	253	85
Kisii Town	1,507	4,530	6,080	3	2,156

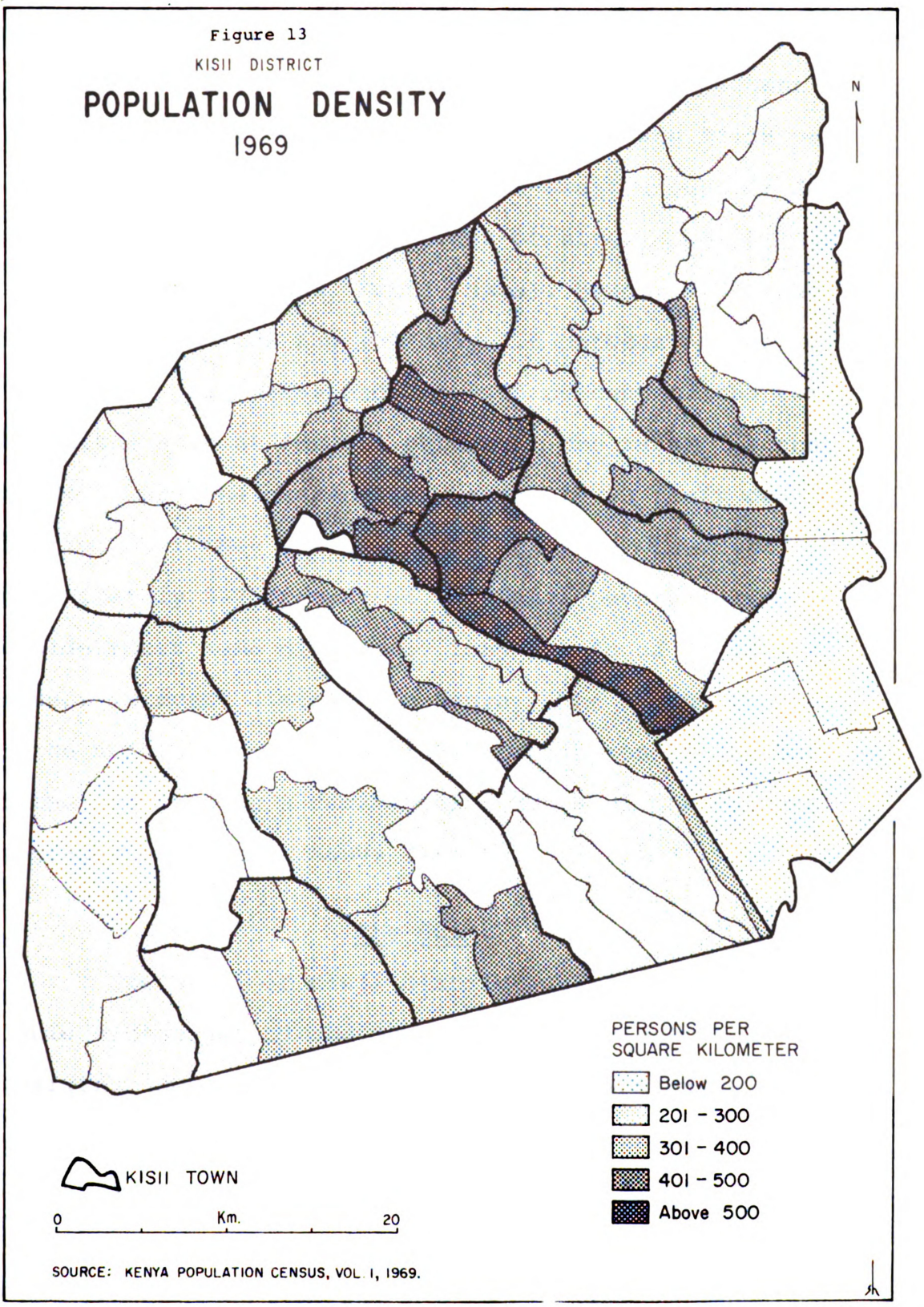
Source: Kenya, 1953, p. 29; Uchendu, 1969, p. 11a; Kenya, 1970, pp. 39-41.

Figure 13

KISII DISTRICT

POPULATION DENSITY

1969



SOURCE: KENYA POPULATION CENSUS, VOL I, 1969.

Kisii District is a remarkably homogeneous area ethnically. Kenya Africans account for 99.98 percent of the total population and the Gusii people are 97.98 percent of the total. The largest non-Gusii groups of Kenya Africans are, in descending order of size: Luo, Kikuyu, Kipsigis, Luhya, Kamba, Kuria, Masai, Nandi, Mijikenda and Meru. Even the Luo are only 0.8 percent of the total population. Europeans made up 0.05 percent of the total and Asians account for 0.1 percent. The result is that the Gusii are the overwhelming majority in their own district, but they are the exact opposite elsewhere. Approximately 5.7 percent of the Gusii people reside outside their home district. They are found in limited numbers in every district in Kenya. The abrupt change in the ethnic composition of the population at the borders of the district is a remarkable feature of the cultural geography of western Kenya (Kenya, 1969, p. 96).

The Gusii

The Gusii of Kisii District are a Bantu-speaking people surrounded by the non-Bantu Luo, Masai, and Kipsigis. They are related to the linguistically similar Kuria to the southwest and to the Logoli group of the Abaluhyia from north of the Kavirondo Gulf. Traditionally, Gusii life centered around the herding of cattle while cultivation was relegated to a secondary position. However, in the last two decades increasing population

pressure has forced the people to devote more efforts to cultivation and consequently less to animal husbandry (LeVine, 1963, pp. 221-255).

Social Structure

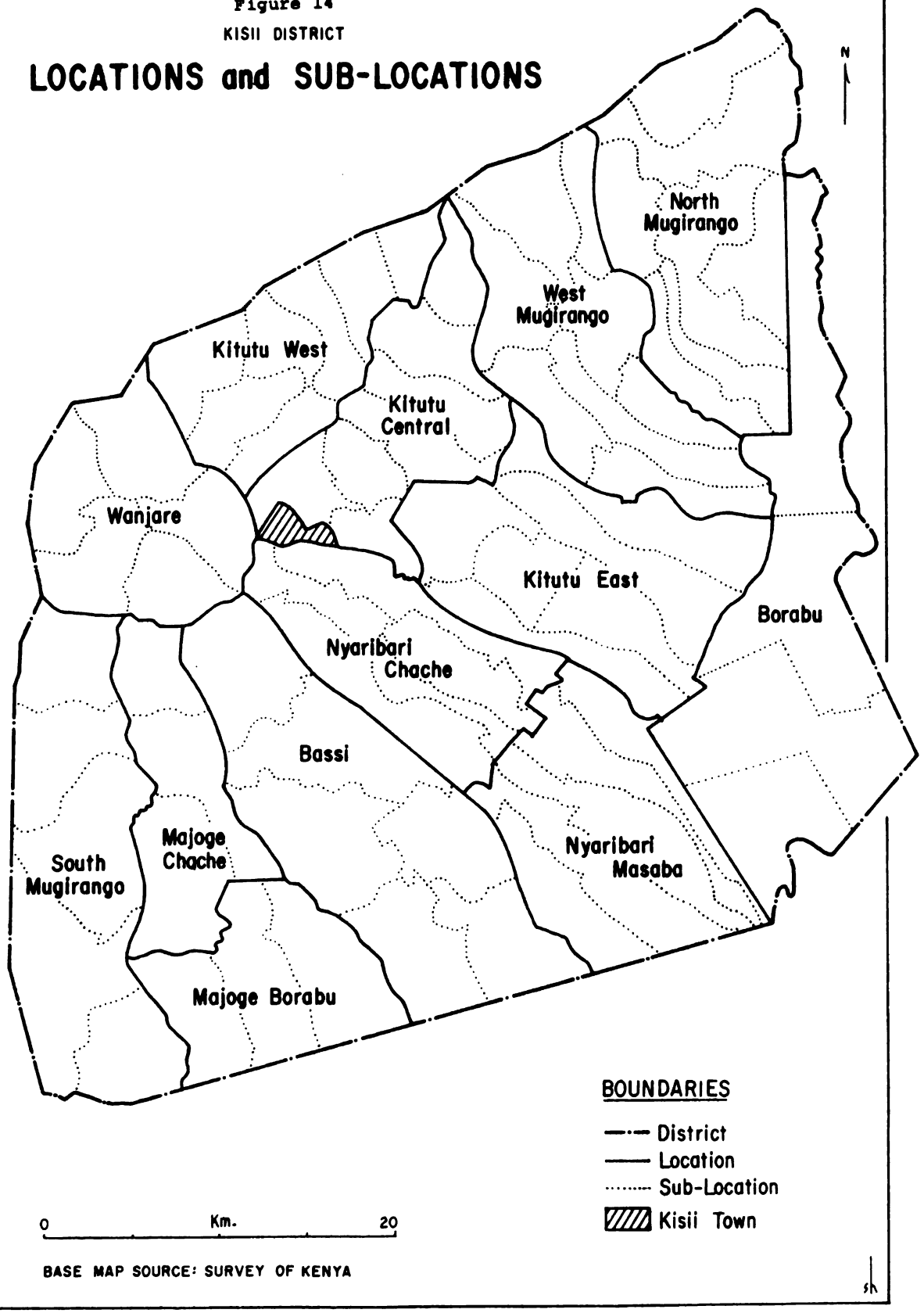
Prior to the advent of British rule in 1907 the Gusii were made up of seven separate but linguistically related groups. All of the Gusii recognize a common ancestor, Mogusii, the founder of the nation and the one after whom it is named. Despite the common ancestor and history the entire national group was never unified. On occasion they were united for purposes of warfare against the Kipsigis, but they generally fought among themselves (LeVine, 1966, pp. 3-4).

Largely due to the separateness of the seven groups, the British structured their administrative subdivisions along similar lines. The territories of the seven groups then became the original seven locations. They were as follows: the Getutu in Kitutu Location, the Mogirango in Mugirango Location, the Nchare in Wanjare Location, the Bassi in Bassi Location, the Nyaribari in Nyaribari Location, the Majoge in Majoge Location, and the Mogusero in South Mugirango Location (see Figure 14). The slight modifications from group to locational names were made by the British, presumably by error rather than plan. In 1907 the Mugirango split into two sub-groups; the splinter group becoming the Mogusero

Figure 14

KISII DISTRICT

LOCATIONS and SUB-LOCATIONS



BASE MAP SOURCE: SURVEY OF KENYA

of South Mugirango Location. Despite their physical separation they consider themselves as one. In 1962 several of these locations were divided to give the present 12 locations, plus the former settlement area, currently found in Kisii District (Maxon, 1969, pp. 350-363).

As the Gusii were not unified, similarly the individual groups lacked central authority. The only exception was the Getutu that consisted of only the Nyankundi clan, rather than numerous clans (Maxon, 1969, p. 350). The other groups of the Gusii are made up of numerous clans that are patrilineal, exogamous, segmented into lineages, and without central authority. Clans and lineages were more localized in the past, but today, after years of movement within the district they are not so territorially distinct. Movement has lessened in recent years because of the lack of vacant land (LeVine, 1963, pp. 221-255).

Much of Gusii social life is organized around the patrilineal descent group. The male members of several homesteads who are descendants of the same grandfather regard themselves as members of a common mourning group. They share in ritual head shaving and sacrificial meat eating at each other's funerals. Two or more mourning groups, with the same grandfather or great-grandfather, form a <u>riiga</u>. Beyond this group little intimate social interaction is possible due to the numbers of people

involved. Several riiga lineages form a clan-house and several of these form a sub-clan. The largest of the social organizations to form an independent political unit before the British came was the clan. Clans are also the largest exogamous unit and the maximal group for the use of kinship terms. The next larger unit of social organization is the group, and finally the Gusii nation forms the largest unit (LeVine, 1966, p. 30).

Before 1907 each clan was essentially an autonomous unit with its own territory and decision-making power. Forces of unity and disunity were in a constant state of ebb and flow. Clans within the same group would carry on prolonged feuds involving the abduction of women and the stealing of cattle. However, due to the exogamous nature of the clans, they had to have periods of friendly relations, or at least a lack of overt hostility, for the purpose of marriage ceremonies. Inter-clan hostilities could be ended by negotiated settlement and the payment of cattle. Participation in warfare also served as a unifying force. Thus, military alliances and the need for wives prevented hostilities from extending for indefinite periods (LeVine, 1966, p. 4).

Today, most of the lineage groups of the Gusii are no longer intact but are fragments found in two or more places in the district. During the 1930's and into the 1940's considerable migration within the district took

place. Generally, the population pressure of the lowlands forced people to seek new homes in the higher parts of Gusii-land in the east. Also, the British administration forced a reduction in hostilities between the Gusii and the Kipsigis to the east, so this area was no longer needed as a buffer zone. Soon, however, population pressure all over the district brought an end to internal migration. Lineage groups that migrate to new areas may become localized under work groups (risaga) that form a geographical unit. A single lineage that has been fragmented into two or more parts may be identified by the local risaga group, or as part of a risaga, in each area. If several lineages within the same clan have migrated to a new area they will interact more with each other than with others (LeVine, 1963, pp. 221-255).

The large risaga work group is based on a small number of homesteads that recognize the reciprocal obligation to participate in the trading of work for beer. While all members of the large risaga are not necessarily of the same lineage they are almost always of the same clan. Each small risaga is made up of members of the same lineage who work together more closely with each other than with the other members of the community. Thus the small risaga is used more often than the large risaga. Boundaries of the large risaga are frequently marked by natural features such as streams, but the

neighborhoods that make up the small risaga do not have clear boundaries. Since there is no formal organization among these groups, people, particularly those residing on the boundary between two groups, will work with first one then the other (LeVine, 1966, pp. 35-36).

The extended family homestead of Gusiiland has both a social and spatial expression. In a monogamous marriage the husband and wife usually reside in the same house and unmarried sons who have been initiated will have their house. In a polygamous homestead each wife will have a house of her own, and the husband will spend time at each. Sometimes the unmarried children will have their own house if numbers demand it. Married sons with their wives and children will have their own houses. These houses will be built closer to their own mother's house than to any other (LeVine, 1966, pp. 26-27).

While the head of the household retains title to the land and cattle each wife will maintain her own land and cattle. The husband is responsible for running the homestead but the individual wives do most of the work in their own fields. Currently, men engage more in field work than in the past when they devoted their time almost exclusively to cattle raising and trading. When a homestead head dies his wealth will be distributed according to his instructions, however, if differing claims are made, a son will usually receive the land that was

cultivated by his mother and the cattle associated with her household. Such claims are not totally unheard of because there is frequently friction between co-wives in the homestead and this tends to influence the son's behavior (LeVine, 1966, pp. 26-27).

Before the coming of the British colonial administration in 1907 there was no central political authority among the Gusii. Political integration was at the clan level, and sometimes at a more local level. Each clan and local community had its own authority system in which considerable influence was wielded by the elders and the wealthy.

In 1907 the British imposed a new level of government on the old system rather than replace the old system entirely. They appointed a District Commissioner as the chief representative of the government in the district. Beneath him are the District Officers for the divisions; which are made up of three or four locations. Within each of the seven groups the government appointed a chief who became a man of considerable influence because of his position. Each chief has under him a number of sub-headmen who function over several clan territories in order to reduce clan parochialism (LeVine, 1966, pp. 66-76).

Within traditional Gusii society, and within the present day society to a large extent, it is the wealthy who are the most influential. That they were also

lineage elders is, to a great extent, a reflection of their wealth. Such men have more cattle wives, sons, and more daughters to allow them to acquire yet more cattle. As they derive much of their wealth and power from their farms they would naturally be the most influential persons when it came to agriculture. Indeed, many of the first coffee growers were either chiefs or government officials of some sort. In order to maintain their wealth they proved to be the first in the area to take up cash crop farming. The great acquisitiviteness of the Gusii is largely caused by the esteem with which the wealthy are held (LeVine, 1966, pp. 66-76; Uchendu, 1969, p. 21).

Infrastructural Development

Transport has been a principal problem in the development of cash crop agriculture in Kisii. It is not that the remote areas are inaccessible, but that the cost of transport over very poor roads becomes excessively high. Currently there are only three sections of road that are tarmac surface in the district (see Figure 15). They are the roads leaving Kisii town for Kisumu in the north, Migori to the southwest, and a four-mile section to Kegati on the road to Sotik to the southeast. The other main roads are murram (gravel); they are passable in all weather. However, most of the access roads are

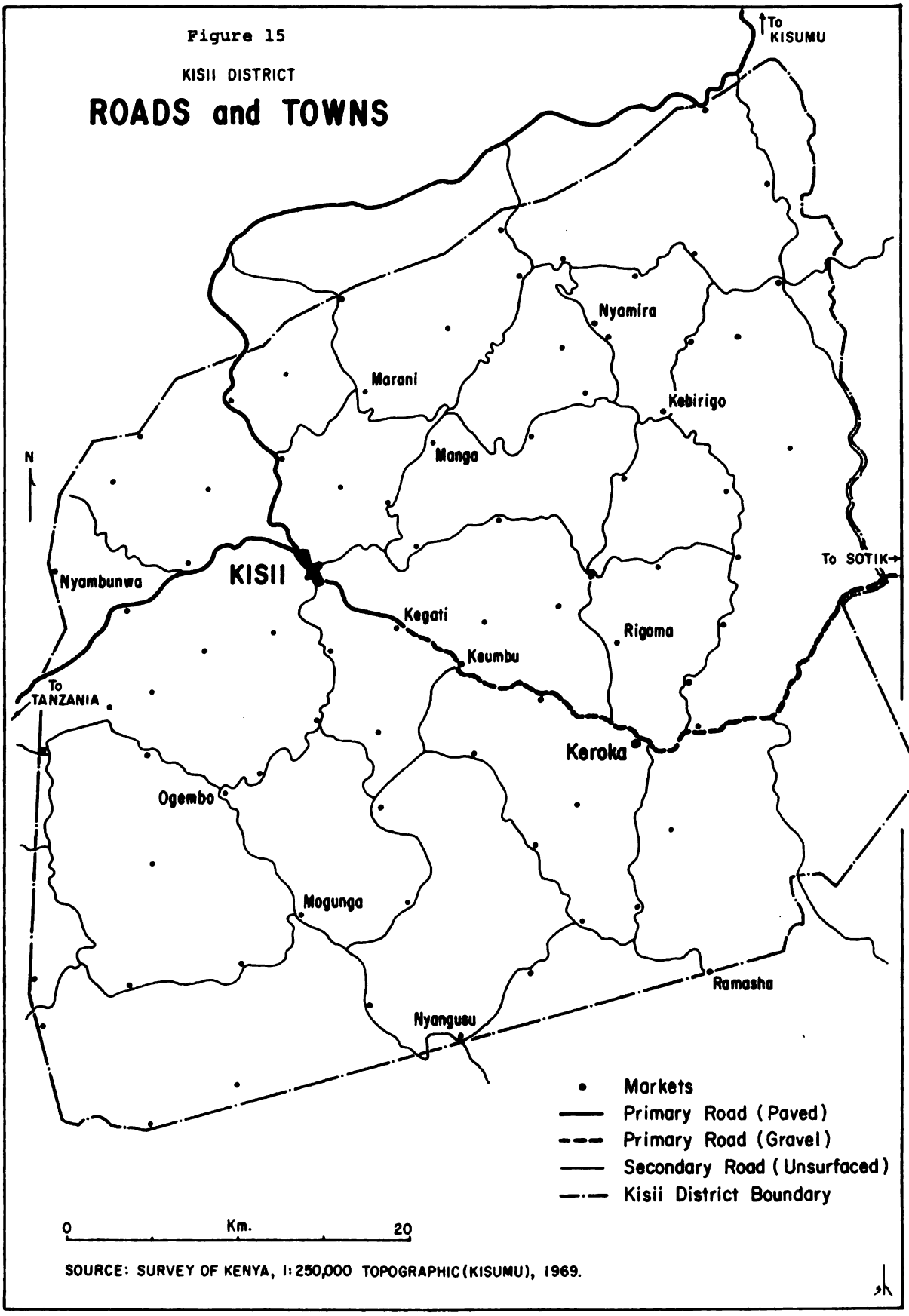


Figure 15
KISII DISTRICT
ROADS and TOWNS
To KISUMU
Nyamira
Marani
Kebirigo
Manga
N
Nyambunwa
KISII
To SOTIK
Kegati
Rigoma
Keumbu
To TANZANIA
Keroka
Ogembo
Mogunga
Ramasha
Nyangusu
Markets
Primary Road (Paved)
Primary Road (Gravel)
Secondary Road (Unsurfaced)
Kisii District Boundary
0
Km.
20
SOURCE: SURVEY OF KENYA, 1:250,000 TOPOGRAPHIC(KISUMU), 1969.

unimproved and very difficult, and therefore expensive, to travel over.

In the late 1950's the Kenya Tea Development Authority began constructing "Tea roads" in the areas of high tea production. The KTDA charges all growers a cess on their production, and much of that money is invested in road improvement to insure that the collection trucks will be able to get into all areas regardless of the weather. Obviously these roads make the marketing of all other cash crops more economic (Uchendu, 1969, p. 50).

Other transportation improvements are planned. A new tarmac trunk road is under construction from Kisii southward to Nyangusu on the southern border of Kisii District, and subsequently farther south. A new road connecting Kisii directly with Kericho to the northeast is now under construction. The present road connecting Kisii to Sotik and then Kericho will be improved in the next three years. The feasibility of connecting Kisii to the Kenya railroad system is under consideration in Nairobi. Also, the present landing strip for light aircraft will be improved (Kisii, District Development Advisory Committee, minutes, March 1, 1971).

Roads are the most important infrastructural development influencing the profitability of cash crop production, but there are numerous other developments aimed at upgrading the rural standard of living that are important in reducing migration to major urban areas.

In 1969 Kisii town for the first time had 24-hour electricity brought in from the generating plant at Homa Bay, 15 miles away. Plans are underway for the construction of two small hospitals in Nyamira and Keroka (see Figure 15). Water systems for these two towns are now under construction and systems for most of the major towns in the district are planned for the next 15 years (Kisii, District Development Advisory Committee, minutes, March 1, 1971).

Of major importance in the district is the expected growth of Kisii town. In 1969 the population was 6080 (Kenya, 1969, p. 41), but the Nyanza Province Town Planning Officer estimates a population in the year 2000 of over 60,000 if the present rate of expansion continues. The most severe problem is that of space. Currently the township covers 250 acres and is expected to expand to over 2000 acres at the turn of the century. Given the high degree of local relief this magnitude of growth will present great problems (Kisii, District Development Advisory Committee, minutes, March 1, 1971). These physical improvements in the district should aid greatly in upgrading the local standard of living by making cash crop farming more profitable.

Kisii District simultaneously represents the hope and horror that is potential in Kenya's future. If programs of rural development can convert sufficient numbers

of Gusii farmers into highly productive cash crop producers without sacrificing food production the future is hopeful. On the other hand, if these programs fail, and the population of the district continues to grow at the same rate as in the recent past, it will certainly experience the manifold horrors of overpopulation.

CHAPTER IV

DATA COLLECTION AND METHODS OF ANALYSIS

Data Collection

Selection of the Study Area

In order to cover a variety of ecological conditions, population densities and potential agricultural development levels the Special Rural Development Project selected 14 different areas in Kenya. One of the 14 areas was in Kisii District where the author was conducting his own field work. After some initial consultation it was decided that it would be mutually beneficial for the writer to work with the SRDP Research and Evaluation Unit in a joint field survey that would serve as the base line for evaluation purposes and also provide the data base for the author's own spatial diffusion research.

The SRDP area for Kisii District covers only Irianyi Division, that is, Nyaribari Masaba, Nyaribari Chache and Bassi Locations. This area was insufficient in size for the proposed spatial diffusion research so it was expanded to include East Kitutu Location, most of Central Kitutu Location and part of North and West

Mugirango Locations (Figure 14). This additional area was included at the author's request as it is where pyrethrum, tea, coffee and passion fruit were first introduced.

Selection of the Sample

Due to the lack of farm plot maps for the entire study area the selection of the sample for use in the field survey was completed in two stages. Overlying the 1:50,000 scale topographic maps used in the field is a grid system, each cell of which is one square kilometer. These cells were numbered in serpentine fashion, beginning in the northwest corner of the study area. Every ninth cell was selected, giving a total of 93. Each sample site was a square area that could not readily be utilized in the field, so using the topographic maps, physical features such as roads, rivers and ridges were used to outline irregularly shaped sampling areas of about 0.75 square kilometer each. Physical features are a simple, accurate and easy method to delimit areas in a place with as much local relief as Kisii. A total of 1,935 short interviews, or about 5 percent of the estimated 40,000 homesteads, were conducted in these areas from March 15 to May 1, 1971. The short interview consisted simply of asking the name of the homestead head and the dates when he first began to raise hybrid maize, coffee, tea, Pyrethrum, passion fruit and grade cattle.

The second stage, conducted during May and June, 1971, was to do a stratified sample of the homestead heads interviewed earlier. This was done by placing the 1,935 names in order of place of residence and selecting every fourth name. A total of 485 in-depth interviews were conducted, representing about 1.25 percent of the homesteads in the study area. The first stage of the sample, the 1,935 short interviews, has a 99 percent confidence level with a reliability level of $\pm$3.0 percent. The second stage, the 485 in-depth interviews, has a 95 percent confidence level with a reliability of $\pm$5.0 percent (Arkin and Colton, 1963, pp. 145 and 152).

The Field Survey and Data Collection

The field interviews were conducted, under the author's supervision, by a team of three Gusii men who normally are employed by the Ministry of Agriculture as agricultural extension agents. After one week of training a second week was devoted to pre-testing the interview schedule. The in-depth interview schedule then underwent modification while the field team began the short interviews. The latter is referred to as the diffusion sample, for these are the data upon which the diffusion maps are based. The diffusion sample was completed in approximately three weeks (see Appendix A for the short interview schedule). The next two months were

devoted to the in-depth interviews (see Appendix B for the in-depth interview schedule).

In addition to the field survey, local data sources were searched, especially annual reports of the district agricultural officer. These sources are the most valuable because they are the only places where statistics are kept in the same format from year to year. But even here the same tables do not necessarily appear each year. Also, the files of various offices provided additional information. Other data were obtained via interviews with the individual crop officers, managers of the cooperative societies, and the manager of the Sotik passion fruit processing plant.

The Interview Schedule

The interview schedule for the in-depth interviews was designed to obtain factual information about the head of the homestead and the farm. With the exception of sociometric nominations, all of the questions required only the recall of facts. The schedule provides locational identification for all respondents. The entire schedule contains 22 questions, each with numerous subparts. The categories of inquiry for each of the questions are as follows: (1) The name of the homestead head and his residence, or if absent, the name of the respondent and relationship to the head. (2) The land tenure characteristics of the homestead, such as the number of

pieces of land, whether they are owned or rented, how the land was acquired, and the state of legal title. (3) The kinds of cash crops grown, when they were first grown and the practices of weeding, pruning and fertilization used. (4) The type of maize, whether hybrid or local, planted during the last year. (5) The types and numbers of grade livestock kept, and when they were first acquired. (6) The numbers and kinds of local livestock kept on the farm. (7) Animal husbandry practices used for local and grade dairy cows. (8) Sources of water supply (well, raintank, river or spring) used for the home, livestock or irrigation. (9) The use of various types of traditional labor, family labor and hired labor for cash crops, food crops, and livestock. (10) Names of markets used when selling chickens or eggs, milk, food crops, or livestock. (11) The kinds of farm records kept. (12) The sociometric nominations (already mentioned) of opinion leaders. (13) Types of client and agent initiated contact with change agencies. (14) The types of demonstrations attended and the ones that were found useful. (15) Whether or not the farmer has ever had a demonstration plot on his land, the number of demonstration plots he has visited in the last year and the number of times he, or others from the farm, have attended courses at the Farmers Training Center. (16) The formal organizations family members belong to and offices held in each. (17) The communications behavior

of the homestead head, such as newspaper and magazine readership, frequency of radio listening, frequency of visits to Kisii, outside the district and to Nairobi, frequency of church attendance, and length of stay outside the district. (18) The primary and secondary occupations of the homestead head, and the respondent if the head is out of the area. (19) The personal characteristics of the homestead head or respondent, including education, literacy, sex, marital status, age, birthplace of the homestead head, birthplace of the head's father, and religion. (20) The number of people living on the farm, including the number of adults and children, the number living away, the number in primary school and higher school, and the persons responsible for paying school fees. (21) The society where the farmer markets his cash crops and the income derived from each. (22) Housing characteristics, including the type of house, the toilet, cooking and lighting facilities, and the possessions of the homestead.

Methods of Analysis

Data Coding and the Raw Variables

Due to the multiple use for which the interview schedule was constructed only selected parts were coded for use in the spatial diffusion research. The data from the 485 in-depth interviews were aggregated to the 93

sampling areas. An effort was made to construct a number of Guttman Scales, but unfortunately the coefficient of reproducibility was not sufficiently high to justify its use, so indices were constructed using the same variables. The 57 raw variables used in the statistical analysis are listed in Table 6.

Diffusion Maps

The 1,935 interviews conducted in the 93 sampling areas (a mean of 20.8 interviews per sampling area) yielded dates of adoption for each of the six innovations. For each sampling area the percent of the farmers adopting each innovation was calculated for the appropriate time period. Calculations were made for 1940, 1945, and beginning in 1950, every two years up to 1970, plus 1971. Each innovation fit into these time slots according to the date of introduction into the study area. These data were then punched on computer cards and used for input into the SYMAP computer mapping program for the purpose of constructing a series of contour maps depicting the percent of adoption within different parts of the study area for selected years.

The SYMAP program generated maps on which a series of closed curves connect all points having the same numeric value. Each data point is the centroid of one of the 93 sampling areas. Between any two contour lines a continuous variation is assumed. Thus, the maps produced

TABLE 6.--Variables from In-Depth Interviews.

Aggregates for 93 Sampling Areas[a]
1. North-south coordinates of sampling area
2. East-west coordinates of sampling area
3. Elevation of sampling area above sea level
4. Annual precipitation
5. Index of distance from Kisii town, based on road quality[b]
6. Mean number of pieces of land per farm
7. Mean acres per farm
8. Mean year of adoption, hybrid maize
9. Mean year of adoption, coffee
10. Mean year of adoption, tea
11. Mean year of adoption, pyrethrum
12. Mean year of adoption, passion fruit
13. Mean acres of hybrid maize per farm
14. Mean acres of local maize per farm
15. Mean acres of coffee per farm
16. Mean acres of tea per farm
17. Mean acres of pyrethrum per farm
18. Mean acres of passion fruit per farm
19. Use of fertilizer index
20. Index based on number of weedings
21. Mean year of adoption, grade cows
22. Mean number of grade animals per farm
23. Mean number of grade cows per farm
24. Mean number of local cows per farm
25. Grade cow practices index
26. Local cow practices index
27. Tick control, number of dippings or sprayings per month, mean per farm
28. Crop progressiveness index, mean number of years from 1972 that each cash crop was adopted
29. Overall progressiveness index, crop progressiveness index plus the mean number of years from 1972 that grade cows were adopted
30. Percent of farmers raising hybrid maize in 1971
31. Percent of farmers raising coffee in 1971
32. Percent of farmers raising tea in 1971
33. Percent of farmers raising pyrethrum in 1971
34. Percent of farmers raising passion fruit in 1971
35. Percent of farmers raising grade cows in 1971
36. Mean number of change agent initiated contacts in last year
37. Mean number of client initiated contacts in last year
38. Mean number of demonstrations attended in last year
39. Mean number of demonstrations found useful in last year

TABLE 6.--Continued.

Aggregates for 93 Sampling Areas
40. Mean number of demonstration plots seen in last year
41. Mean number of Farmer Training Center courses attended
42. Mean number of formal memberships
43. Mean number of offices held in formal organizations
44. Communications index for sampling area
45. Education-literacy index for sampling area
46. Mean age of heads-of-households
47. Mean number of people per farm
48. Mean number of adults per farm
49. Mean number of children per farm
50. Mean number of family members currently living on farm
51. Mean number of children in school per farm
52. Mean number of children in high school or above per farm
53. Mean income from cash crops per farm
54. House type index
55. House facilities index
56. Household possessions index
57. Population density of sub-location where the sampling area is located

[a]Mean number of interviews per sample area, 5.2.

[b]Value of 1 for each km. of all-weather road, 2 for dry-weather roads, and 3 for footpaths.

will not be completely accurate in every detail because the areas between the sampling areas were not surveyed. Instead the maps will depict the pattern of spatial diffusion in a somewhat more general form.

The contour intervals used on the diffusion maps are similar to the percentages used in the adopter categories by Rogers (Rogers, 1971, pp. 183-185). The six intervals, which will be referred to as adoption levels, are as follows.

TABLE 7.--Adoption Level Percentages.

Level I, No Adoption	Level IV, 50.1% to 84.0%
Level II, 0.1% to 16.0%	Level V, 84.1% to 99.0%
Level III, 16.1% to 50.0%	Level VI, 99.1% to 100.0%

Level I, no adoption, was used to depict those areas where no farmers had accepted the innovations. Level II goes up to 16.0 percent, eliminating the innovation category as the sample size was not adequate to allow the use of a category of only 2.5 percent. To use the innovator category would have required interpolation beyond the limits of the data. The remaining deviation from the Rogers adopter category percentages is Level VI which represents 100 percent acceptance.

Because of the data limitations this study will not be able to deal with the innovator class (the first

2.5 percent to adopt). Instead, the category of innovator will be included in an expanded early adopter classification (the first 16.0 percent to adopt). A true innovator in Kisii may well have adopted many different innovations besides those investigated here. Since all of these innovations were introduced by change agencies it is logical to assume that the first farmers to adopt them were well integrated into the social system. Thus, the questions asked cannot really address themselves to those in the innovator category, and particularly the first of the innovators.

Factor Analysis

Factor analysis is a statistical technique used to reduce a large number of raw variables to a more manageable number of conceptual factors. The assumption upon which factor analysis is based is that many variables are intercorrelated with each other, and therefore a new conceptual variable (usually referred to as a factor or sometimes as a dimension) can be constructed that will be highly intercorrelated with one or a cluster of raw variables. Some measure of the relationship the variables have to each other can be obtained by examining the simple intercorrelation matrix.

In a factor analytic problem each raw variable will relate to each conceptual factor in a different manner. The closeness of fit between a variable and the

factor is referred to as the loading and is measured in the same manner as the coefficient of correlation, that is, the values range from 1.00 to -1.00. A loading approaching plus or minus 1.00 indicates a close correlation between the raw variable and the factor. Loadings approaching 0.00 indicate no relationship. The numerical value of the loading indicates the closeness of fit between the raw variable and the factor, but when two variables have opposite signs it indicates how they relate to each other. A positive loading indicates a direct relationship with the factor and a negative loading an inverse relationship. This can be referred to as loading in opposition. Thus, if two variables load in opposition, one approaches its maximum numeric value in those observational units where the other approaches its minimum numeric value. Another way of stating it is that the factor has dichotomized between the two variables. The fact that a given variable has a positive or negative loading on a factor is meaningless in and of itself; it only becomes important when both high positive and high negative loadings occur on the same factor.

The naming of factors sometimes presents problems. If all the variables loading highly on a factor are simply measures of the same underlying characteristic the problem is easy for it is only necessary to identify that characteristic. Complications arise when the raw variables seem

to be unrelated but load on the same factor. In such cases it may be necessary to use some rather long and unwieldly titles.

An important characteristic of factor analysis is that the factors derived are unrelated to each other. Also the first factor explains more than any other factor, and it may be located between independent clusters of interrelated raw variables which will result in numerous moderate loadings and perhaps none that are really high. In order to reduce the number of variables loading moderately on a factor, the matrix is frequently rotated to increase the relationship between the clusters of interrelated variables and the factors. The use of orthogonal rotation does not change the uncorrelated nature of the factors, but it does clarify the variables related to each factor. In the current problem, varimax rotation, a type of orthogonal rotation, was used to produce a better fit between the variables and the factors.

The next step in factor analysis is the construction of a factor score matrix. This explains the relationship between the observational unit and the factor. The more involved a raw variable is with the factor the higher its weight. Scores are given in standard deviation units, thus if an observational unit contributes little to the factor its score will be very low, approaching 0.00, or the mean for the contribution

of all observational units to the factor. Observational units will have high (positive) or low (negative) factor scores in the same manner as their raw variables relate to the factor (see Blalock, 1960, pp. 383-389; Rummel, 1967, pp. 444-479; and Cattell, 1965, pp. 190-215 and pp. 405-435).

Multiple Regression and Correlation

Multiple regression is used to indicate the amount of total variation of a dependent variable that can be accounted for by a series of independent variables acting together. However, if the independent variables are highly intercorrelated among themselves an erroneous interpretation could result because one of the basic assumptions is that the independent variables are unrelated and the values for the observational units are normally distributed. Therefore, factor scores can be used as the independent variables because they are by definition unrelated. Also, an independent variable cannot be simply a surrogate measure of the dependent variable or an erroneously high correlation will be the result (Blalock, 1960, pp. 326-329).

The next chapter will examine the diffusion process for each of the six innovations in detail, as well as the results of the factor analysis for the 485 in-depth interviews. Then the adoption of innovations

will be related to the conceptual factors through the use of multiple regression and correlation.

CHAPTER V

THE SPATIAL ATTRIBUTES OF INNOVATION DIFFUSION IN KISII DISTRICT

Introduction

With few exceptions (Nwala, 1971 and Ramachandran, 1969), spatial diffusion research has focused upon the developed countries, particularly Sweden and the United States. The study offered here, focusing on a developing area, offers an alternative view of the spatial diffusion process. The answers to three general questions are sought here: First, does the spatial diffusion process in a developing country follow the same general pattern found in the more developed countries? Second, what spatial constraints or influences can be identified that effect the spatial spread of innovation? And, third, what relationships exist among a series of geographic, socio-economic and demographic variables, and the diffusion of innovation. The methods used to answer the questions include mapping of the spatial spread of innovation, factor analysis and multiple regression and correlation.

The Spatial Diffusion Process

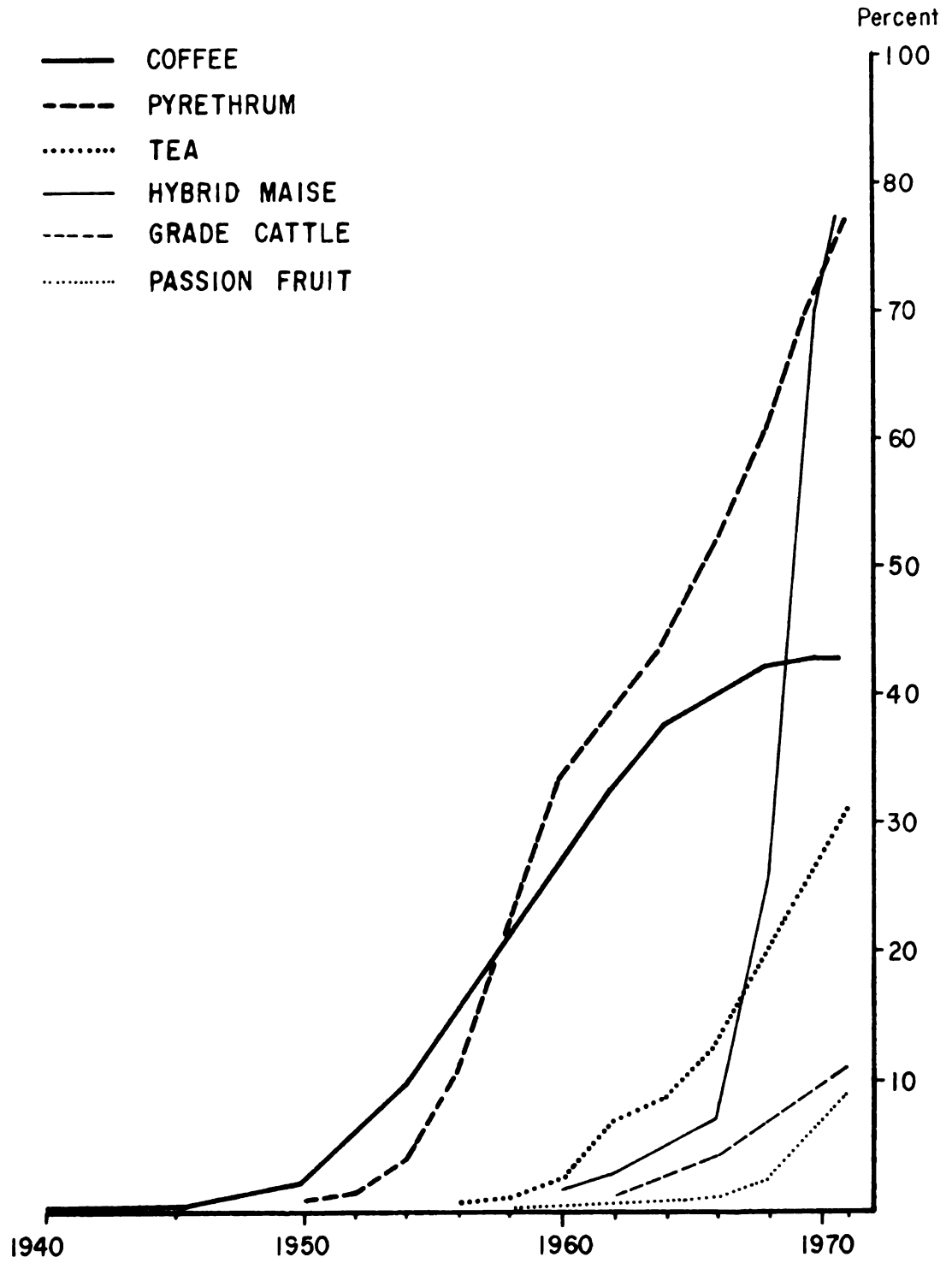
The purpose of this section is to analyze the geometry of the spatial diffusion of each innovation. Comments on the introduction of each innovation will precede the diffusion analysis. Levels of adoption, referred to in the previous chapter, will be used to facilitate the discussion.

Each of the innovations investigated has its own distinct growth curve (see Figure 16). Coffee presents a classis "S" shaped growth curve, with a slow rate of adoption in the initial period, followed by a rapid, steady growth, and finally another slow adoption rate as the growth curve levels off. Pyrethrum experienced a very rapid acceptance rate until 1960 when an uncertain market caused a slight slow-down in the acceptance rate. The upper inflection preceding the final phase is discernible in the last three years. Hybrid maize has had the fastest acceptance rate in the history of Kisii, but here too the growth curve is beginning to level off as the 100 percent level is approached. Tea has enjoyed a rate of adoption, in the central part of the growth curve, about equal to that of coffee. Passion fruit and grade cattle are both in the initial part of their respective growth curves as they have not completed the upward inflection that precedes the central growth period.

The spatial distribution of each innovation in 1971, as exemplified by the percent of farmers using the

Figure 16

CUMULATIVE PERCENT ADOPTION



innovation in each sampling area is depicted in Table 8. A high positive correlation would indicate a similar spatial pattern. No correlation indicates an overlap between the areas of adoption but no relationship between the percent of adoption found in each sampling area. A strong negative relationship between two innovations indicates that where one innovation is present the other is absent.

TABLE 8.--Innovation Intercorrelations Percent Adoption, 1971.

	Coffee	Pyrethrum	Tea	Passion Fruit	Grade Cattle	Hybrid Maize
Coffee	1.00					
Pyrethrum	-.62	1.00				
Tea	-.48	.40	1.00			
Passion Fruit	-.26	.04	-.03	1.00		
Grade Cattle	-.19	.12	.55	-.17	1.00	
Hybrid Maize	-.36	.33	.17	.22	.11	1.00

Three reasons can be offered for the relationships found among the individual innovations. First, the current distribution is the result of a unique set of origins for each innovation that is further modified by a unique diffusion pattern. Second, the differing ecological constraints selectively modify the spatial distribution of

each innovation. And third, the complimentarity or mutual exclusiveness of each innovation will determine whether or not there is spatial overlap.

For example, the negative relationship between coffee and pyrethrum is the result of all three forces. First, coffee was introduced on the western side of the study area and pyrethrum on the east. Second, coffee does not do well at the higher altitudes and pyrethrum does poorly at lower altitudes. And third, they are competitive in that the farmer who removes land from food production must then decide which commercial crop to plant.

A casual glance at the maps of diffusion can be deceiving because they depict the percent of adoption, not production. Also, they show the percent of farmers in each area who have at some time adopted the innovation in question. A few of those farmers may not currently be growing the crop or raising cattle. In those areas where the adoption rate is highest each farmer will usually be using the innovation very intensively, but on the periphery of the adoption area where the level of adoption is low the farmers usually raise small quantities.

Spatial Diffusion of Coffee Adoption

Aribica coffee was first planted in Kisii in 1921 but it was not until 1935 that more than a few acres were planted. At that time two group farms were

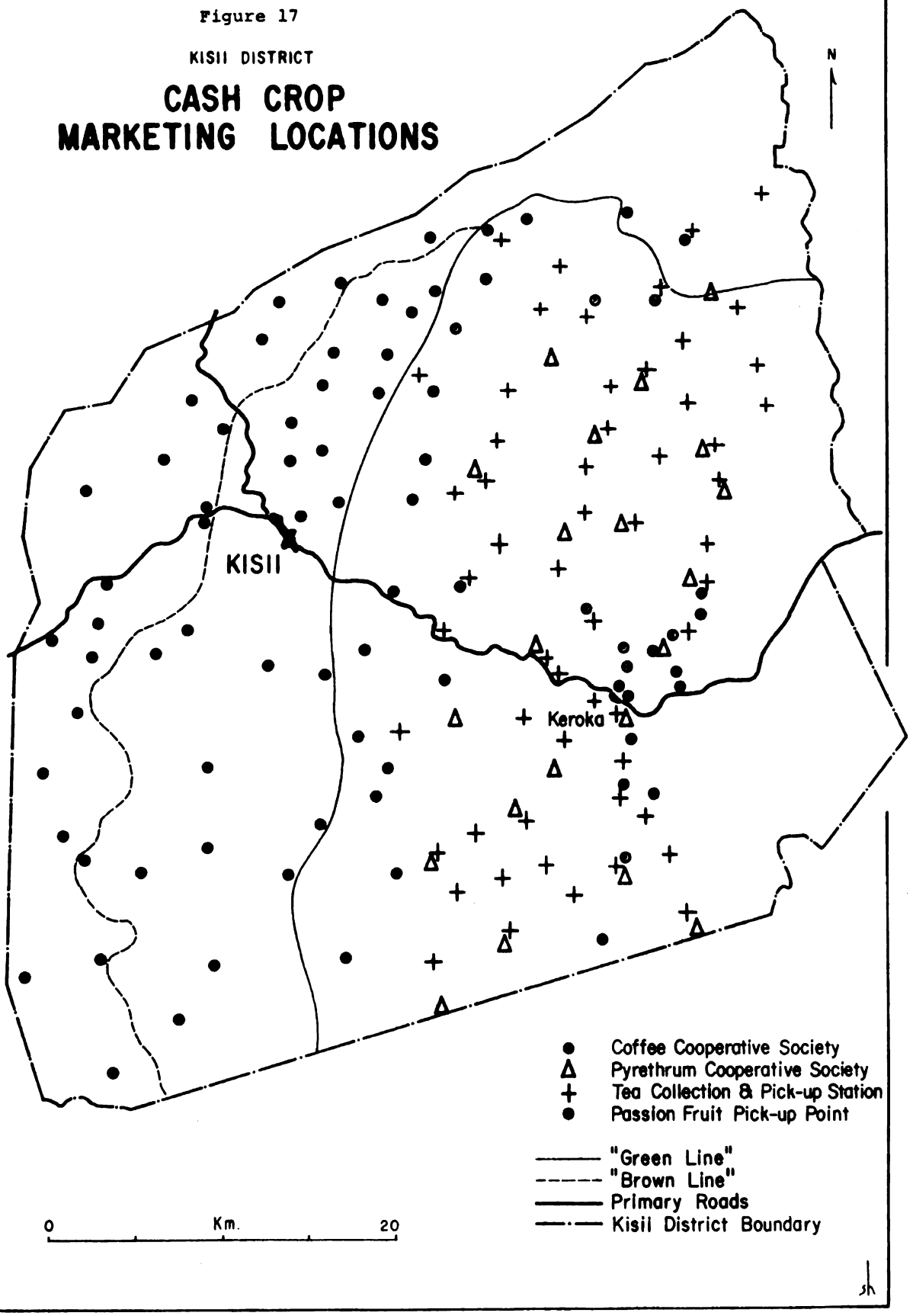
started in Nyaribari Location, but they failed because of the Gusii preference for private ownership, and the long distance each group member had to walk to get to the plot. Kisii District was one of the first areas in Kenya where Africans were allowed to plant coffee. The British administration had previously refused to allow African ownership for fear of plant disease and inadequate quality control. In the late 1930's private planting of coffee was allowed in Kitutu, Nyaribari and Bassi locations. It was not until the 1950's that coffee began to attain significant acceptance as a cash crop. During the 1950's and the early 1960's there was a steady increase in adoption and spread of coffee growing across Gusiiland; while from 1962 the adoption rate was much slower (Uchendu, 1969, pp. 35-37a).

Coffee is marketed through the 26 Coffee Societies and initial processing (cleaning and grading) is carried out at the 65 coffee factories. Six additional coffee factories are planned. The original factories were started at Morumba, Kitutu Location in 1947, Mogunga, Bassi Location in 1952 and in Nyaribari location at Nyosia and Nyaturubo in 1953 and 1954, respectively (see Figure 17 for all cash crop marketing locations). Other factories were established at this time outside the study area. The last society was opened in 1960; since that date all of the new factories have been branches (Interview No. 2).

Figure 17

KISII DISTRICT

CASH CROP MARKETING LOCATIONS



Two facts lead to the conclusion that the 1964 ban on additional planting has not been taken seriously in Kisii District. From 1965 to 1971 the marketing societies have constructed 21 new factories and have 6 more planned. Also, membership in the Kisii coffee cooperative societies grew from 41,512 in 1964 to 45,408 in 1966 and to 53,536 in 1968. Since 1968 there has been a slight decline in membership (Kisii, Annual Reports, 1964, pp. 6-7; 1967, pp. 46-51; and 1968, p. 68).

The decision on when and where to build a new coffee factory is based on a combination of two factors. First is the distance farmers must transport their coffee to an existing factory and second is the amount of coffee produced in the new area. If there is sufficient production at a long distance a new factory will be built. Part of the new factory construction since 1966 could have been catching up with the need, but certainly eight years after the ban all needs would have been taken care of, unless additional planting was going on (Interview No. 2).

Figure 16 indicates that for the study area the rounding off at the top of the logistic curve began in 1964. In the future there will be either very little new adoption of coffee, or perhaps none. As regards production, Kisii District has continually increased its portion of the Kenya total (see Table 9). In the early 1960's only about 2 percent of Kenya coffee was accounted for by

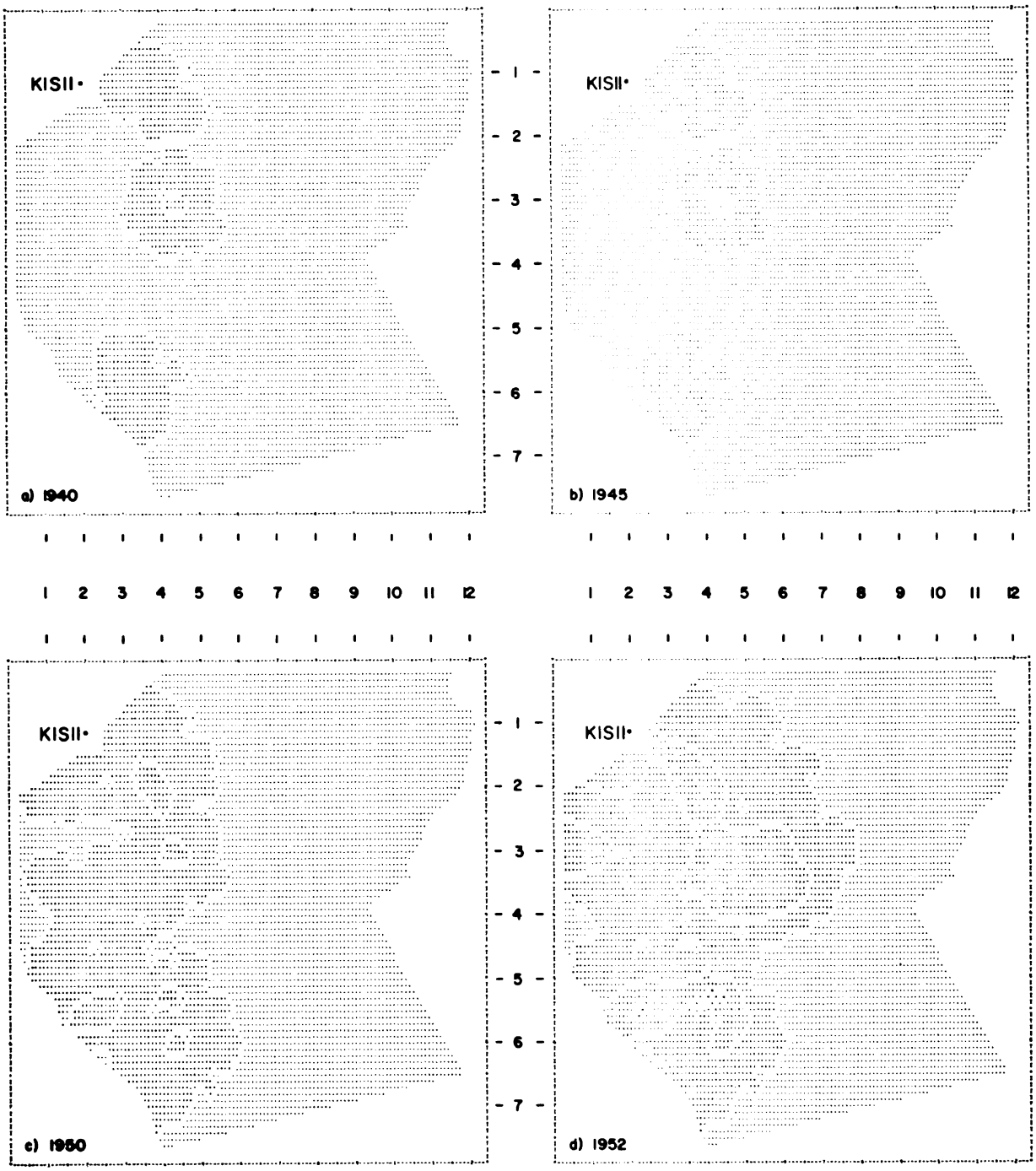
TABLE 9.--Cash Crop Returns, Kenya and Kisii District, 1960-1970, Kh.[a]

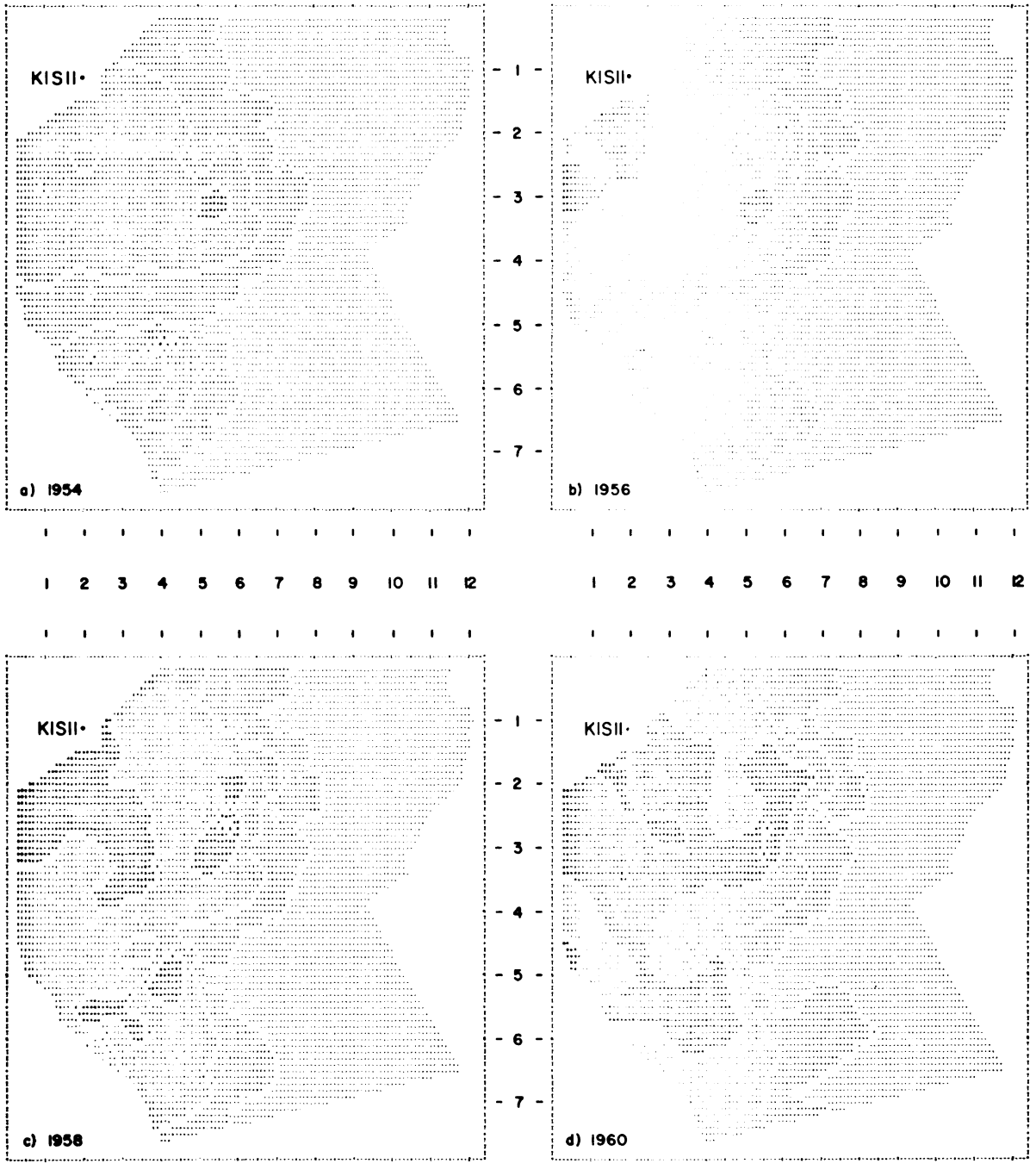
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Coffee										
Kenya	9,416,000	10,424,000	10,482,000	10,996,000	13,926,000	12,944,000	18,619,000	13,995,000	12,676,000	16,569,000
Kisii	244,883	231,086	230,050	285,196	400,962	457,862	694,862	469,832	935,436	717,741
Percent[b]	2.6	1.9	2.1	2.9	2.8	3.8	3.8	3.6	7.4	4.3
Pyrethrum										
Kenya	2,470,000	2,470,000	2,214,000	1,089,000	908,000	1,475,000	2,532,000	2,699,000	2,629,000	1,261,000
Kisii	129,783	279,888	128,180	123,016	245,714	535,500	643,650	912,586	692,191	520,662
Percent	5.3	11.3	5.8	11.3	27.1	36.3	25.4	33.8	26.3	41.3
Tea										
Kenya	5,323,000	4,788,000	6,694,000	6,829,000	7,790,000	7,331,000	9,906,000	8,927,000	9,290,000	11,159,000
Kisii	1,255	2,145	5,646	8,919	24,487	--	52,209	77,032	113,108	200,706
Percent	0.02	0.04	0.08	0.13	0.25	0.5	0.5	0.9	1.2	1.8
Passion Fruit										
Kenya[c]	826,000	693,000	758,000	531,000	530,000	551,000	675,000	806,000	810,000	912,000
Kisii	--	--	--	3,750	2,374	16,716	10,243	1,714	1,614	8,715
Percent				0.7	0.4	3.0	1.5	0.2	0.2	1.0

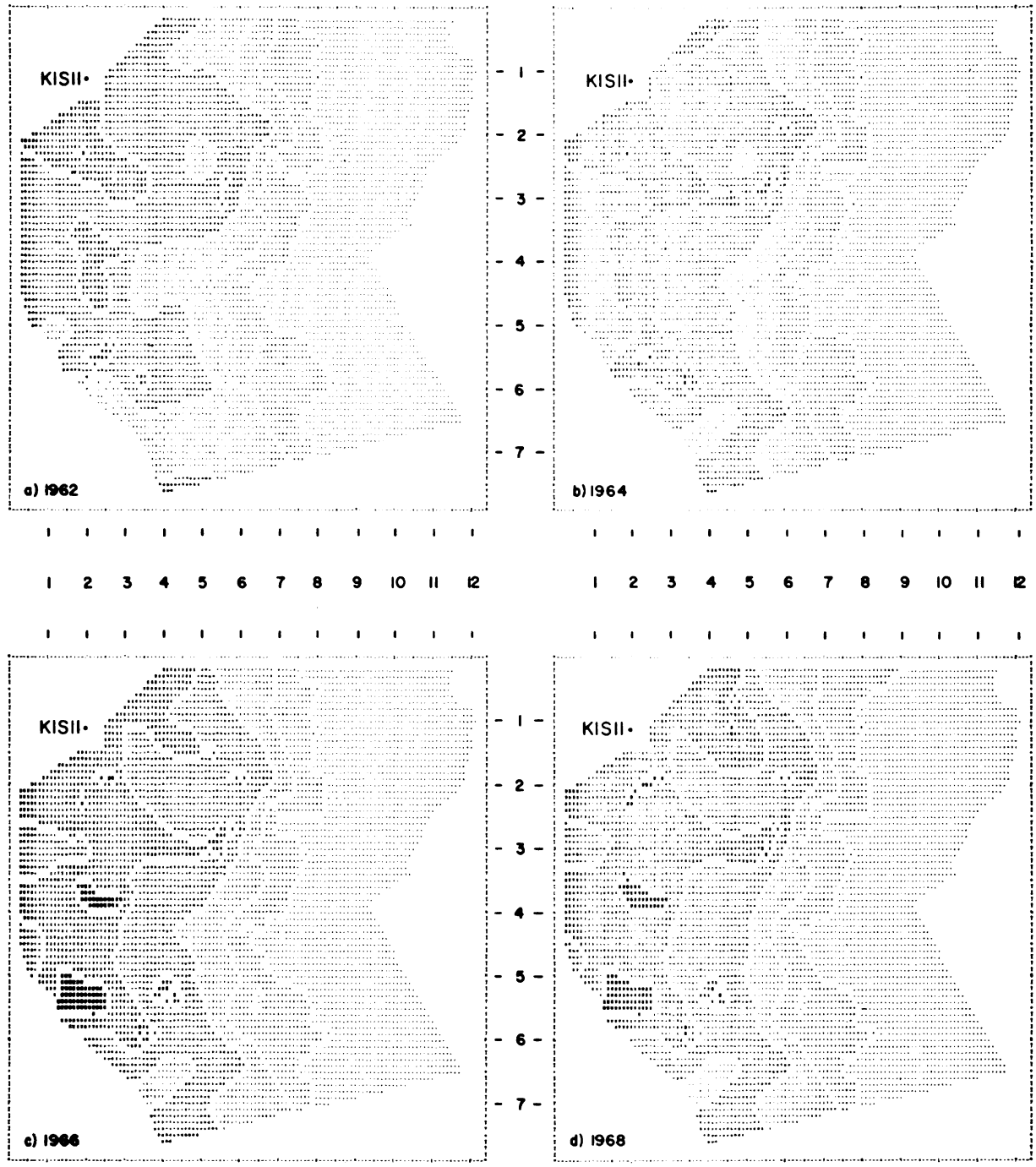
[a]Kh 1.00 = U.S. $2.56 [b]Kisii District as a percent of total Kenya production.

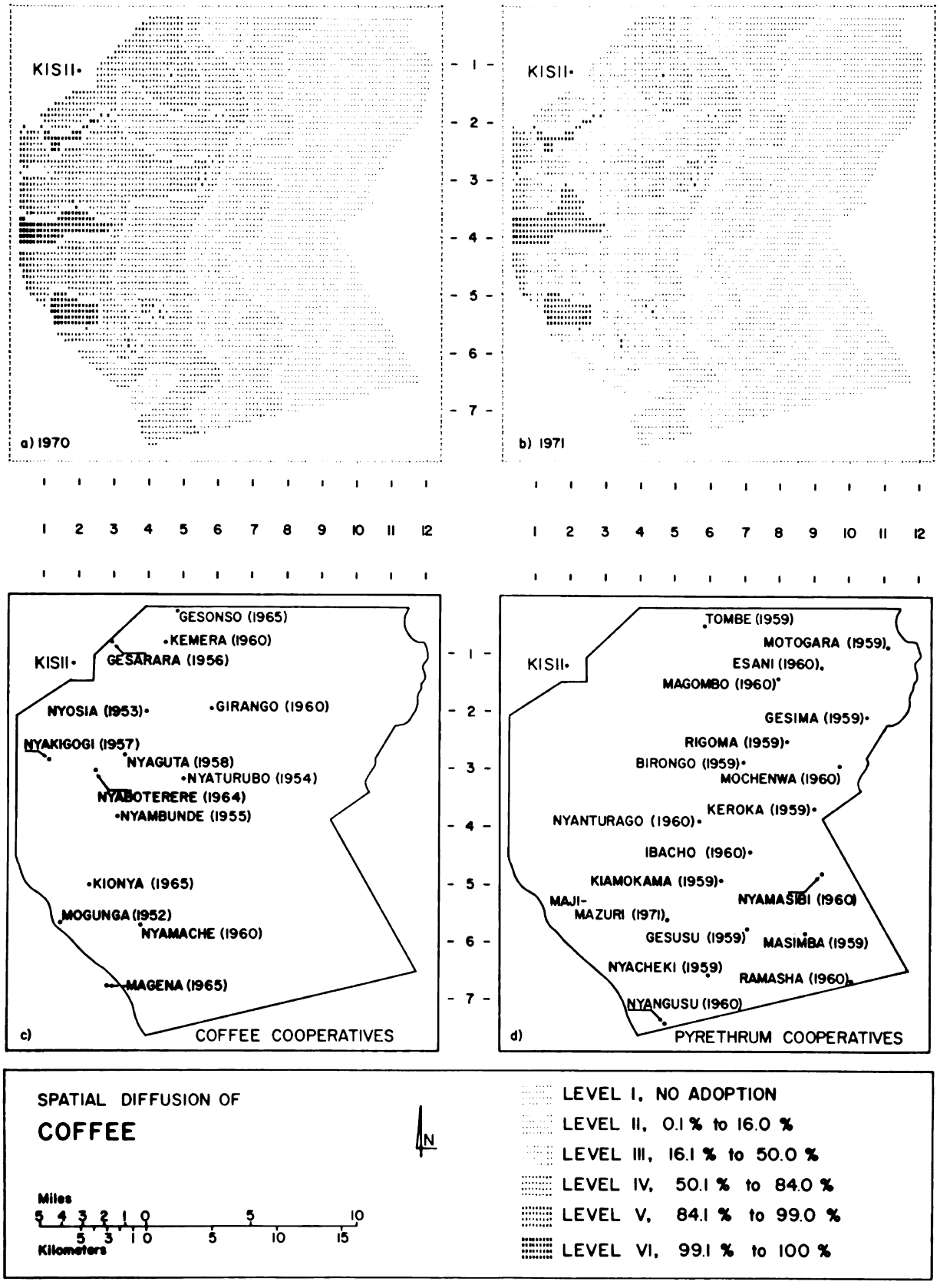
[c]Listed only as "Fruit," no national production figures for passion fruit are given.

Sources: Compiled from Kisii District, Annual Reports, 1959 to 1970, and Kenya, Economic Survey, 1963, 1967, 1969, and 1970.


KISII
a) 1940
b) 1945
c) 1950
d) 1952
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7
SPATIAL DIFFUSION OF
COFFEE
N
Miles
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %


KISII
a) 1954
b) 1956
c) 1958
d) 1960
1 2 3 4 5 6 7 8 9 10 11 12
SPATIAL DIFFUSION OF
COFFEE
N
Miles
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %


KISII
a) 1962
b) 1964
c) 1966
d) 1968
1 2 3 4 5 6 7
1 2 3 4 5 6 7 8 9 10 11 12
SPATIAL DIFFUSION OF
COFFEE
N
Miles
5 4 3 2 1 0 5 10
5 3 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %


KISII
a) 1970
b) 1971
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7
GESONSO (1965)
KEMERA (1960)
GESARARA (1956)
NYOSIA (1953)
GIRANGO (1960)
NYAKIGOGI (1957)
NYAGUTA (1958)
NYATURUBO (1954)
NYABOTERERE (1964)
NYAMBUNDE (1955)
KIONYA (1965)
MOGUNGA (1952)
NYAMACHE (1960)
MAGENA (1965)
c) COFFEE COOPERATIVES
TOMBE (1959)
MOTOGARA (1959)
ESANI (1960)
MAGOMBO (1960)
GESIMA (1959)
RIGOMA (1959)
BIRONGO (1959)
MOCHENWA (1960)
KEROKA (1959)
NYANTURAGO (1960)
IBACHO (1960)
KIAMOKAMA (1959)
NYAMASIBI (1960)
MAJI-MAZURI (1971)
GESUSU (1959)
MASIMBA (1959)
NYACHEKI (1959)
RAMASHA (1960)
NYANGUSU (1960)
d) PYRETHRUM COOPERATIVES
SPATIAL DIFFUSION OF
COFFEE
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %

Kisii, but this had increased to 7 percent by 1968, but dropped to 4 percent in 1969 (Kenya, 1964a and 1969a; and Kisii, Annual Reports, 1960-70).

In 1940 coffee was grown in three separate places in the study area (Figure 18a). Little or no further adoption took place in the 1940 to 1945 interval, but by 1950 acceptance had spread considerably, and in 1952 coffee was grown by a few farmers in about one-third the final area where adoption occurred in 1971. After 1952 the forward edge of the diffusion wave gradually moved outward, and finally stabilized in the mid-1960's. From the very beginning new nodes did not appear in isolated locations where there had been no previous adoption; instead higher levels of adoption appeared. Frequently these higher levels of adoption were a prelude to the construction of a new coffee factory. The processing carried out at the factory requires large amounts of water so they are located along streams. After the construction of the factory it is sometimes possible to identify that location as a new diffusion node. In other cases there is usually a gradual movement of the higher level of adoption into the immediate area.

The first coffee factory to be constructed was at Mogunga (H1.5-V5.5)* in 1952 (Figure 18a). Nearby was

*Refers to locational coordinates on the maps of spatial diffusion, hence H1.5-V5.5 is Horizontal 1.5 and Vertical 5.5.

one of the original places where coffee was introduced in 1940. The first growers were forced to transport their coffee beans to Kisii for over a decade before the factory was built. By the time of construction adoption had reached Level III so there certainly was enough local production to justify the factory. The post-construction period saw a continual increase in adoption in the surrounding area; first a spread of Level III, then the emergence and spread of Level IV adoption. By 1962 Level V emerged a few km. to the northeast, and in 1964 Level VI, complete acceptance, was achieved, which necessitated the construction of the nearby Kionya (H3.0-V5.0) factory in 1965. This area epitomizes the development of pre-factory adoption that is the reason for construction of a factory and the cause of a post-construction increase in adoption.

The second factory to be constructed in the study area was built at Nyosia (H4.0-V3.0) in 1952. In 1950 this area stood out as a Level III enclave within a larger area of Level II adoption. Level III then spread over a large area so that it no longer stood out as an area of higher adoption at construction time. No great increase in adoption occurred in the immediate area after the installation of the factory, and by 1966 the surrounding area was one of lower adoption in relation to the larger area. So, in this case, the slightly higher

level of adoption predated the factory, but no adoption response resulted from the placement of the factory.

The Nyaturubo factory (H5.0-V3.0), the third in the study area, was built in 1954. Nearby was one of the original areas of introduction. When constructed in 1954, a Level IV node was clearly visible near the factory site. This level then increased in size and by 1958 had coalesced with the same level found to the north. Also, that same year a Level V developed at the factory site and eventually joined with an extension of that level from the west. In 1968 a small area of 100 percent adoption came into being just to the north of the factory (H5.5-V3.0). Again, as with Mogunga, adoption came before the factory, followed by increased acceptance of coffee growing in the immediate area after construction.

The remainder of the study area seems to have followed the same general pattern. There was always a sufficient number of people growing coffee within a reasonable distance to justify the construction of the factory. Since the factory required sitting on a stream it often was not placed in the middle of the area of higher adoption. Normally the factory site does not stand out as a diffusion node, but a definite market location attraction can be detected. Higher levels of adoption gradually move in the direction of the new factory rather than some other direction. Perhaps the

best example of this can be seen around the Nyakigogi factory (H1.5-V3.0). In 1956 this area stood out as a place needing a factory, so one was built in 1957. However, adoption did not increase in the immediate area, instead the surrounding land saw an increase in adoption. By 1971 the lower level of adoption adjacent to the factory had been nearly eliminated.

In the southern part of the coffee-growing area is an anomaly. Southwest of Magena (H3.0-V6.5) and Nyamache (H4.0-V5.5) towards the southern border of the district there are no coffee factories, but acceptance of coffee has reached Level IV. This seems strange in light of the close relationship of factory sites and high adoption areas to the north. That is, until one considers the differences in transport. For here is the only part of the study area where there are substantial numbers of donkeys available for use as pack animals. It appears, therefore, that the ability to inexpensively and easily transport the coffee beans has encouraged the adoption of coffee as a cash crop.

Places of abnormally low adoption sometimes stand out on the map. An example would be the area around Keumbu (H5.0-V2.5) that had a lower acceptance rate in 1956. No topographic or economic reason for this abnormality can be offered for the temporary lag in adoption. By 1966, ten years after it first appeared,

it ceased to exist. A possible cause could be a local opinion leader who opposed the innovation, retarding the rate of adoption. However, this is only speculation and cannot be verified.

In summary, it appears certain that the location of the coffee factories, that serve as the marketing sites, exert a strong influence on the spatial diffusion pattern. The earlier adopters are those individuals willing to invest more work to gain a cash income as they had to literally carry (except in the south of the adoption area) the coffee beans to the factory.

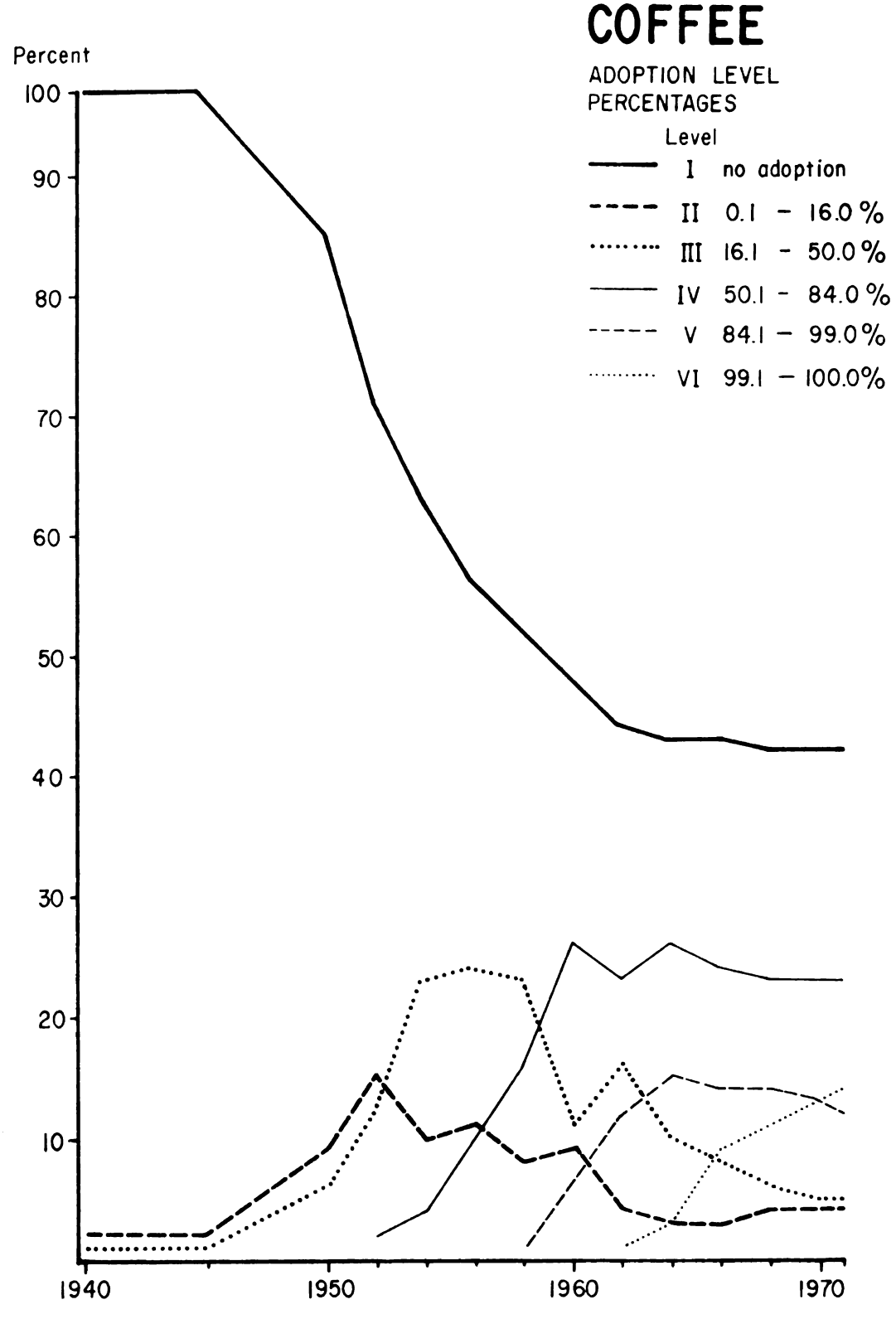
When considered within the Hagerstrand typology of spatial innovation this adoption pattern displays only three of the four stages. Stage I, the primary stage, existed from 1940 to 1950. Regional contrasts were certainly present, but they were by no means strong as the adoption level was low everywhere. Stage II, the diffusing stage, is evident from 1950 to 1962. A strong outward movement of the diffusion wave is evident, but isolated diffusion nodes do not exist. Instead there are small peaks of higher adoption, rising above a lower level of adoption. A reduction in regional contrasts is achieved by the enlargement of the adoption peaks until they coalesce to form broad regions at the higher level of adoption. Stage III, the condensing stage, is noticeable from 1962 to 1971. In a general way, the rate of increase

is equal in all areas that had adopted coffee by 1962. While virtually no increase in the area of adoption took place, the area with the higher levels of adoption increased in size so that the former peaks became broad areas.

Figure 22 pictures the percent of the sampling areas at each level of adoption by year. In 1940, 97 percent of the sampling areas had no farmers growing coffee. That figure was reduced to only 42 percent by 1971. The number of sampling areas in Levels II and III first increased, then decreased as the higher adoption levels were reached in more areas. The top three adoption levels appeared later and at different times. Levels IV and V decreased slightly in extent after 1960 and 1964, respectively, but Level VI continued to expand. This graphic analysis indicates that after 1964 there was only one new area of adoption. An increase in intensity for the highest adoption levels continues as these areas comprise more and more of the total. Thus the gradient between no adoption and complete adoption steepens over time.

Adoption level percent graphs offer another way of depicting the innovation waves suggested by Morrill. It can be seen that the top line, indicating the decline in areas with no adoption, is the growth curve in reverse. Initially the spread of the diffusion wave's leading edge

Figure 22


COFFEE
ADOPTION LEVEL
PERCENTAGES
Level
I no adoption
II 0.1 - 16.0 %
III 16.1 - 50.0 %
IV 50.1 - 84.0 %
V 84.1 - 99.0 %
VI 99.1 - 100.0%
Percent
100
90
80
70
60
50
40
30
20
10
1940
1950
1960
1970

is slow, then it speeds up and finally slows down again. The other adoption levels indicate the character of the diffusion wave. Levels II, III, IV and V each reach their maximum extent in succession, then begin to decline. Such behavior would indicate that the outer edge of the diffusion wave moves outward at low adoption levels, then the areas where adoption has taken place increase in intensity as the outer edge of the wave advances at a slower speed. As each successive adoption level enters and fades away the gradient from no adoption to saturation steepens. Between 1966 and 1971, for example, Level I nearly ceased to move outward, Level II expanded slightly, Level III declined considerably in areal extent, Levels IV and V retreated slightly in areal extent, and Level VI continually expanded. Thus the diffusion wave does not move outward and upward at the uniform rate suggested by Morrill, but it spreads rapidly outward at low intensity and then increases in adoption percent while the outer edge advances very little. Figure 5 (page 62) compares the waves suggested by Morrill with those found in Kisii. Basically, the principal differences between the two wave patterns is the greater outward movement at low intensity in Kisii during "T_2" and the effect of distance friction during "T_3" and "T_4" in the Kisii graph. Similar patterns were found for all the innovations with adequate acceptance levels to generate a rather complete diagram.

Spatial Diffusion of Pyrethrum Adoption

The first few commercial pyrethrum plots were planted in the Rigoma area (H8.0-V2.5), Kitutu Location, in 1950 (see Figure 23a), where a nursery had been established. The first introduction was not very successful because of the poor quality of the clone varieties. In fact, the number of farmers raising pyrethrum at that time was so small that the random survey did not locate any of the original growers. Beginning in 1956 the adoption rate began to increase rapidly, with the diffusion wave moving from the eastern border of the district toward the west. Pyrethrum has proven to be particularly popular with the Gusii farmer because of its desirable characteristics such as high profitability and the ease of establishing a new plot. Also it can be adopted in small units that are amenable to the intensive Gusii farming system (Uchendu, 1969, p. 37).

Between 1954 and 1960, the percent of farmers within the study area growing pyrethrum rose from about 4 percent to about 38 percent. Projecting that rate out to 1968 would have meant nearly complete adoption within the study area. In 1960 the farmers of Kisii District produced about 60 percent more than their quota set by the Pyrethrum Marketing Board. The Board paid the full price for all production within the quota and full price of KSh. 5.83 per kilogram (U.S. $.34 per pound) for the

first one-third of the overproduction, but only KSh. 2.20 per kilogram (U.S. $.13) for the remainder. In response to the financial penalty for overproduction many farmers uprooted much of their pyrethrum. Fortunately, only very few uprooted all of their plants (Kisii, Annual Report, 1961, p. 13).

In 1962 a system of individual production quotas was introduced in which every producer was allocated a specific poundage of dried flowers and was warned he would receive lower payments per pound for over- or under-production. This system apparently bolstered confidence in the future, although the District Agricultural Officer did not recognize it at the time. In his annual report he wrote, "For reasons which are not clear, interest in Pyrethrum sharpened in July and by the end of the year the acreage had very much increased again" (Kisii, Annual Report, 1962, p. 10). After that date pyrethrum adoption continued, though as a reduced rate as compared to the 1954 to 1960 period (see Table 9). Pyrethrum, as of 1971, had not reached the top of the "S" shaped growth curve as the rate continues unabated.

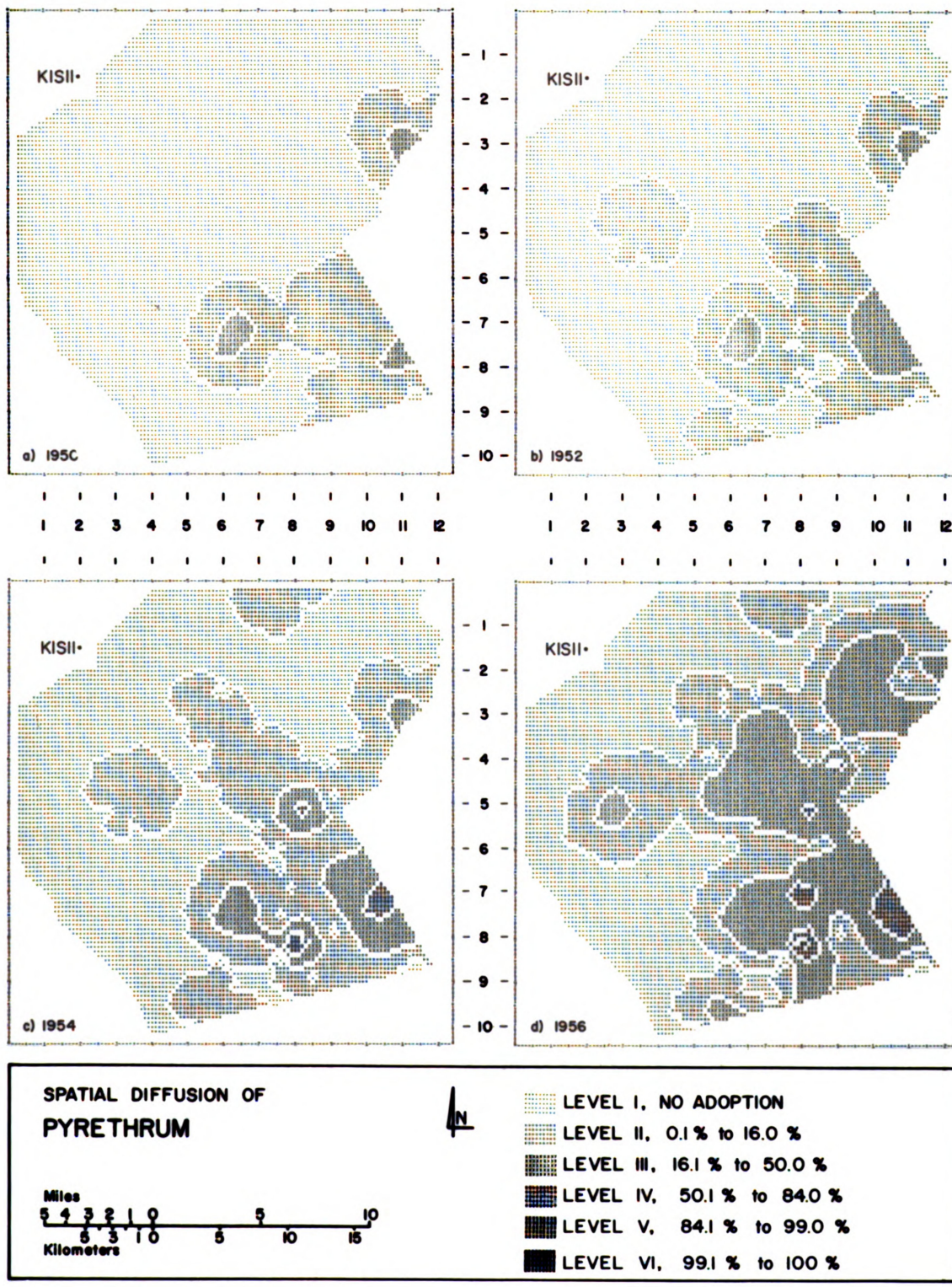
The importance of Kisii District to Kenya pyrethrum production continues to increase. In 1961 (Table 9) it contributed only 4 percent of the total pyrethrum production of the country, but by 1968 that level had increased to 34 percent. The cash return to Gusii farmers

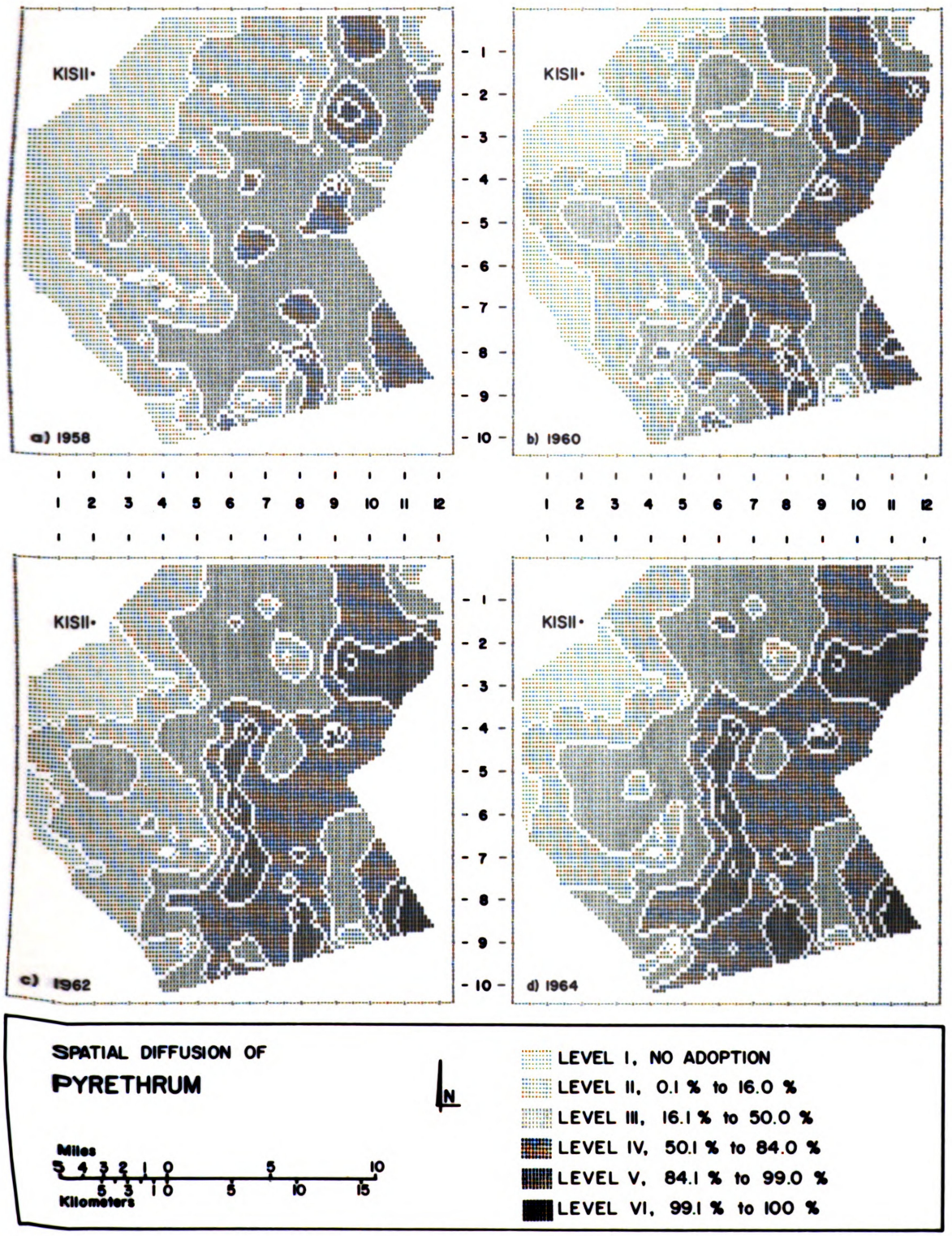
increased from KŁ 130,000 (U.S. $332,000) in 1960 to a peak of KŁ 913,000 (U.S. $2,337,000) in 1967 (see Table 9). The problem of overproduction again arose, and due to the punitive price reduction and lower prices the total revenue went down. But large-scale rallies prevented the reduction of adoption that occurred from 1960 to 1962. In 1969 a low of KŁ 520,000 (U.S. $1,331,000) was reached but a drop in pyrethrum production throughout Kenya allowed Kisii to increase its portion to 41 percent of the total. In 1967 pyrethrum earned Gusii farmers more than coffee, but coffee then took over the lead again in 1968 and 1969. However, the future for pyrethrum in Kisii District looks relatively good so it should regain the lead (Kisii, Annual Report, 1961-1970).

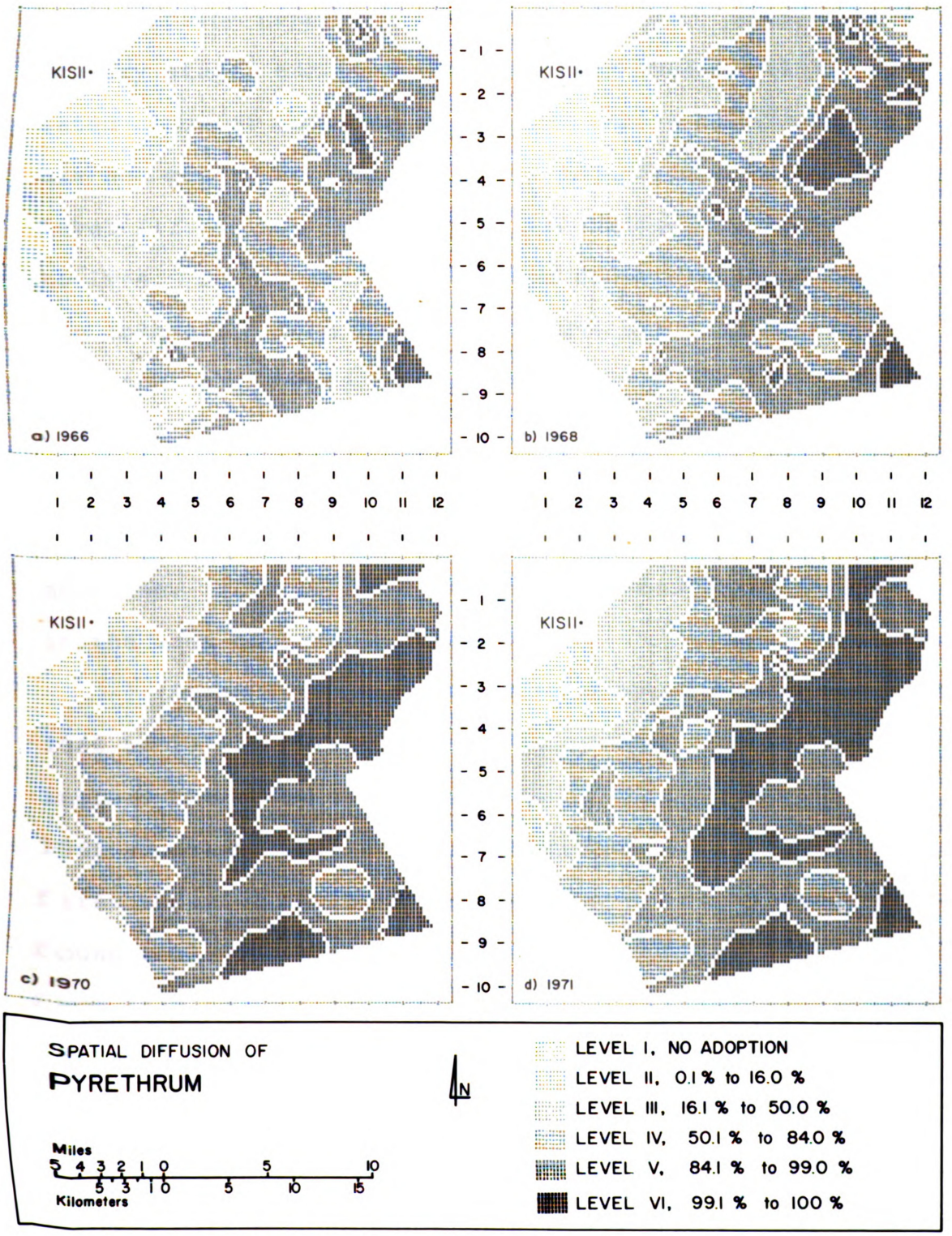
From 1950 to 1954 (see Figure 23) pyrethrum was accepted over a large area, but the percent of adoption in a particular area was low. Small areas with a higher level than the surrounding territory emerged, and finally in 1956 an area (H8.0-V8.0) reached 100 percent adoption for the first time. Two years later, just north of Keroka (H9.0-V4.0), everyone was growing pyrethrum. During this initial phase the farmers had to market their pyrethrum with the Masaba Farmers Cooperative Society in Keroka. To get the dried flowers to Keroka was expensive as vehicles had to travel long distances to pick up only small amounts of pyrethrum. But in 1959 the

Masaba Cooperative Union, with full responsibility for pyrethrum marketing in Kisii District, was established. At that same time 12 local societies were formed, followed by 12 more local societies in the middle of 1960 (Interview #3). The individual cooperative societies therefore greatly reduced the expense and difficulty of getting the pyrethrum flowers to a marketing place.

By the end of 1960 (Figure 24b) no new areas of complete acceptance had surfaced, but a significant expansion of Level IV took place. In 1962 an area of high adoption on a north-south axis emerged (H6.5-V4.0 to H6.0-V8.0). Within that area were three spots with complete acceptance of pyrethrum growing. These three were all located near one of the marketing societies. The northern most place was near the Birongo cooperative society, while the two places to the south were between Nyaturago and Kiamokama, and Kiamokama and Gesusu cooperative societies, respectively. For the next nine years there was little expansion of the forward edge of the diffusion wave, instead a constant intensification took place. It is quite significant that all of the areas with 100 percent adoption are located less than 5 km. from a pyrethrum society. Considering that the Gusii will often walk 10 or more km. to go to a local market, this distance in indeed short.


KISII.
a) 1950
b) 1952
c) 1954
d) 1956
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10
SPATIAL DIFFUSION OF
PYRETHRUM
N
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers


KISII
a) 1958
b) 1960
c) 1962
d) 1964
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10
SPATIAL DIFFUSION OF
PYRETHRUM
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %

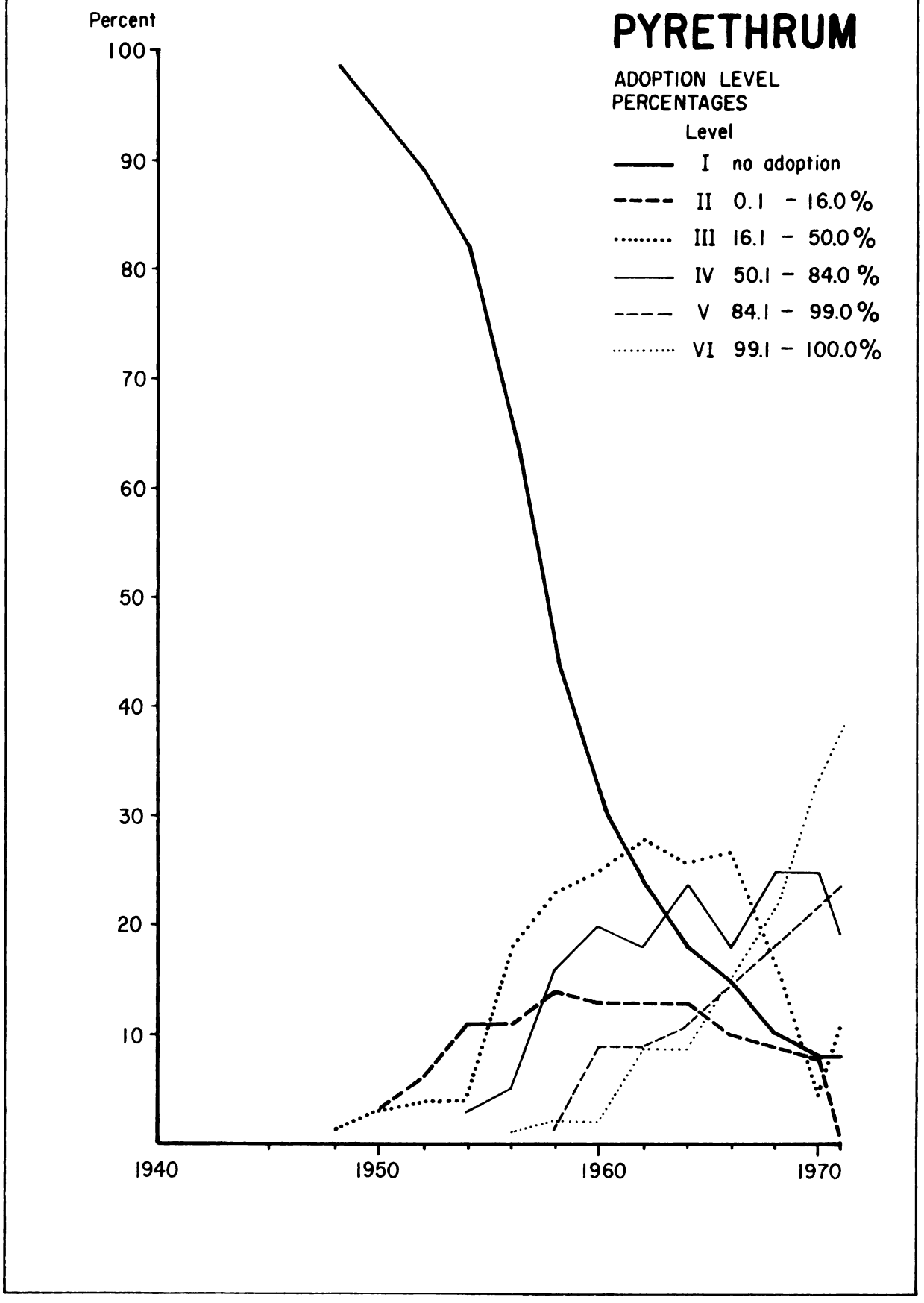

KISII
a) 1966
b) 1968
c) 1970
d) 1971
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10
SPATIAL DIFFUSION OF
PYRETHRUM
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %

In the Hagerstrand typology of spatial innovation the diffusion process proceeds as follows: Stage I, the primary stage, can be identified from 1950 to 1952. Isolated nodes of adoption exist, but the regional contrasts are not great, as exemplified by the maximum of adoption Level III. Stage II, the diffusing stage, is from 1954 to 1964. Only a few new isolated nodes developed during the interval. Most important is the build up of high adoption levels with numerous adoption peaks (i.e., small areas of higher adoption levels). In 1959 and 1960 the pyrethrum cooperative society offices were constructed, and the result was a considerable expansion of Level IV adoption. This period also experienced a large increase in the area of Level V adoption.

Stage III, the condensing stage, is manifest from 1966 to 1971. Relatively little outward movement occurred, instead there was an increase in intensity. Beginning in 1966 adoption Level V expanded considerably. Level VI first appeared during Stage II in 1956, and by 1966 was found in 11 isolated nodes of various sizes. The interval from 1970 to 1971 saw the rapid expansion and coalescence of Level VI areas. Stage IV has not been entered as there are still areas with no pyrethrum adoption.

Figure 26, showing the percent of the sampling areas at each adoption level, exhibits the same pattern as coffee, only more exaggerated. The areas with no

Figure 26

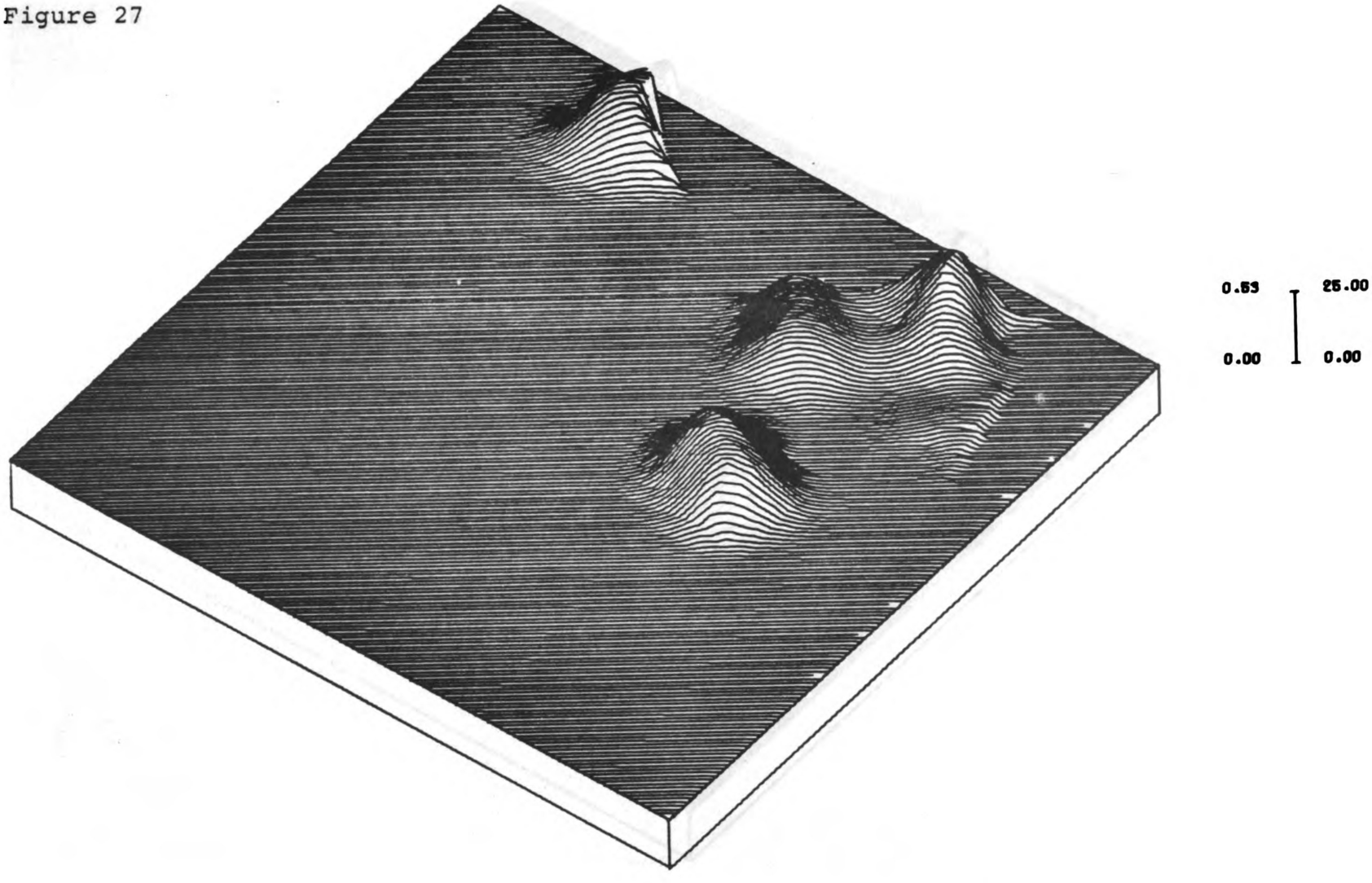

PYRETHRUM
ADOPTION LEVEL PERCENTAGES
Level
I no adoption
II 0.1 - 16.0%
III 16.1 - 50.0%
IV 50.1 - 84.0%
V 84.1 - 99.0%
VI 99.1 - 100.0%
Percent
100
90
80
70
60
50
40
30
20
10
1940
1950
1960
1970

pyrethrum adoption decrease rapidly and constantly for the entire time period. The lower levels of adoption, II and III, increase to maximum extent in the late 1950's and the early 1960's, then decline to very low percentages. Level IV went up to 20 percent of the total, then started fluctuating up and down, with a trend towards expansion. The two highest levels, V and VI, increased steadily for the time period.

This pattern depicts an initial rapid outward movement at low adoption levels, followed by intensification so that by the end of the time period the gradient from no adoption to complete adoption was very steep. It is possible to go from a place where pyrethrum is not grown to where all farmers raise it in only a distance of 10 km.

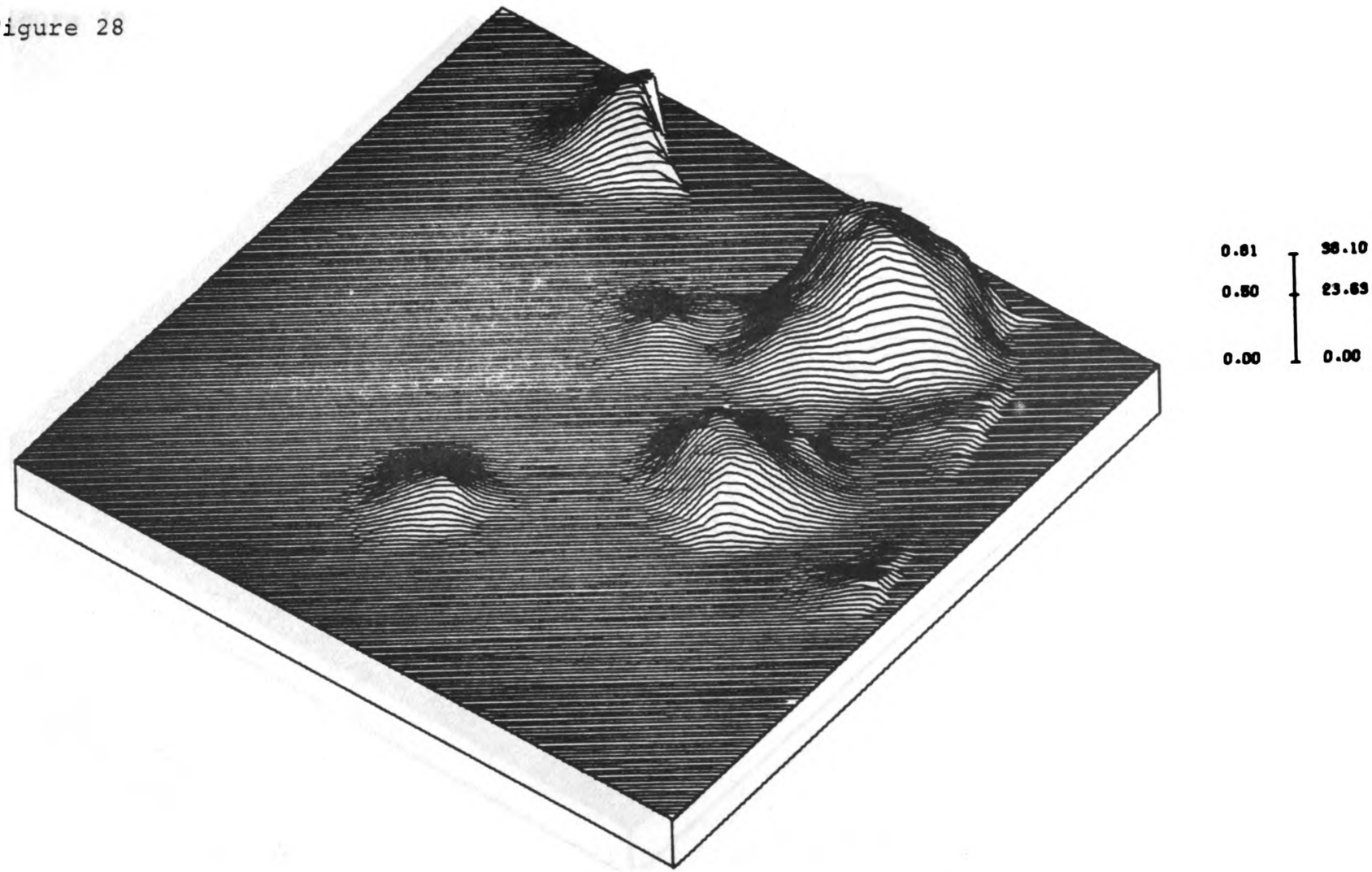
Figures 27 through 38 are three-dimensional oblique views of the spatial diffusion of pyrethrum adoption. The hills or peaks that are seen represent the percent of farmers who have adopted pyrethrum. Thus, the higher the hill or peak, the greater the percent of adoption for that year. The vertical scale to the right gives the percent of adoption represented by the various heights. In the early diagrams the boundary of the study area is not visible, but it begins to emerge as the diffusion wave reaches the edges of the study area. The diagram for 1971 has the boundary of the study area

Figure 27



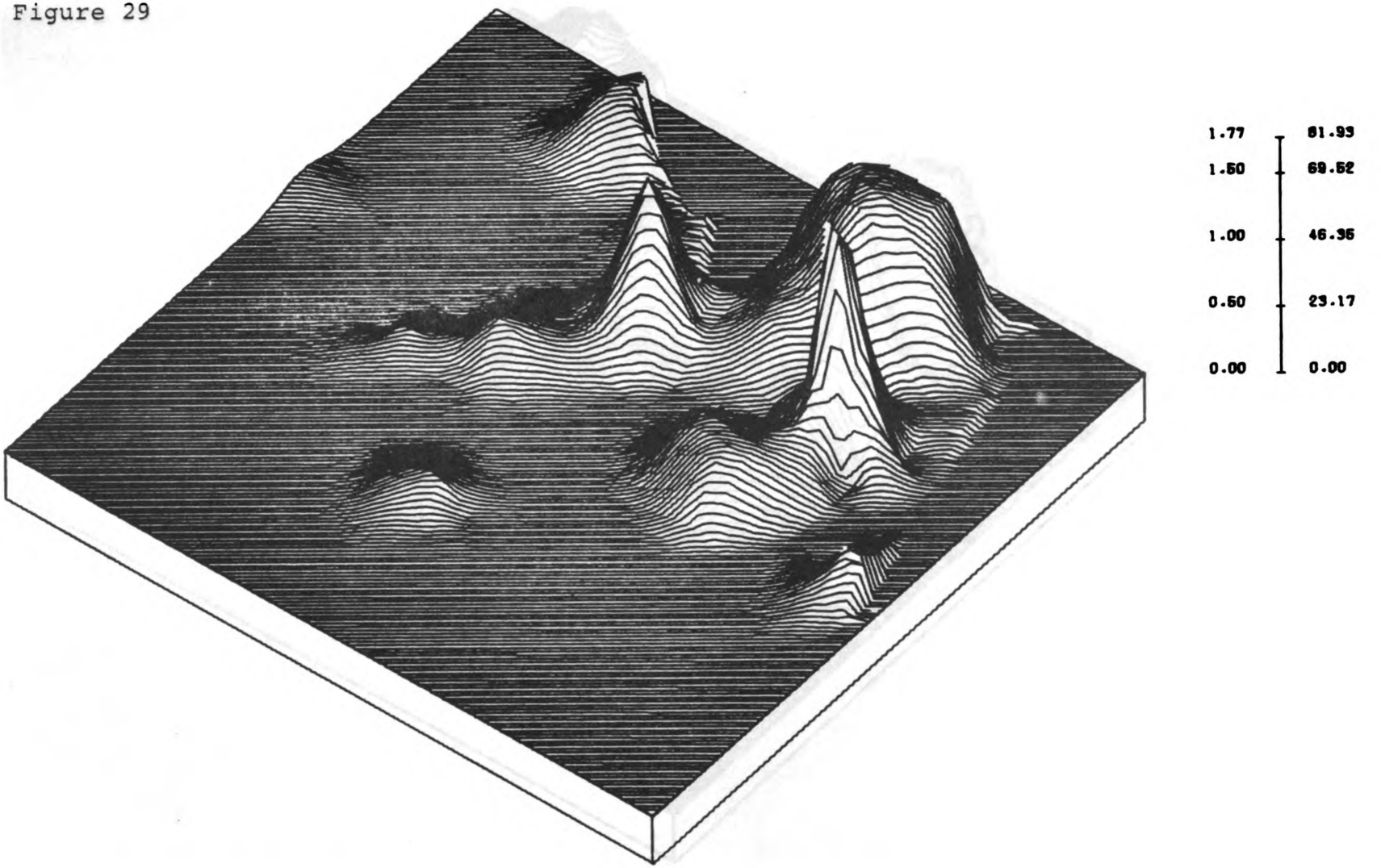
PYRETHRUM DIFFUSION 1950

Figure 28



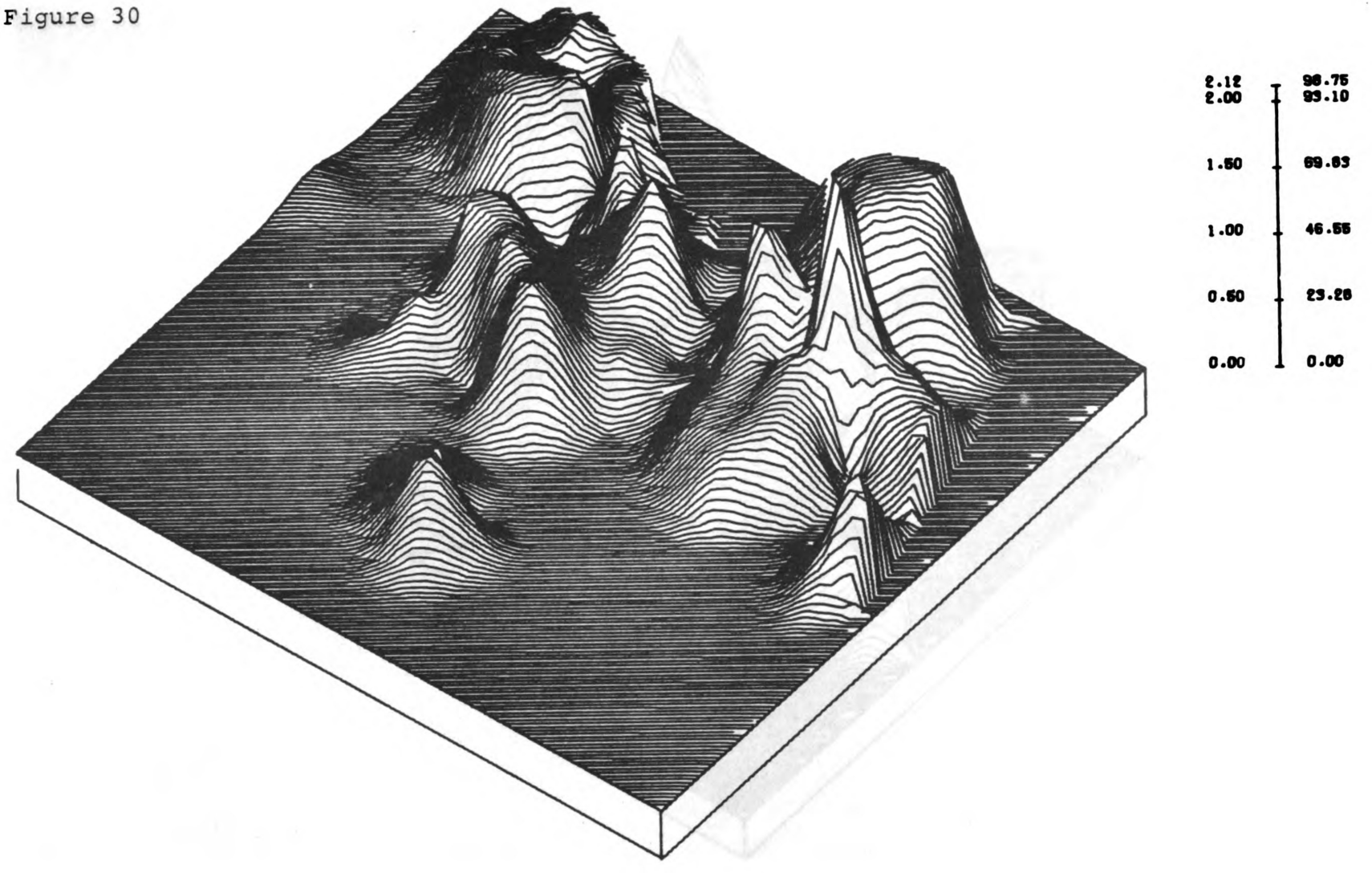
PYRETHRUM DIFFUSION 1952

Figure 29

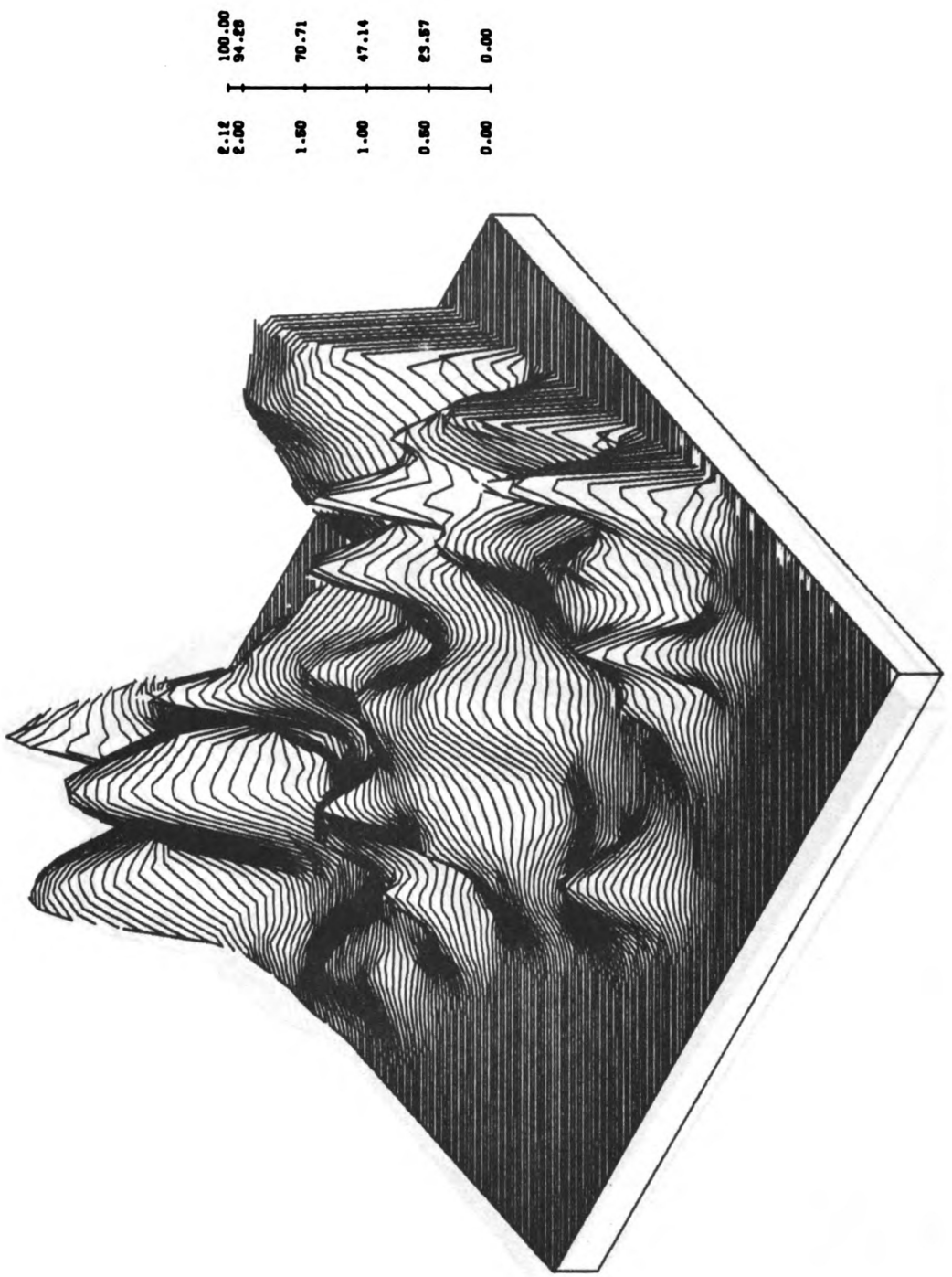


PYRETHRUM DIFFUSION 1954

Figure 30



PYRETHRUM DIFFUSION 1956


100.00
94.28
70.71
47.14
23.57
0.00
2.12
2.00
1.50
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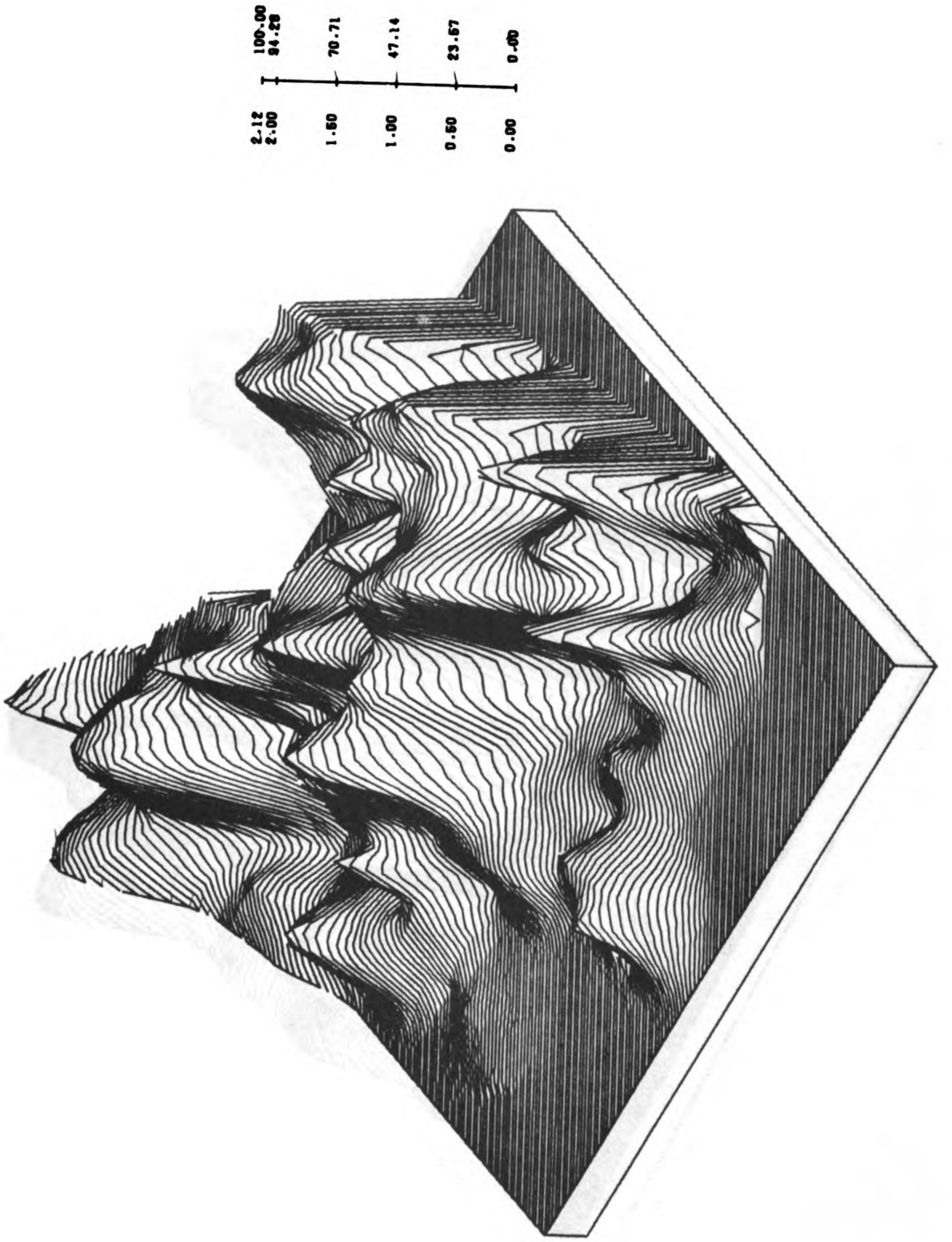
PYRETHRUM DIFFUSION 1958

Figure 31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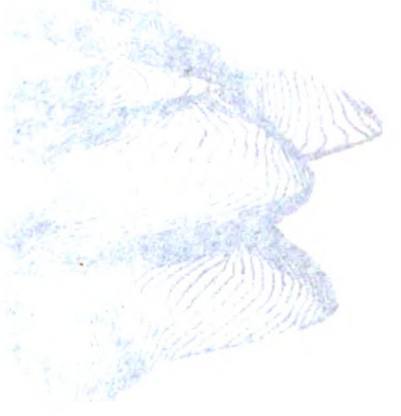
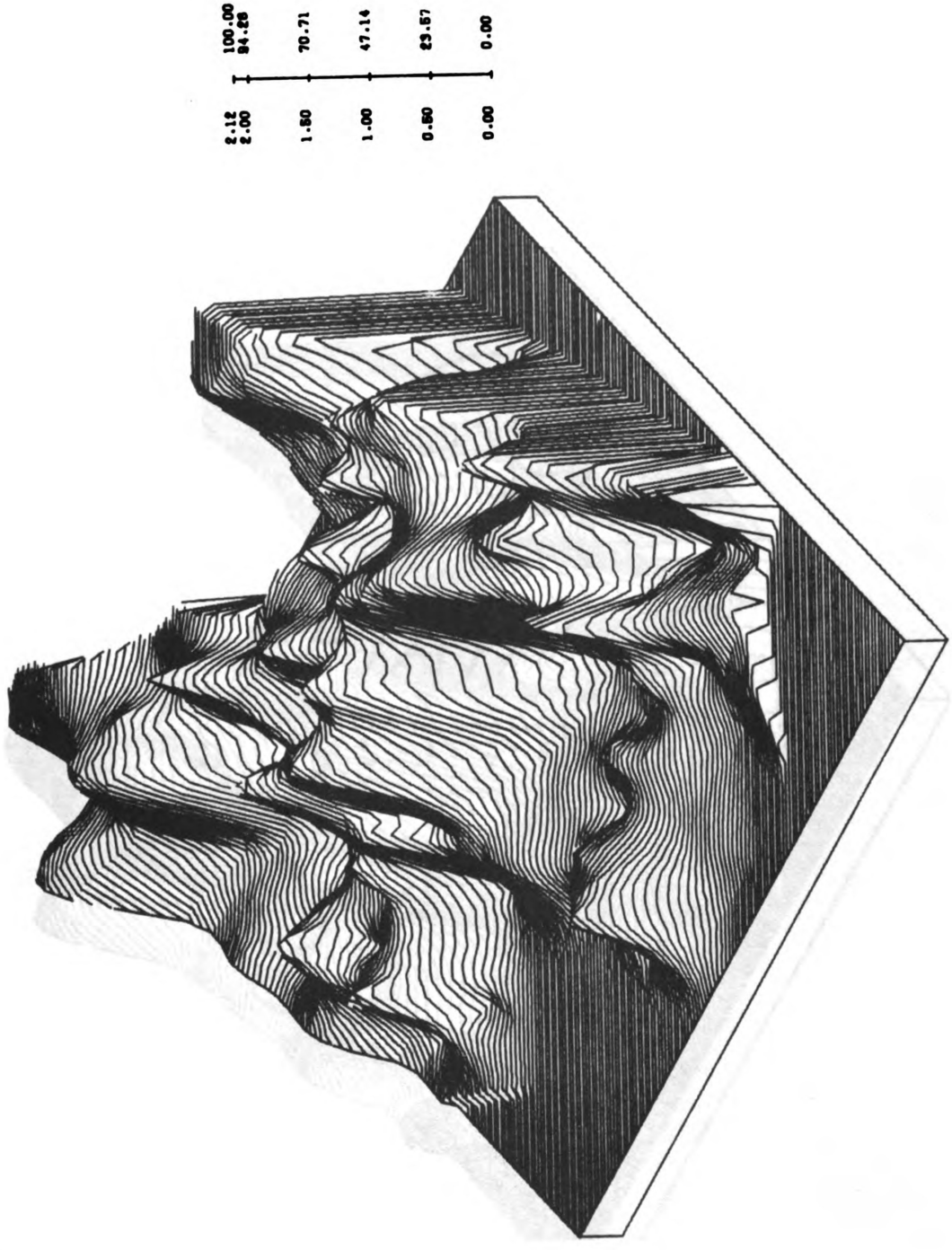
PYRETHRUM DIFFUSION 1960

Figure 32

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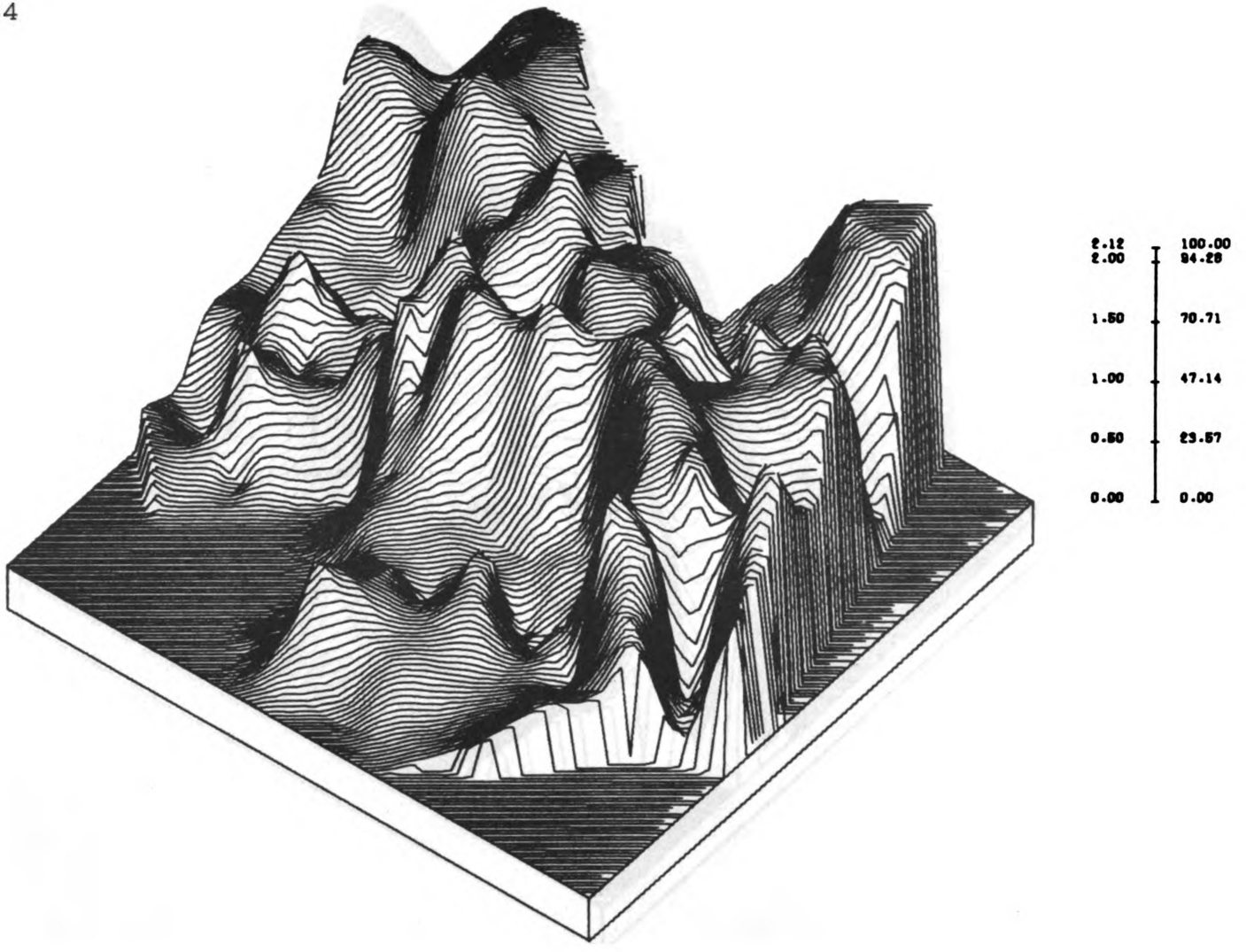
PYRETHRUM DIFFUSION 1962

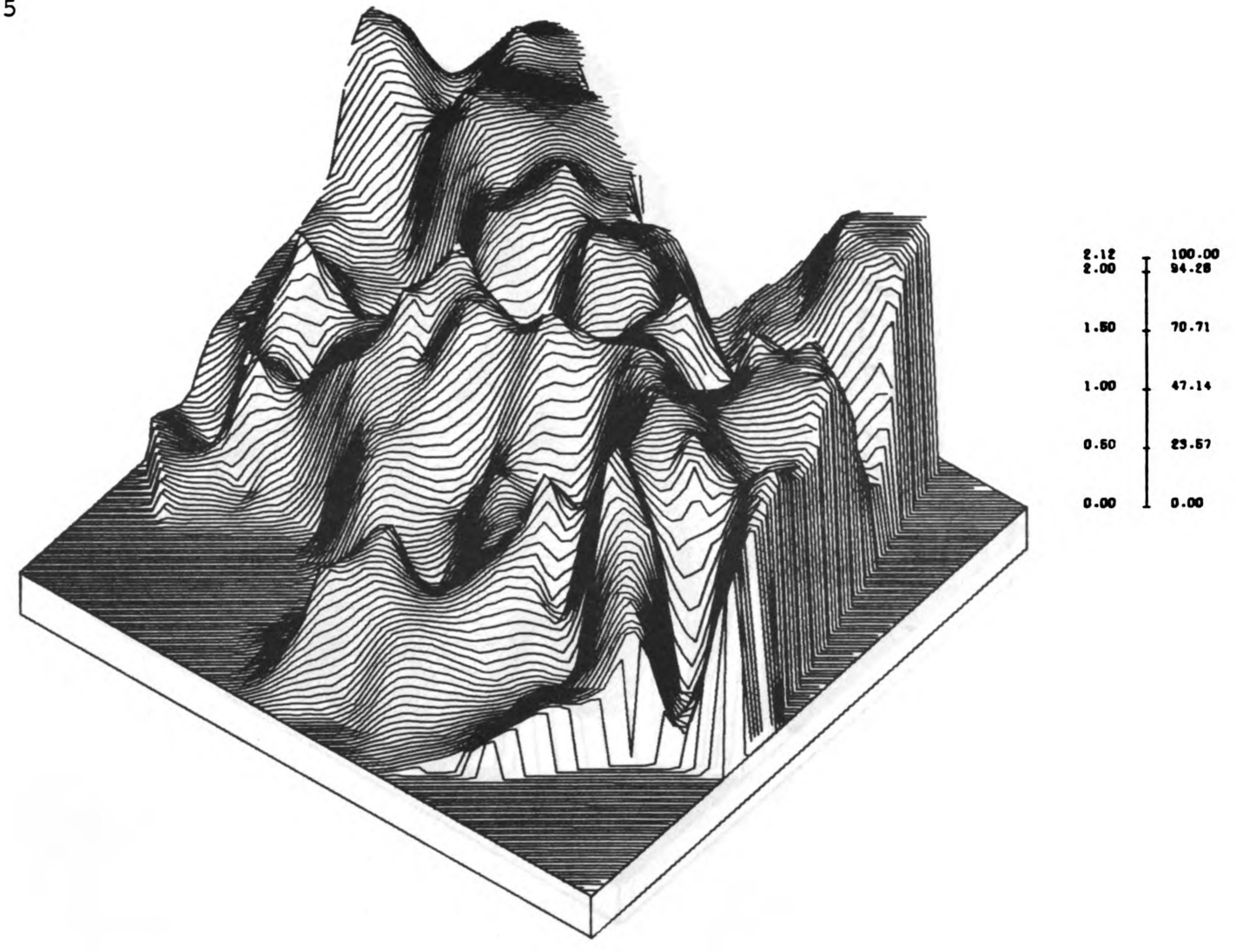
Figure 33

Figure 34

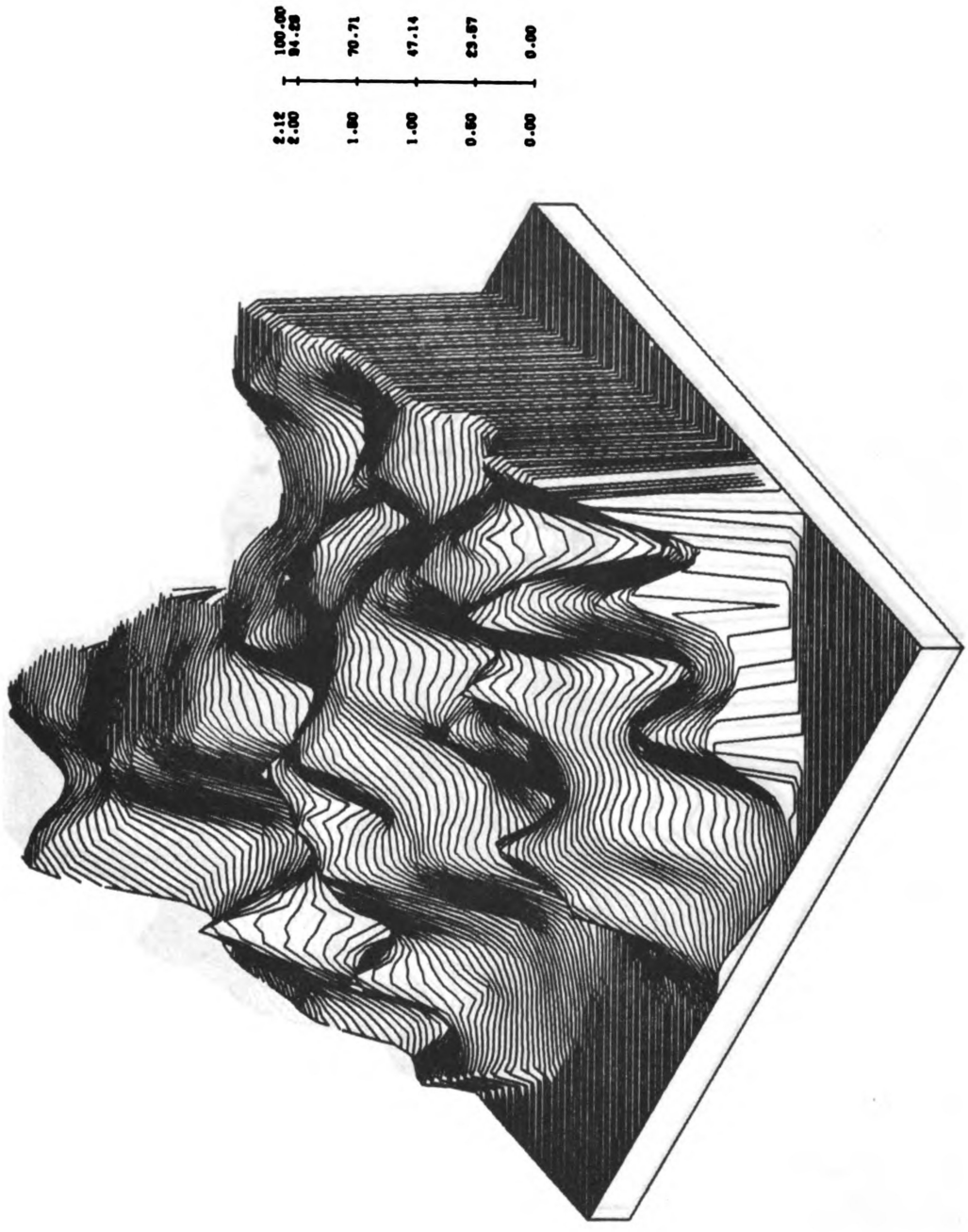


PYRETHRUM DIFFUSION 1964

Figure 35



PYRETHRUM DIFFUSION 1966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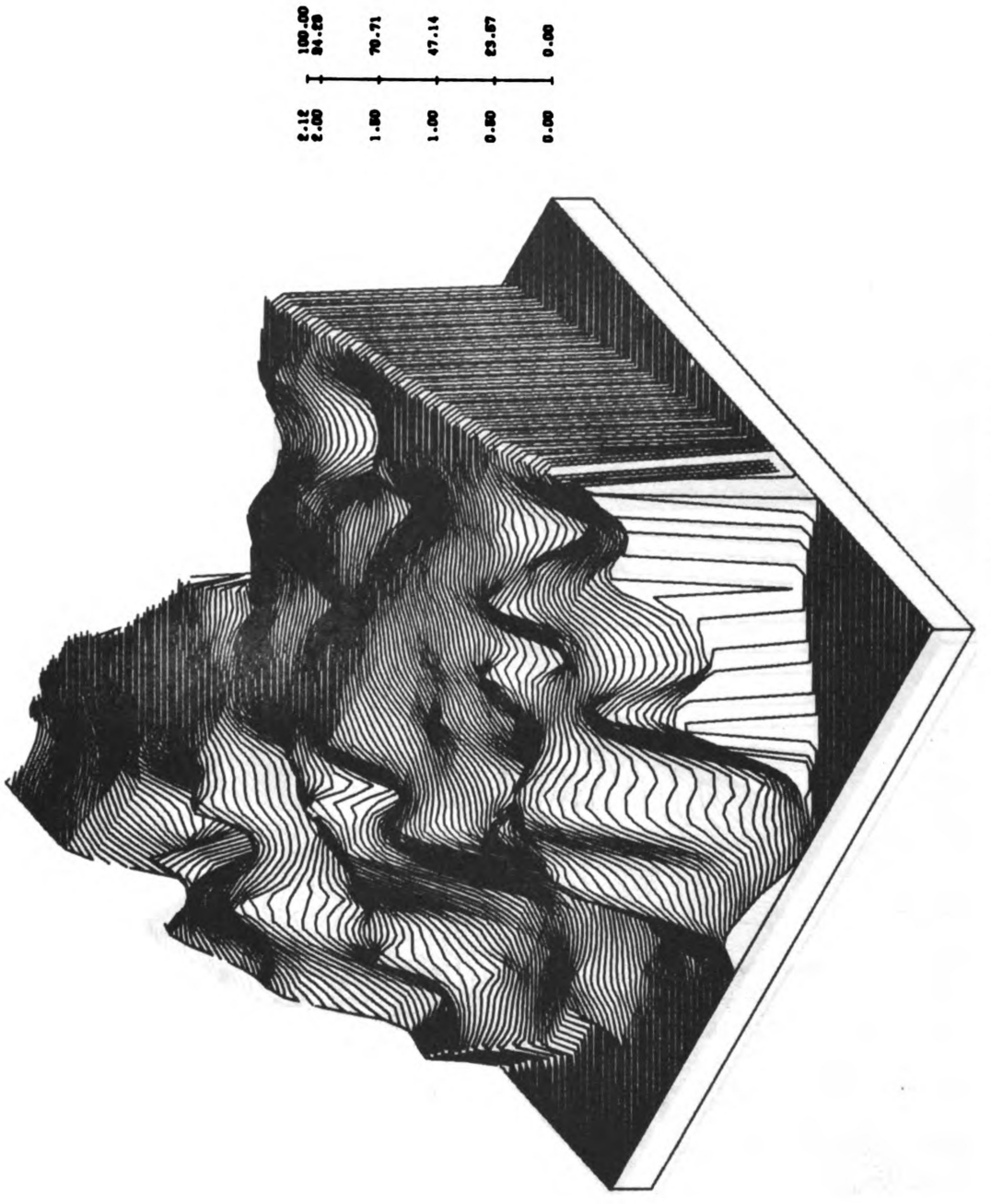
84.29
70.71
47.14
23.57
0.00
2.12
2.00
1.50
1.00
0.50
0.00
PYRETHRUM DIFFUSION 1968

Figure 36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84.29
70.71
47.14
23.57
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2.12
2.00
1.50
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PYRETHRUM DIFFUSION 1970

Figure 37

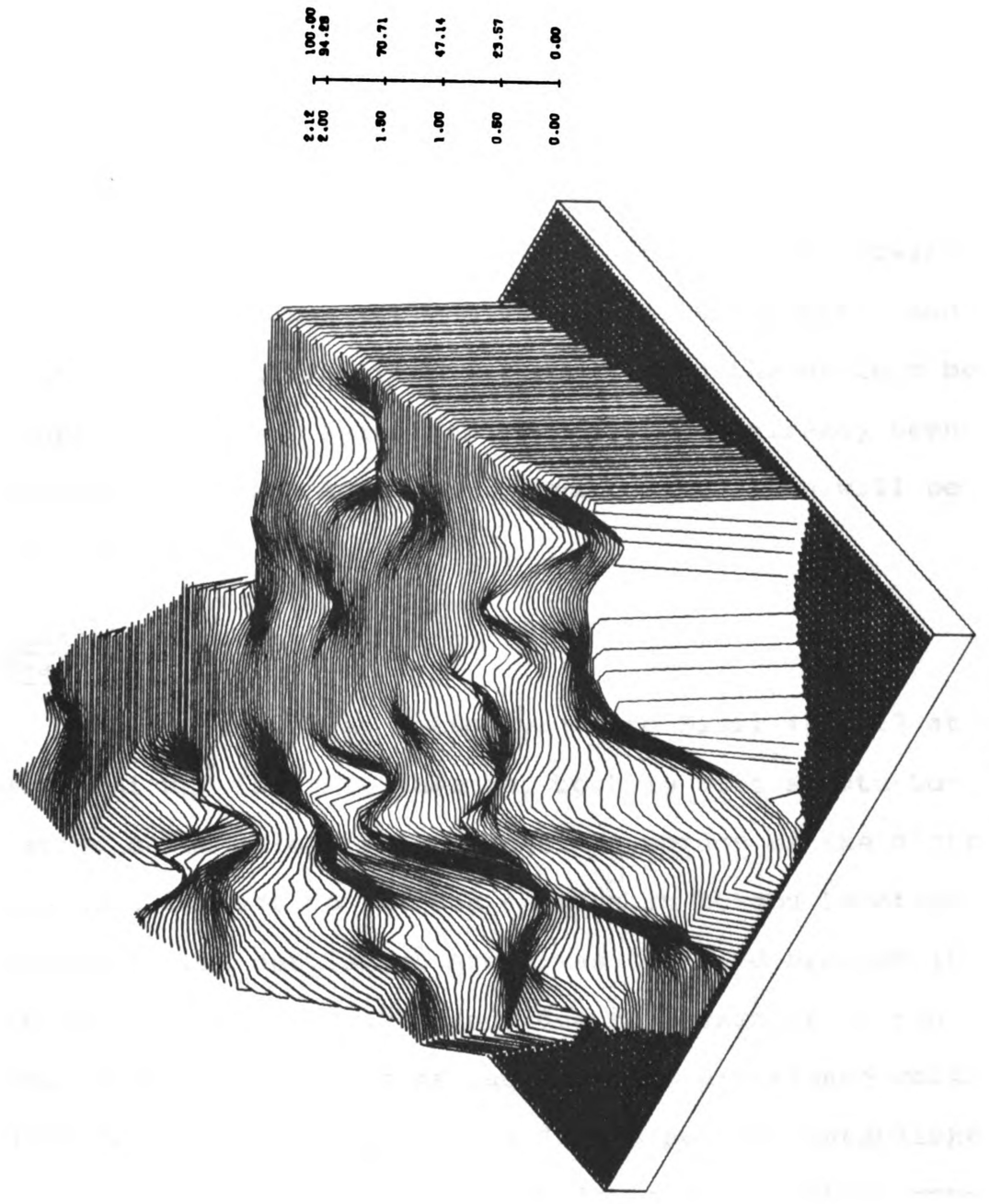

100.00
94.29
70.71
47.14
23.57
0.00
2.12
2.00
1.50
1.00
0.50
0.00
PYRETHRUM DIFFUSION 1971

Figure 38

clearly depicted. These SYMVU diagrams are simply a three-dimensional version of the SYMAPs that appeared earlier.

There are three principle features of the SYMVU diagrams that should be noticed. First, the development of peaks of adoption that cover only a very small area. Second, the tendency of these peaks to plateau outward when they reach the maximum value of 100 percent. And third, the infilling that takes place in the valleys between the peaks. Pyrethrum diffusion has already been covered in detail so no additional explanation will be offered here.

Spatial Diffusion of Tea Adoption

Tea was first introduced into Kisii in 1957 at Mokomoni and later at Magombo, both in East Kitutu Location a few miles from the eastern border of the district. The area closest to the tea estates in Borabu Location (formerly the Settlement Area) was selected because it is ecologically suitable and, due to proximity to the tea estates many Africans had previous experience working with tea. At the beginning a "Tea Line" was established around the original diffusion node in an effort to control the outward expansion of tea growing. Anyone living inside the line could grow tea while those outside the line were prohibited. Each time the line was moved,

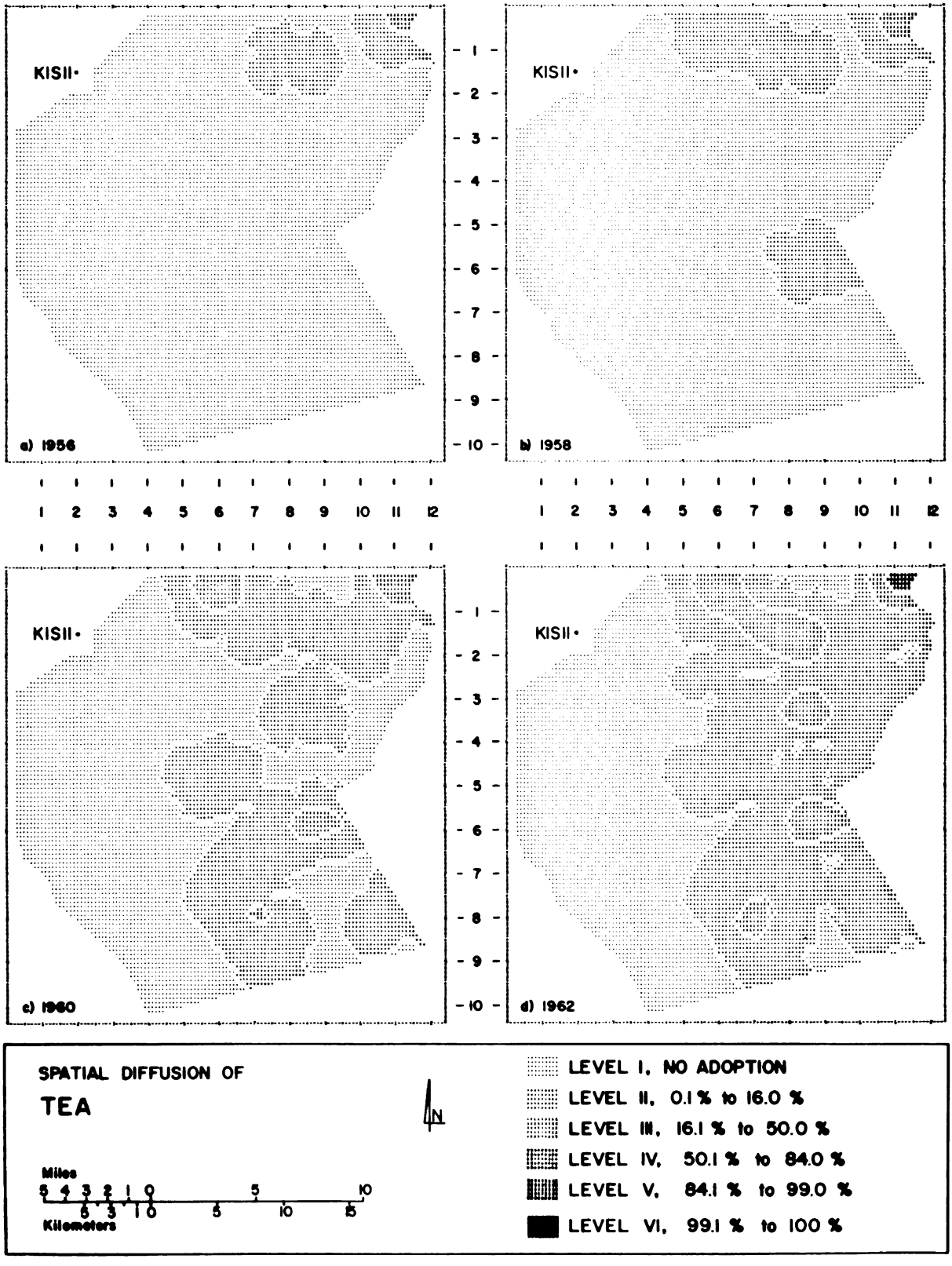
usually annually, it was extended outward for three miles. When the Kenya Tea Development Authority took over the administration and marketing of tea in 1964 most of the area where tea is now grown was within the "Tea Line" (Interview No. 1).

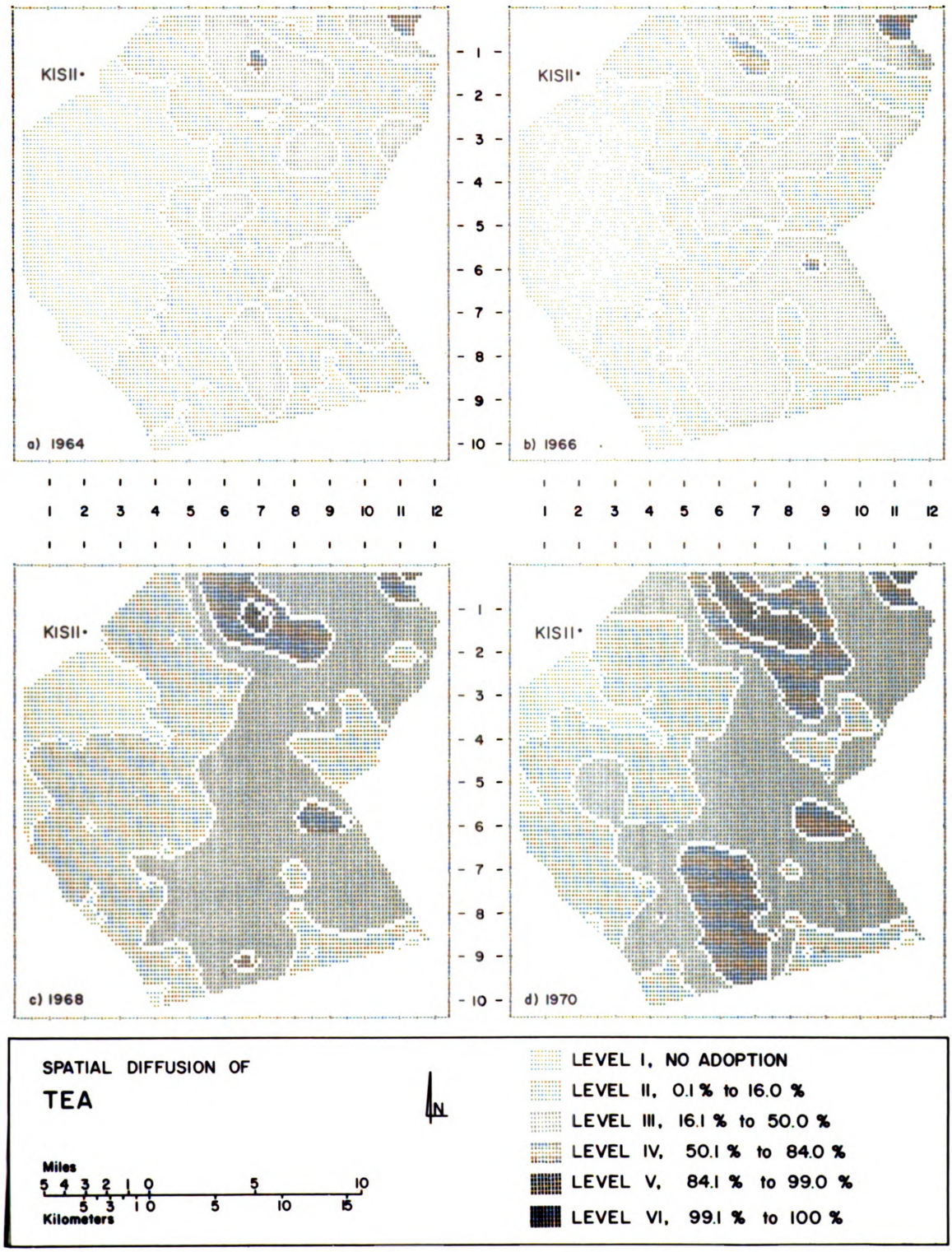
Currently within the study area about 30 percent of the farmers are raising tea. Kisii District is relatively unimportant in relation to total tea production in Kenya. In 1961 only 0.04 percent of the nation's production came from this district; and in 1969 it had increased to only 1.8 percent (see Table 9). This low percent is due to the massive production from the tea estates in Kericho District. However, if the current rate of adoption continues, tea should be earning as much money for the district within ten years as either coffee or pyrethrum (Kenya, Economic Survey, 1964 and 1969).

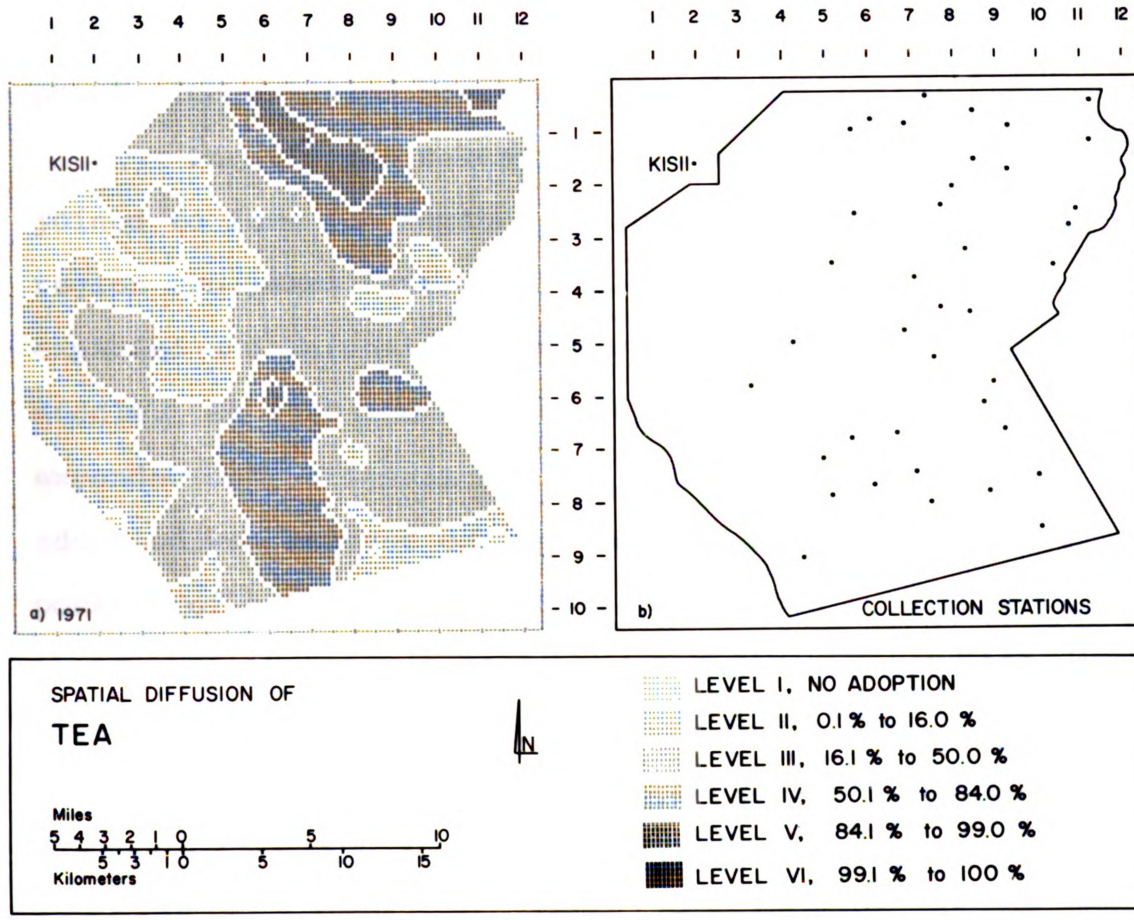
The present tea officer advocates that plantings be prohibited below 1500 meters (5,000 feet) with elevations over 1650 meters (5,500 feet) ideal for tea. The district is now divided into an optimal area (to the east of the "Green Line" on Figure 17) where anyone who is economically and technically able may raise tea. In the marginal zone (between the "Green Line" and the "Brown Line" on Figure 17) the tea officer will probably inspect the site selected for planting by the farmer and suggest

a new site if it is not adequate. The site inspection process itself acts as a deterent to further adoption. Also the Kenya Tea Development Authority does not want the area where tea is grown to increase in size but wants to intensify planting within current production areas in order to reduce to cost of collecting the tea (Interview No. 1).

Tea adoption first took place in the study area when expansion from the Kebirigo area (see Figure 39), just north of the border, spilled over. Partly because this area is close to the tea estates to the east it reached Level III the first year, 1956. By 1958 tea had been accepted rapidly as a cash crop, and low-level adoption took place along much of the northern border as a result of even greater activity to the north. To the south a new node emerged near Keroka (H9.0-V6.0). The only intensification was a result of the Level III area (H11.0-V0.5) increasing from 20 percent to 30 percent adoption. By 1960 several new adoption locations appeared within the study area, but only two (H8.5-V3.0 and H10.5-V8.0) were new nodes, the others were either the result of expansion or diffusion from north of the border. By 1962, the rapid expansion that began in the southeast in 1960, had resulted in the merger of Level II over most of the eastern side of the study area, but with pockets of non-adoption remaining. Several new areas of


KISII
a) 1956
b) 1958
c) 1960
d) 1962
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10
SPATIAL DIFFUSION OF
TEA
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %


KISII
a) 1964
b) 1966
c) 1968
d) 1970
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10
SPATIAL DIFFUSION OF
TEA
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %


1 2 3 4 5 6 7 8 9 10 11 12
KISII
1 2 3 4 5 6 7 8 9 10
a) 1971
1 2 3 4 5 6 7 8 9 10 11 12
KISII
b)
COLLECTION STATIONS
SPATIAL DIFFUSION OF
TEA
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %

Level III adoption appear and the extreme northeast corner emerged as Level IV. During the four years from 1960 to 1964 several new diffusion nodes developed above the general low level of adoption and a strong outward movement of the diffusion wave took place. Regional contrasts were great as places of non-adoption were closely juxtaposed with areas of Level III adoption.

In 1966 the seven separate areas of Level III joined to form two regions, which merged into a single region two years later. The three Level IV areas of 1968 expanded and intensified as Levels V and VI appear in the middle. In 1970 the forward edge of the diffusion wave expanded only slightly but the number of areas with no adoption was reduced considerably by the elimination of pockets of non-adoption. Level III moved outward with the result that Level II diminished in size. In 1971 there was continued intensification but little outward expansion, resulting in a steeper gradient between Level I and the higher levels. In the future there should be continued intensification with very little outward expansion.

Using the Hagerstrand typology of spatial innovation, Stage I is found in the period from 1956 to 1958. Rapid outward spread at low adoption levels is the principal characteristic. Except in the northeast corner, where Level III is reached due to spill over from the north, there are no marked regional contrasts. Stage II

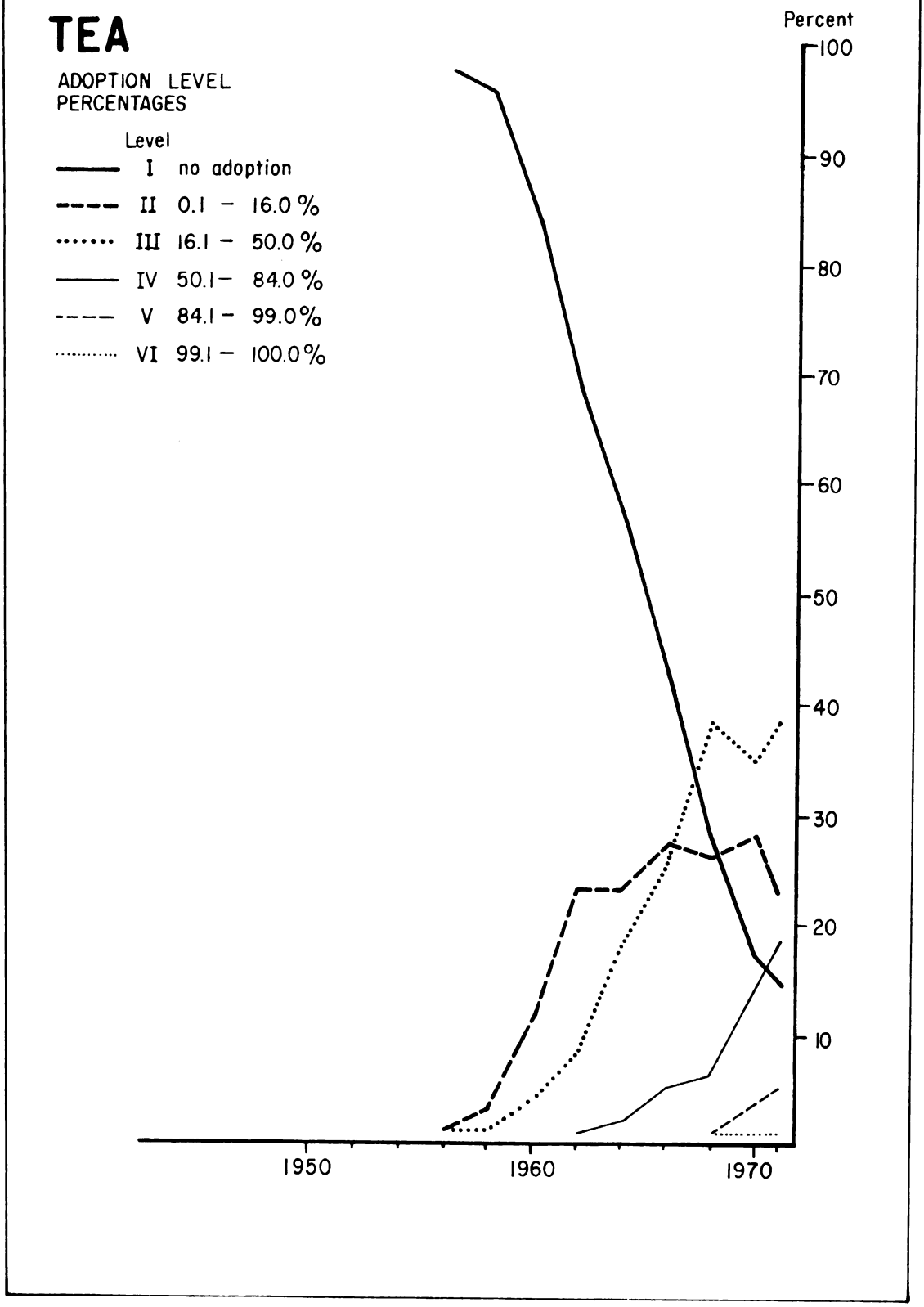
is first noticeable in 1960 when rapid outward expansion of higher adoption levels is much in evidence. Also expressed in the 1962 and 1964 maps, Stage II is epitomized by the emergence, expansion and coalescence of higher adoption levels. Stage III is found in the 1966 to 1971 period. After most of the outward expansion had taken place (before 1966) there was an overall intensification of adoption, manifested by the coalescence and expansion of the higher adoption levels.

Figure 42 shows that tea has experienced an even greater amount of low-level adoption than the other innovations. The amount of territory with no adoption has decreased rapidly and steadily, and the areas under Levels II and III have increased to a higher percent of the total than for the other innovations. This is indicative of widespread low intensity adoption. These levels (II and III) appear to be starting their decline as the amount of land under the highest three levels of adoption begin to increase. Given the Kenya Tea Development Authority policy encouraging intensification it is logical to expect Levels V and VI to increase rapidly in the next few years.

Spatial Diffusion of Passion Fruit Adoption

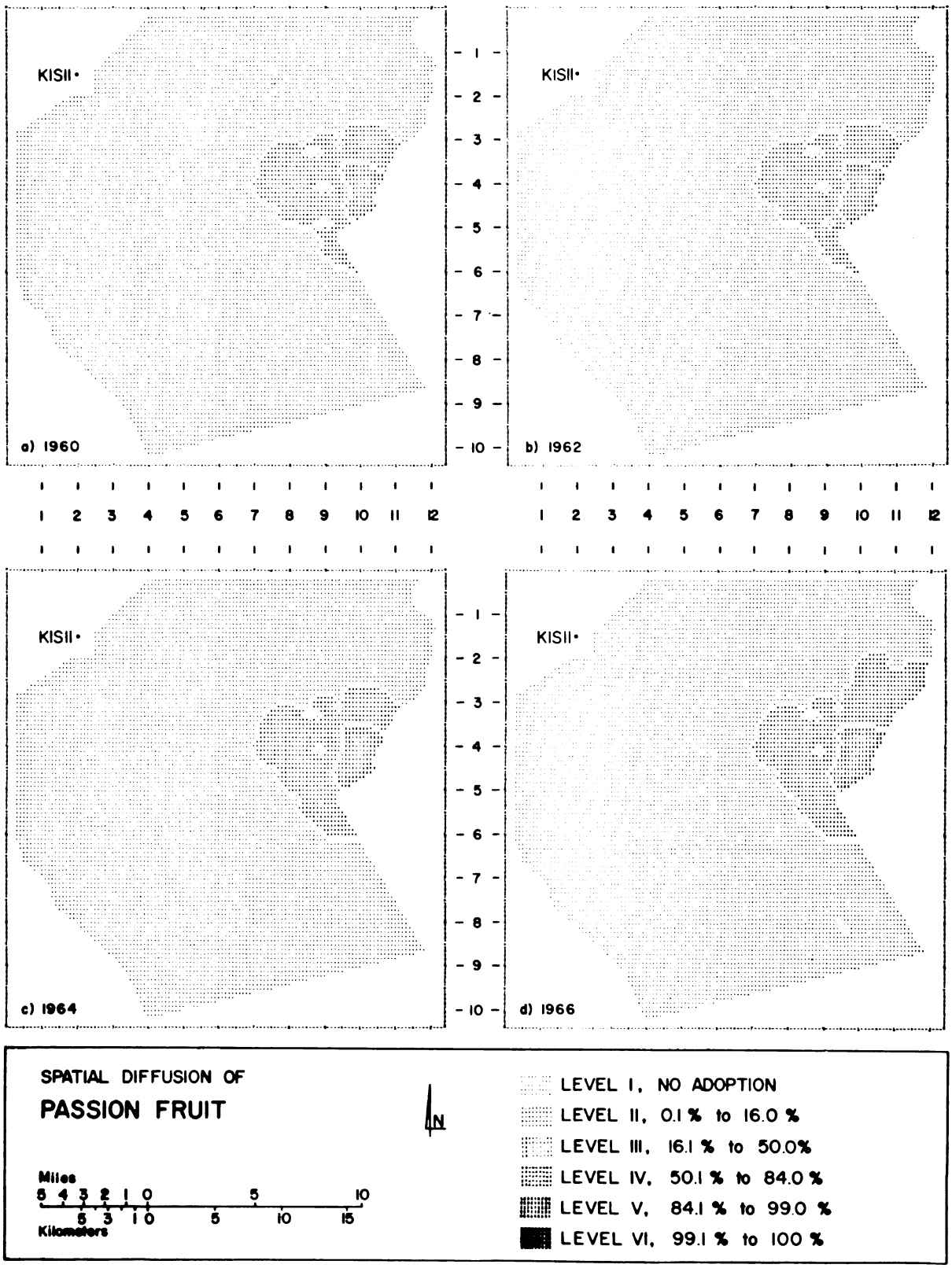
Passion fruit has been grown in western Kenya since 1934 on large-scale European-owned farms in the

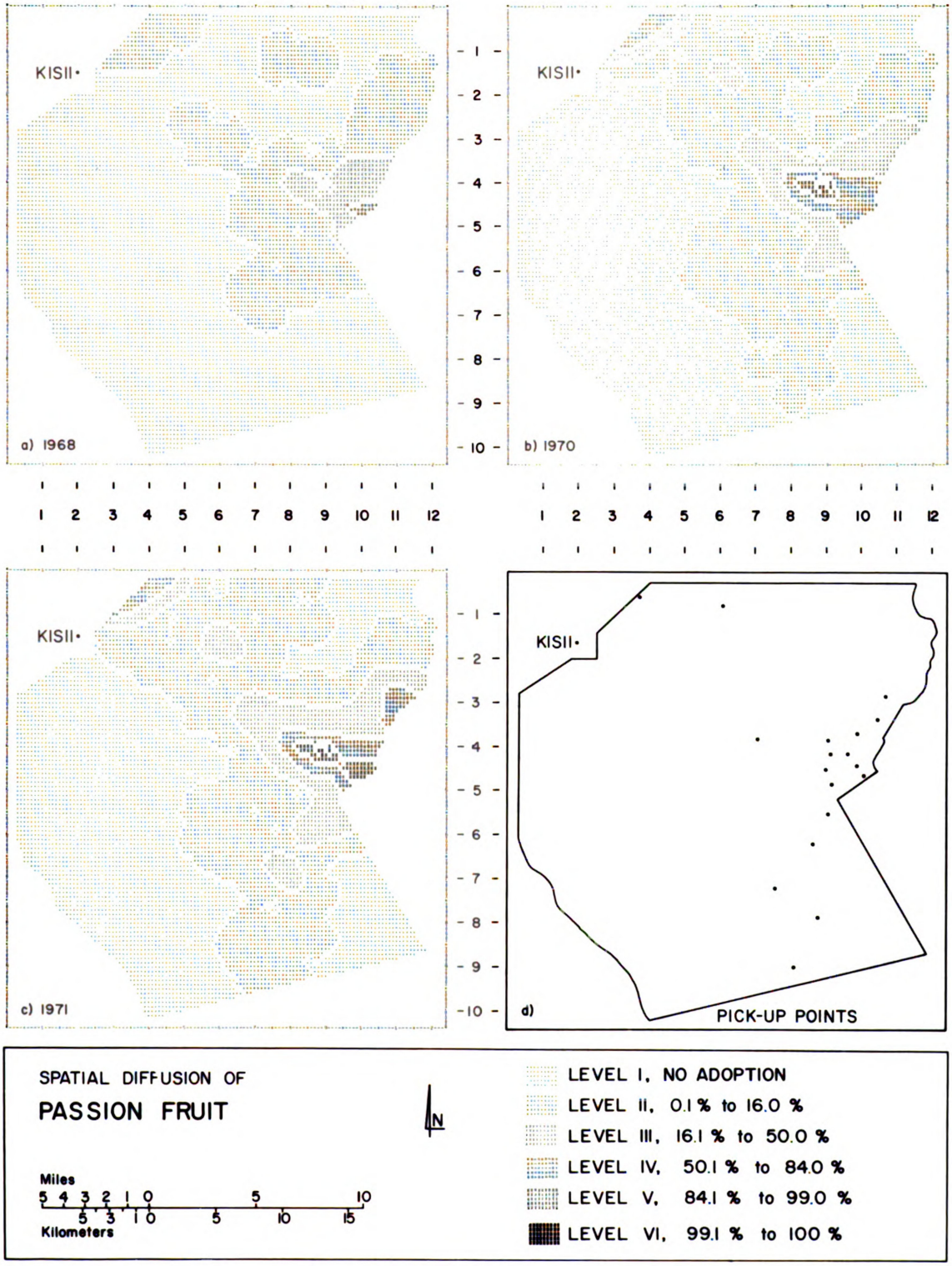
Figure 42


TEA
ADOPTION LEVEL
PERCENTAGES
Level
I no adoption
II 0.1 – 16.0 %
III 16.1 – 50.0 %
IV 50.1 – 84.0 %
V 84.1 – 99.0 %
VI 99.1 – 100.0 %
Percent
100
90
80
70
60
50
40
30
20
10
1950
1960
1970

Sotik area. In 1959 the manager of the processing plant in Sotik sent out some of his employees to encourage their friends to grow passion fruit. As most of them lived in the Keroka area, which is the closest area in the district to the factory, the crop began diffusing from there (see Figure 43). The adoption rate was on the rise when a three-fold disaster struck in 1966. First, the crop was struck with the brown-spot disease that destroyed many of the vines. Second, in fear of overproduction the price was cut by 50 percent. Third, the manager of the processing plant discarded any fruit that he considered inferior. The farmers incurred a double loss because they had to pay to transport the passion fruit to the factory before it was rejected. The present manager of the passion fruit processing factory was not sure of the relative impact of each factor, but suspected disease to be the most important (Interview No. 4).

Since the passion fruit industry was not associated with the government some different approaches were used to encourage adoption. After the 1966 disaster the company decided to send its collection truck into the growing areas every day. Normally it would visit an area only once per week, so the daily trip was obviously uneconomic, but the goal was to convince the farmers that the company was interested in them. Also the manager personally visited the growing areas almost daily. Soon


KISII
a) 1960
b) 1962
c) 1964
d) 1966
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10
SPATIAL DIFFUSION OF
PASSION FRUIT
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0%
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %


KISII
a) 1968
b) 1970
c) 1971
d)
PICK-UP POINTS
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10
SPATIAL DIFFUSION OF
PASSION FRUIT
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %

farmers were convinced and then replanting and new adoptions took place. By 1970 production by weight exceeded that of 1965. It appears that the adoption rate will increase because the potential profit per acre is greater for passion fruit than for any other cash crop grown in Kisii District (Interview No. 4).

At this time the contribution that passion fruit makes to the cash crop economy of the district is rather limited. In the year of maximum production it brought in only K£ 16,700 (U.S. $42,750). Most of the country's production comes from western Kenya as Kisii and the Sotik areas are the only major producers of passion fruit. Even in the best of years passion fruit accounts for only 3.0 percent of the total fruit production of Kenya.

Passion fruit was first introduced into Kisii in 1959. The diffusion maps for 1960, 1962 and 1964 (Figure 43) show no spread, which was indeed the case, but due to the intervals used the intensification is concealed. The maximum rate of adoption for area H10.0-V4.5 in 1960 was 21.7 percent, 28.6 percent in 1962 and 33.3 percent in 1964. The reason for the slow rate of adoption was the reluctance of the Department of Agriculture to encourage farmers to grow passion fruit due to an uncertain future.

Another adoption area (H11.0-V3.0) was added to the north of the original node in 1966, and in 1968 the diffusion of passion fruit accelerated, with a low level

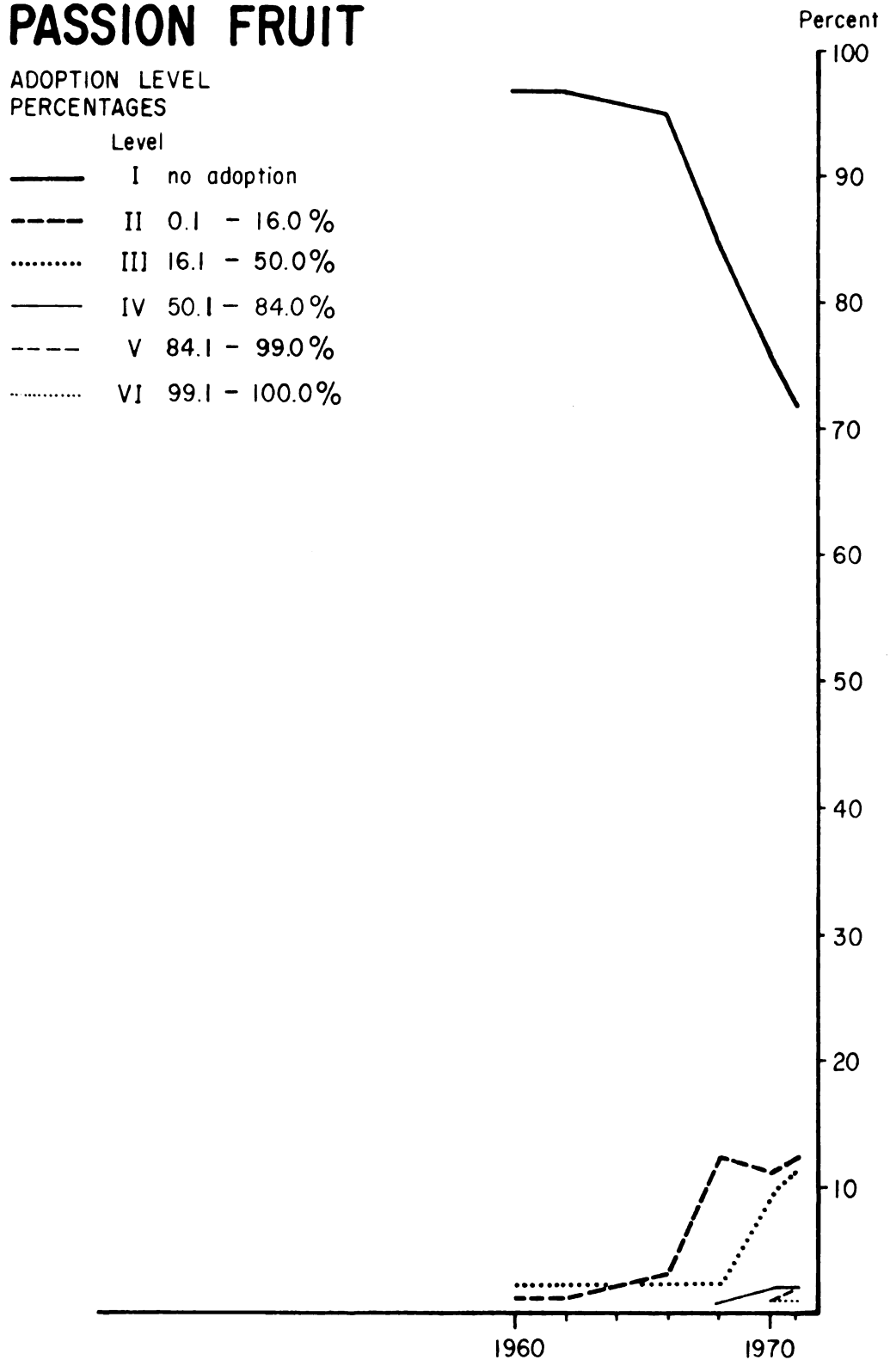
of adoption being reached at five new areas in the north and south, but not in the west. Also a Level IV area developed (H10.0-V4.5) at the original point of introduction. Only in 1968 (Figure 44), which marks the end of Stage I, did passion fruit expand beyond the original area of introduction. New nodes developed in 1967 and 1968, but it was only at the first diffusion node that the higher levels of adoption were reached.

Stage II is first pictured in 1970, showing a very rapid outward expansion and coalescence of all the formerly isolated nodes during the previous two years. The main area of concentration remains the Keroka area, but a new secondary node has begun to develop in the far northwest of the study area. By 1971 there was a slow outward expansion and the emergence of a Level IV (H11.0-V3.0). This area will very soon coalesce with the Level IV area around Keroka. Stage II has only begun; it will take the creation of numerous new nodes of diffusion before Stage III can be entered.

Figure 45 shows just how new passion fruit is in Kisii District. After an initial period of six years in which there was very little spatial spread in passion fruit adoption, the crop began to diffuse rapidly. Levels II and III also started to increase in 1966. Two principal differences in the pattern of passion fruit adoption as opposed to the other innovations are, first, the time lag

Figure 45

PASSION FRUIT



before the crop was accepted widely, and second, the early appearance of Levels IV through VI. This indicates a greater degree of spatial concentration than the other innovations have exhibited.

Spatial Diffusion of Grade Cattle Adoption

Towards the end of 1961 six grade cows were placed on two African farms in Kisii District (Kisii, Annual Report, 1961, p. 17). By the end of 1962 there were 68 farmers registered to keep grade cattle; they owned 89 cows. Early adoptions were exclusively cows, but today there are a few grade steers. Retarding the adoption of grade cows were the Gusii County Council By-Laws stipulating the requirements for registration. They were: (1) a stock-proof perimeter fence surrounding two acres of paddocked grazing land planted to either Kikuyu or Star grass, (2) one-quarter acre of fodder crops, (3) an adequate watering point, (4) a milking shed, (5) a calf pen, (6) a spray pump, (7) regular spraying of local cattle for six months previous to adoption and the removal of all ticks, and (8) attendance at a Farmer Training Center course (Kisii, Annual Report, 1963, p. 13).

The number of grade cows in Kisii expanded from 89 in 1962 to 10,207 in 1967, but over half of these were in the former settlement area (Kisii, Annual Reports, 1963, p. 16; and 1967, pp. 3 and 7). In January 1969 the Small Holder Credit Scheme operated by the German

Agricultural Team was established in Kisii. This team is responsible for giving loans to the African farmers for the purpose of increasing their output. To qualify for a loan the farmer must demonstrate to the satisfaction of the team that he will be able to pay off the loan in five years. A breakdown of the loans can be seen in the following table.

TABLE 10.--Small Holder Credit Scheme.

	Percent of Loans Granted in Each Category
Grade cows	58%
Water development	11
Tea development	12
Pyrethrum development	11
Passion fruit development	5
Miscellaneous	3
	100%

Source: Interview No. 5.

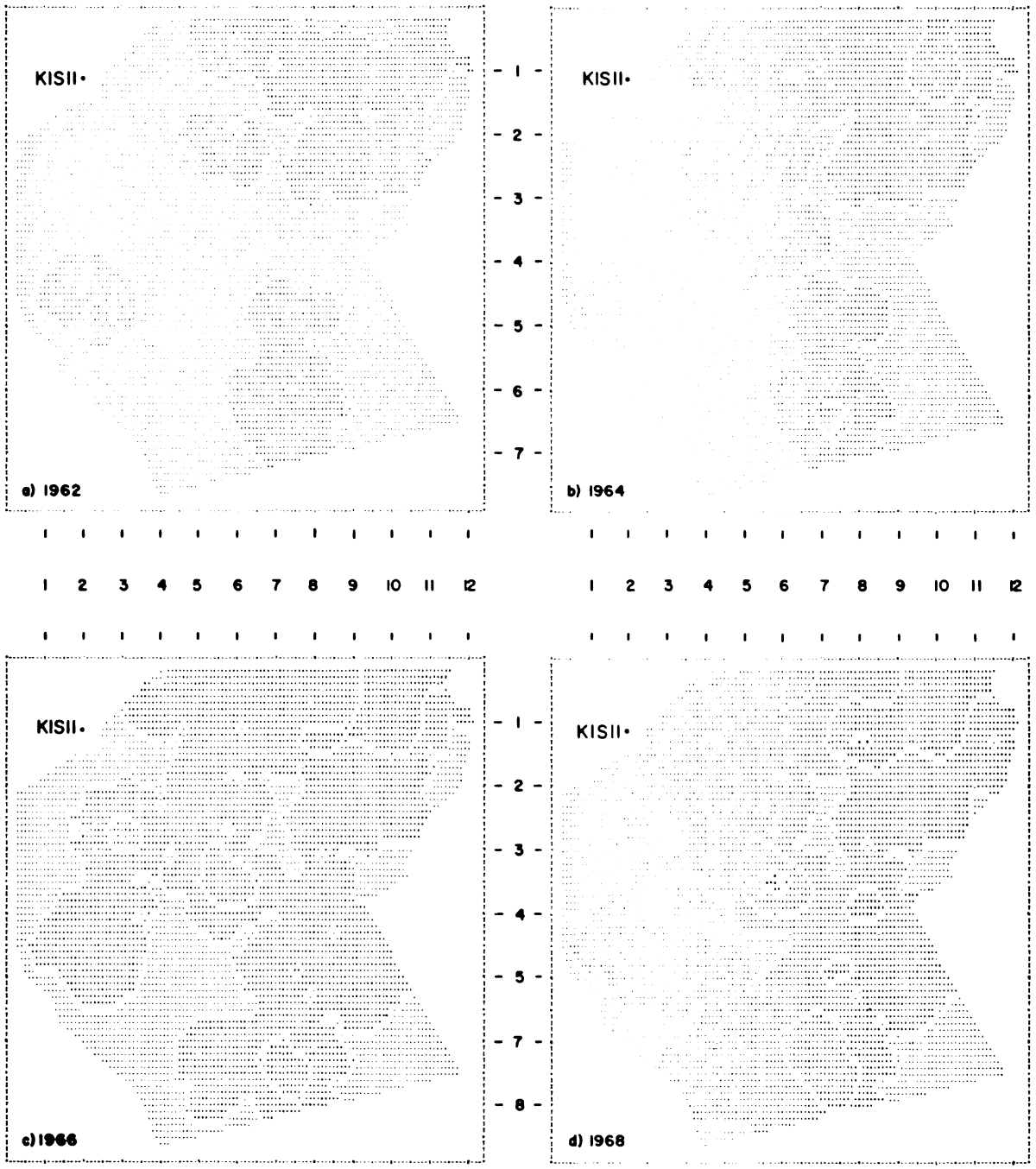
With nearly 60 percent of the loan money being allocated for grade cows it is logical to assume that the percent of adoption will continue to grow.

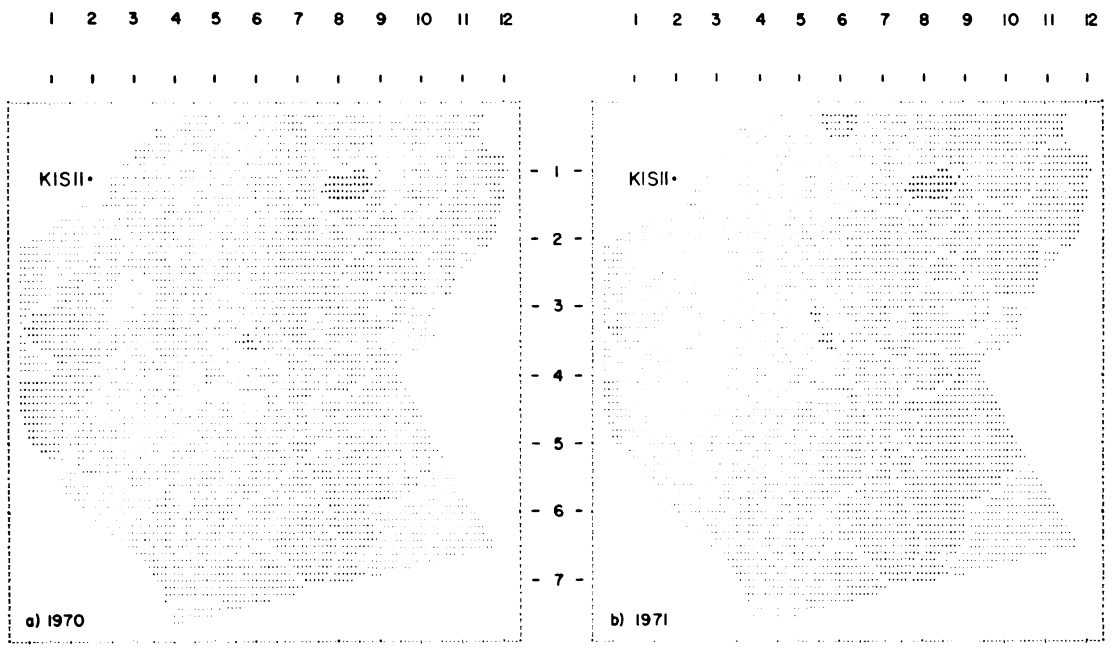
The milk will be used for local consumption, but here a few problems exist. Due to the lack of transport ability some of the areas with more grade cows have saturated the local market. In this case a local market is that area over which a man can walk. To remedy this the government, with the cooperation of the German Agricultural Team, plans to install milk coolers in a few

locations so the farmers can store their evening milk for transport into Kisii town the next morning. There are presently no plans to distribute the milk outside the district (Interview No. 5).

By the end of 1962 about 30 farmers in the study area owned 35 grade cattle (Kisii, 1962, p. 16). Most of the owners were located in the northern part of the study area (see Figure 46a), causing the merger of the Level II adoption areas in that section. To the south there existed only isolated adoptions. Two years later, in 1964, the formerly isolated areas had very tenuously coalesced. At that time there was the development of four nodes of Level III adoption.

Stage I, the primary stage, ended with the 1964 map. Adoption was widespread spatially but nowhere was it intense. The numerous nodes reflect only one, or a few, grade cattle each. Stage II, the diffusion stage, beginning in 1966, exhibited rapid outward movement as Level II increased in extent. Only a minimal expansion of Level III occurred as most new adoption was the result of widespread low-level adoption. In 1968 there was very little expansion outward, instead many pockets of non-adoption, surrounded by adopting areas, were eliminated as more farmers acquired grade cattle. Differences between the non-adopting areas and the Level II areas are slight because most of the latter are at the lower end


KISII.
a) 1962
b) 1964
c) 1966
d) 1968
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8
SPATIAL DIFFUSION OF
GRADE CATTLE
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %



SPATIAL DIFFUSION OF

GRADE CATTLE

N

Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers

- LEVEL I, NO ADOPTION
- LEVEL II, 0.1 % to 16.0 %
- LEVEL III, 16.1 % to 50.0 %
- LEVEL IV, 50.1 % to 84.0 %
- LEVEL V, 84.1 % to 99.0 %
- LEVEL VI, 99.1 % to 100 %

of the category. Thus, the relatively few adoptions have generally been widely scattered with few concentrations. The only intensification is exemplified by the appearance of two areas of Level IV (H8.0-V1.5 and H6.0-V3.5). In 1970 the strong regional contrasts are most expressed, in contrast to the Hagerstrand's Stage II.

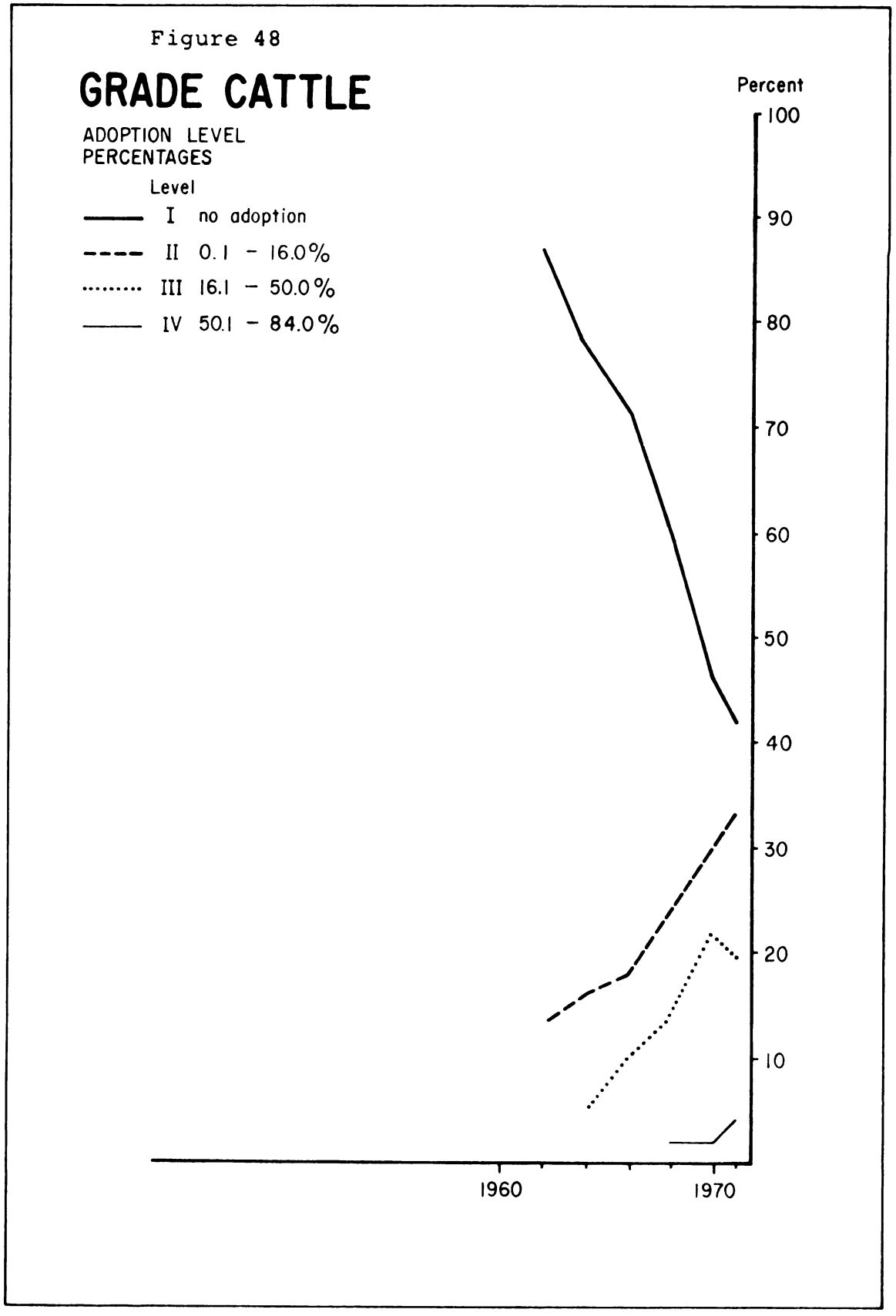
By 1971 there was a further reduction of the non-adopting areas, a slight expansion of Level III and the emergence of another Level IV (H6.0-V0.5). Adoption had expanded to over half of the study area. In the next three or four years most of the non-adopting areas will be eliminated so Stage III can be entered when all areas will increase at approximately the same rate. Stage IV is still many years away.

Figure 48 shows how the non-adopting areas have been reduced in number and the lower adoption levels have expanded. Level II should continue to grow, and Level III will probably increase after a short term decline. Level IV is just beginning to develop. Considering the price of a grade cow and, more importantly, the problems involved in acquiring a loan to purchase one, the growth rate exhibited here is quite remarkable.

Spatial Diffusion of Hybrid Maize Adoption

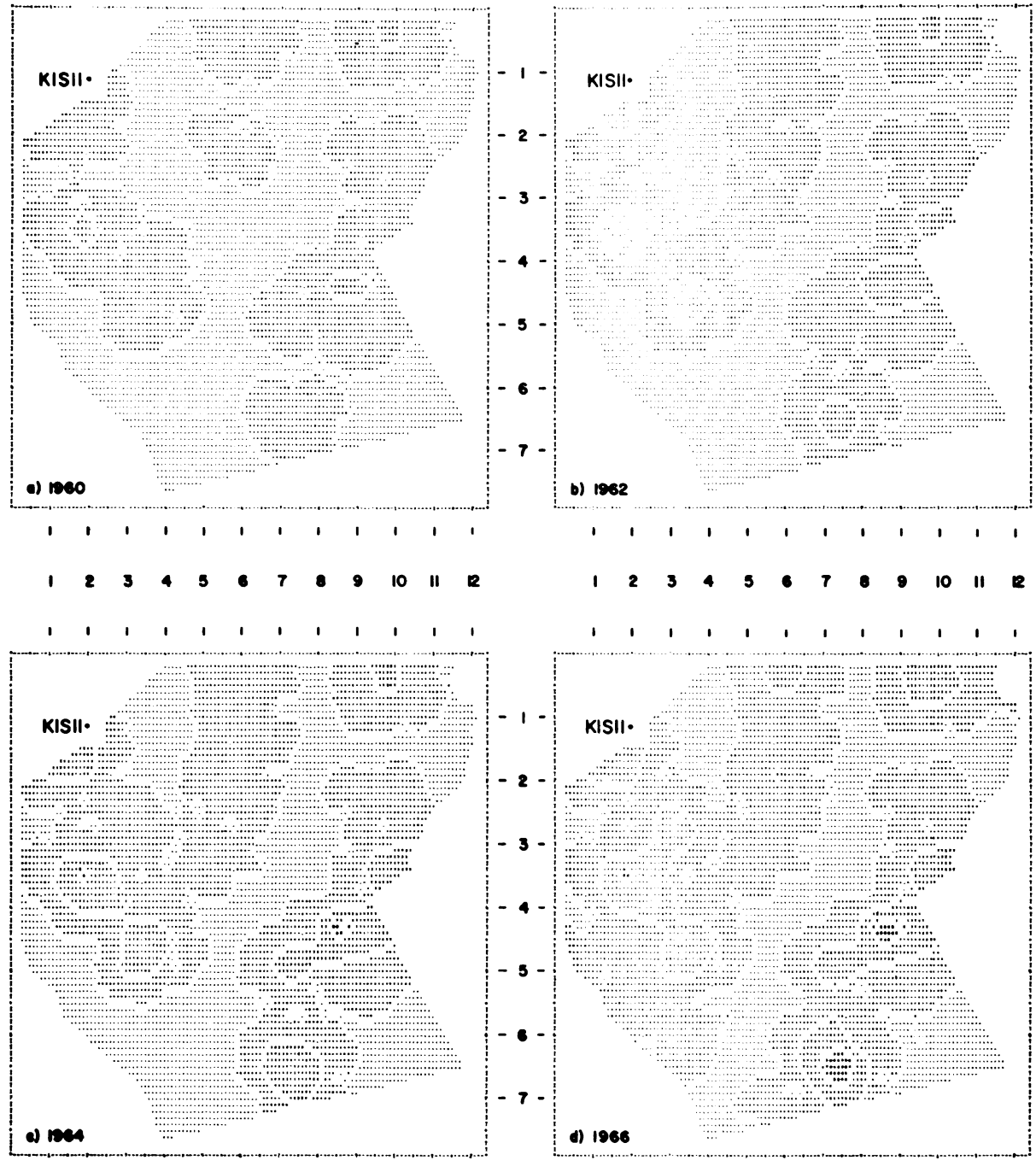
When a Gusii farmer is asked the date he first started raising local maize he will usually answer that

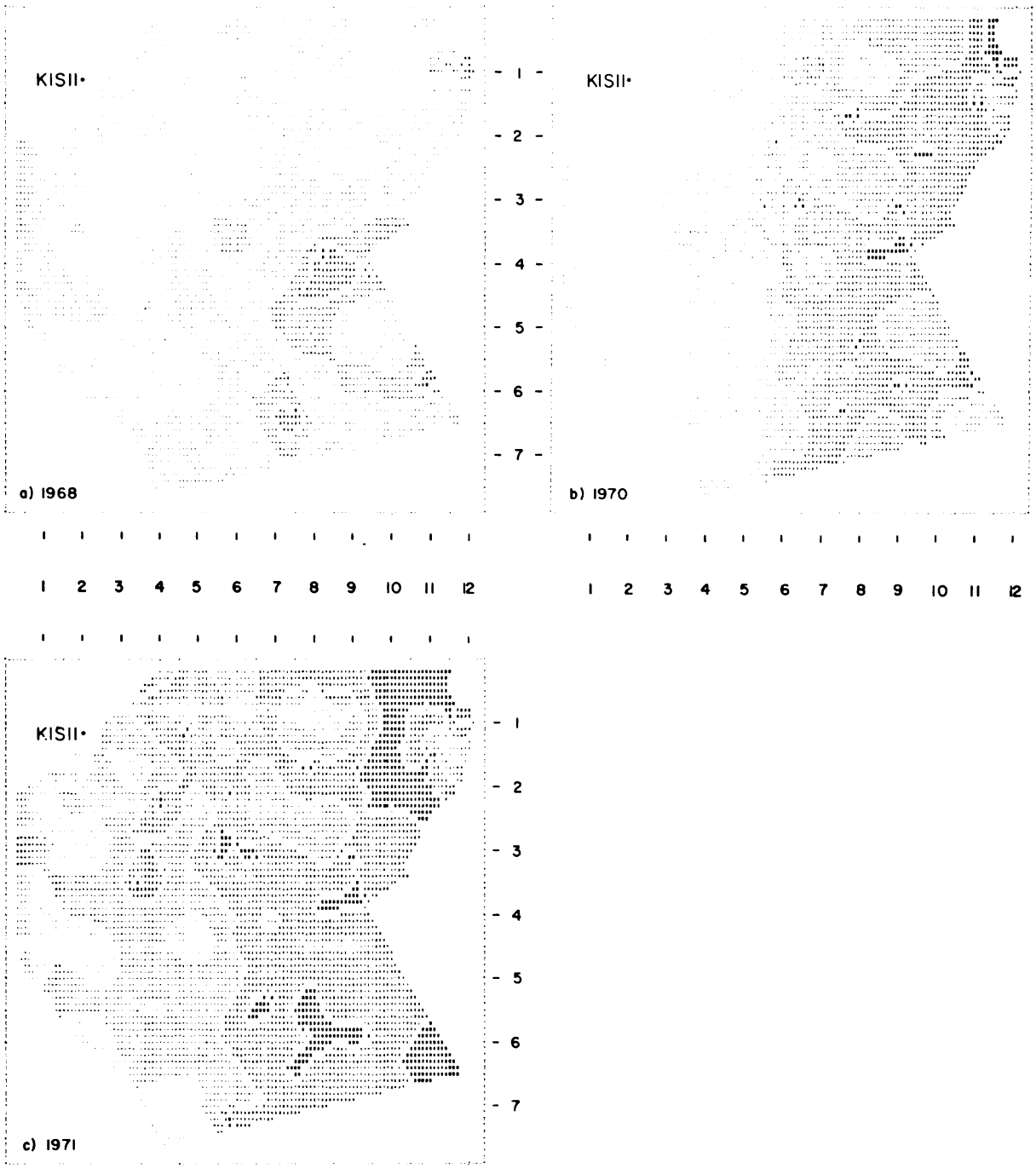
Figure 48


GRADE CATTLE
ADOPTION LEVEL
PERCENTAGES
Level
I no adoption
II 0.1 - 16.0%
III 16.1 - 50.0%
IV 50.1 - 84.0%
Percent
100
90
80
70
60
50
40
30
20
10
1960
1970

it was there when he was born. Maize has long been a staple in the Gusii diet. Normally it is dried and ground into maize flour, then boiled in water to make a thick porridge called posho. Since the hybrid maize seeds provide yields approximately twice that of local maize, and the crop is similar in taste to the old, it has been adopted very rapidly. Local maize is grown throughout the district so no one place appeared to be most appropriate for introduction. Hence, the agricultural department introduced it through extension agents simultaneously throughout the district. A fairly slow rate of adoption was experienced for the first six years, then it became very acceptable and was adopted much faster than any crop in the history of Kisii District. By mid-1971 only about 20 percent of the farmers in the study area had not adopted. Assuming a decline in the adoption rate at the top end of the "S" shaped growth curve we can predict that it will take about five more years to achieve complete adoption.

Hybrid maize was first introduced into the study area in 1959 at nine different places simultaneously (see Figure 49). Two of these original nodes were close enough to have merged and three of them had advanced to adoption Level II. In 1960 the pattern could be described as Hagerstrand's Stage I, the primary stage, but there are no strong contrasts in the percent of adoption from one area to another.


KISII
a) 1960
b) 1962
c) 1964
d) 1966
1 2 3 4 5 6 7
1 2 3 4 5 6 7 8 9 10 11 12
SPATIAL DIFFUSION OF
HYBRID MAIZE
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %


KISII
a) 1968
b) 1970
c) 1971
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7
SPATIAL DIFFUSION OF
HYBRID MAIZE
N
Miles
5 4 3 2 1 0 5 10
5 3 1 0 5 10 15
Kilometers
LEVEL I, NO ADOPTION
LEVEL II, 0.1 % to 16.0 %
LEVEL III, 16.1 % to 50.0 %
LEVEL IV, 50.1 % to 84.0 %
LEVEL V, 84.1 % to 99.0 %
LEVEL VI, 99.1 % to 100 %

By 1962 an eastern and a western section could be identified as a result of the coalescence of most of the Level II areas. In the intervening two years from 1960 to 1962, the Level II adoption areas expanded to seven. The map for 1962 still represents Stage I because the rapid outward movement had not begun. By 1964 an expansion of Level III areas took place and three areas of Level IV adoption developed (H7.5-V6.0; H8.5-V4.0; and H2.0-V3.5). By 1966 the eastern and western parts were still separate because only moderate expansion took place at all levels and in all locations.

Stage II, the diffusion stage, is presented only in 1968. Major expansion, coalescence and intensification took place in the preceding two years causing the merger of most areas of Level III adoption into one region. Also, Level IV emerged as an important area, as well as the development of three Level VI positions (H8.0-V4.0; H11.0-V6.0; and H7.5-V6.0). This time period is classified as Stage II on the basis of the rapid outward movement, but regional contrasts are strengthened over Stage I due to the development of areas with complete acceptance of hybrid maize. These contrasts represent the intensification of nodes that existed in earlier time periods.

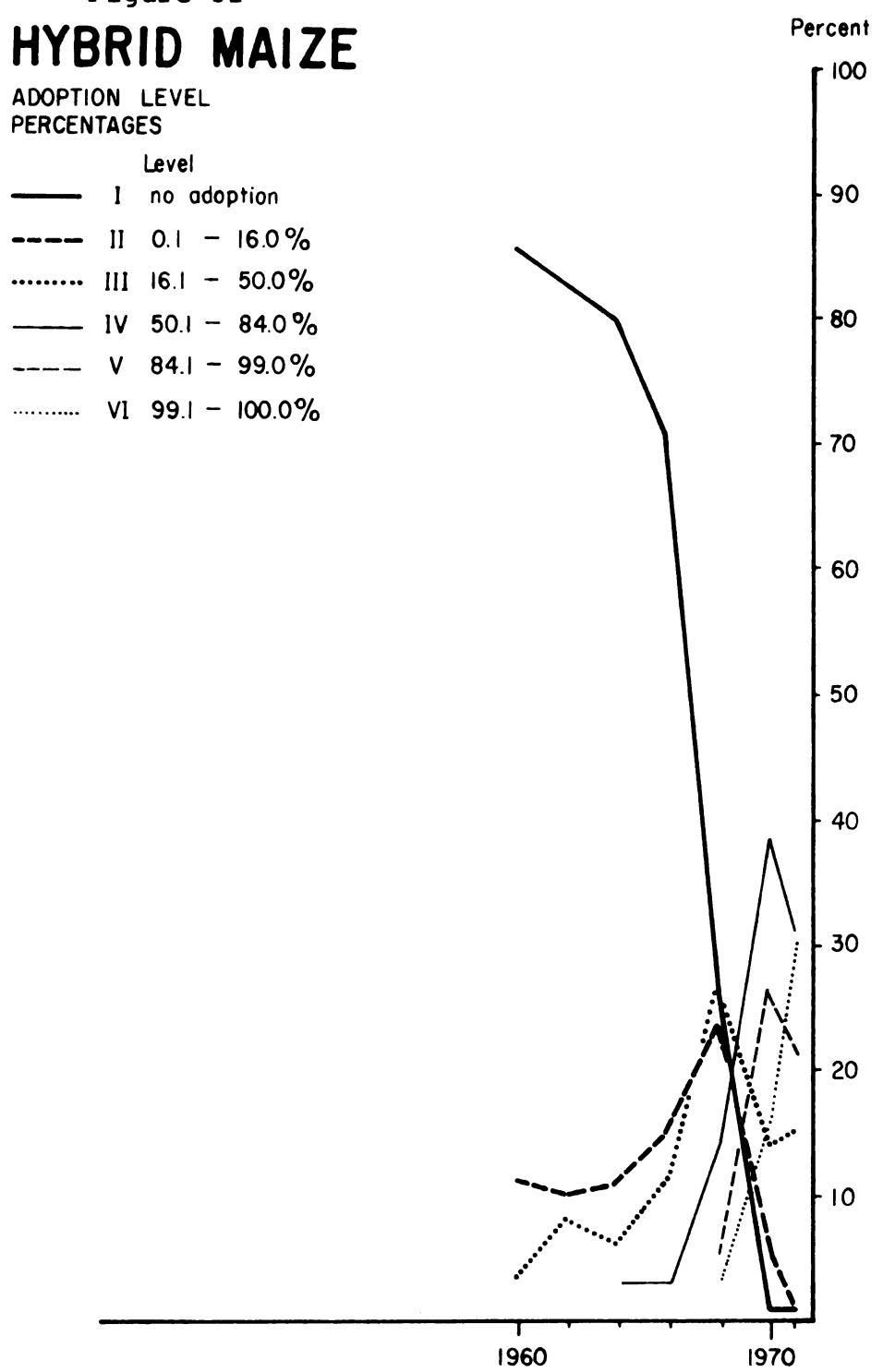
Stage III, the condensing stage, is found in 1970 and 1971. Only one area with no adoption of hybrid maize exists at the latter time (H8.0-V1.0). Level IV and above

occupies most of the study area, and Level V adoption has merged to cover an extensive region. Fully thirteen different places have achieved total acceptance of hybrid maize. In the 1970 to 1971 time interval, the area occupied by Level V enlarged considerably and the Level VI places expanded. If the places that are at Level VI adoption continue to expand at the present rate it will only be three or four years before most of the study area has achieved complete adoption. Thus, Stage IV, the saturation stage, will probably be quite noticeable by 1974, and the entire study area should reach near 100 percent use of hybrid maize by 1975 or 1976.

Figure 51, showing the percent of sampling areas at each adoption level presents the same basic pattern as the other innovations being examined, only in a more compressed form. The area with no adoption forms the "S" curve in reverse due to the slow start of the spatial diffusion process, followed by the rapid outward movement of the diffusion wave, and finally a slowdown as the final few areas show a reluctance to adopt. Levels II and III increase to a peak in 1968, the year of greatest expansion, and decline rapidly. Levels IV and V accelerate rapidly to a 1970 peak and begin to fall. Only Level VI continues to show signs of increasing in the future.

Figure 51

HYBRID MAIZE



Generalizations on the Diffusion Process

The spatial diffusion of agricultural innovations in Kisii District follows the Hagerstrand typology of spatial innovation reasonably well, with two exceptions. Stage I, the primary stage, is characterized in both southern Sweden and Kisii District by a few isolated locations where a small percent of the farmers have accepted the innovation in question. Stage II, the diffusion stage, is one of the exceptions. In the Hagerstrand typology this stage exhibits the development of new diffusion nodes and the leveling of regional differences. In Kisii new nodes appear but regional differences are strengthened rather than leveled. New and old nodes increase in adoption percentages until they become peaks of very high adoption that stand out above the surrounding area. Stage III, the condensing stage and the second exception, is characterized by Hagerstrand as exhibiting equal increases in all areas. In Kisii this stage primarily involves infilling between the adoption peaks and the expansion of peaks do form plateaus. Also, the gradient of the diffusion wave's outer edge becomes steeper. Stage IV, the saturation stage, is not found in Kisii District for any of the innovations.

For coffee and pyrethrum, the location of marketing outlets is important in determining the spatial diffusion pattern. The construction of a marketing site

seems to encourage farmers in the immediate area to adopt that particular crop. For passion fruit and tea, that have only pick-up points, which can be easily moved, the market location influence cannot be detected. Grade cattle and hybrid maize do not enter the marketing picture in the same manner so cooperative marketing sites are not important.

There is an obvious tendency for the peaks of high adoption to merge. Each individual adoption peak will generate its own large-scale regional information field in much the same way an individual will generate his own Personal Information Field. Because of the close juxtaposition of the adoption peaks the large-scale regional information fields will tend to overlap, therefore the farmers in between will have more information about the innovation at their disposal and will have a greater probability of adopting.

Hagerstrand's research on innovation diffusion in southern Sweden revealed that the same areas within the region of study were repeatedly the starting point for new innovation waves (Hagerstrand, 1953, p. 293). The area of multiple origin is characterized by a population with high receptivity to innovation. In the Kisii study such innovation centers were not found. Each of the six innovations had its own set of starting points. Three indicators, pyrethrum, tea and passion fruit, started in

the eastern part of the study area, but not in exactly the same locations. The lack of innovation centers would suggest that the important control on the location of original introduction is ecological rather than social. Thus, any innovation could be introduced in any part of an area with homogeneous ecological conditions with an equal chance of success. In a region with a non-uniform distribution of receptivity to innovation it would be important to precisely locate the innovation centers, but in an area of homogeneous receptivity such as Kisii it becomes less important.

Factor Analysis and Multiple Regression and Correlation

Two separate factor analysis routines were executed. The first was with all 57 variables measuring innovation, socio-economic, demographic and locational characteristics. The second was with 31 variables, all innovation measures having been removed. The larger group was analyzed to determine the kinds of relationships that exist between the innovation measures and the other socio-economic, demographic and locational variables. The second, with no innovation measures, was used to generate factor scores for inclusion in a series of multiple regression and correlation models.

Factor Analysis A, 57 Variables

The extraction of 13 factors explained 77.73 percent of total variable (see Table 11). The 13 factors are as follows.

Factor I-A, East-West Dichotomy (13.28 percent of variance). This, the most complex of all the factors, is primarily a measure of location, as all of the measures loading on it are notable for their spatial distribution. Loading in conjunction, from the highest in descending order are: east-west coordinate, elevation, the two pyrethrum variables (mean year of adoption and percent of farmers raising) and distance from Kisii town. Loading in opposition to the above group of variables are the three coffee variables (percent growing, mean number of acres per farmer and mean year of adoption) and precipitation. Thus, as one moves from west to east across the study area the percent of farmers growing coffee declines, precipitation decreases, elevation increases and the percent of the farmers growing pyrethrum increases. Also, the mean acreage per farm planted to coffee declines as the mean acreage per farm planted to pyrethrum increases. Obviously the distance from Kisii increases as does the numerical value of the east-west coordinate.

Factor II-A, Grade Cattle (9.49 percent of variance). Because of the low relationship on the intercorrelation matrix between the grade cattle measures and all

TABLE 11.--Factor Analysis A, 57 Variables (Total Explained Variance: 77.73%).

Factor (Variance) Variables	Highest Loading	Communality
I-A. East-West Dichotomy (13.28%)		
East-West Coordinate	-.88	88.90%
Elevation	-.75	71.70
Annual Precipitation	.63	66.64
Distance from Kisii	-.67	80.04
Mean Year Coffee Adoption	.88	88.07
Mean Coffee Acres per Farm	.91	93.13
Percent Coffee Adoption, 1971	.93	93.96
Mean Year Pyrethrum Adoption	-.71	82.54
Mean Pyrethrum Acres per Farm[a]	-.43	79.02
Percent Pyrethrum Adoption, 1971	-.71	71.42
Weeding Practices Index	.44	76.38
Fertilizer Practices Index	-.37	68.24
Mean Year Tea Adoption[a]	-.43	60.44
Percent Tea Adoption, 1971	-.45	72.15
II-A. Grade Cattle (9.49%)		
Mean Year Grade Cattle Adopted	.82	80.51
Mean Number Grade Cattle per Farm	.86	86.70
Mean Number Grade Cows per Farm	.87	86.54
Grade Cow Practices Index	.88	86.07
Percent Farms with Grade Cattle, 1971	.77	77.95
Local Cow Practices Index	.50	71.46
III-A. Population Characteristics (8.71%)		
Mean Total Farm Population	.93	95.47
Mean Number of Adults on Farm	.84	85.43
Mean Number of Children on Farm	.85	83.64
Mean Number of Family on Farm	.92	90.54
Mean Number of Children in Primary School	.67	79.48
Mean Number of Pieces of Land	.53	67.07
IV-A. Cosmopolite Characteristics (8.57%)		
Mean Number Agent Initiated Contacts	.82	83.93
Mean Number Client Initiated Contacts	.73	87.23
Mean Number Demonstrations Attended	.77	82.32
Mean Number Demonstrations Found Useful	.78	83.27
Mean Number Farmer Training Center Courses	.36	60.63
Mean Number Formal Memberships per Head	.65	70.45
Mean Communication Index	.74	85.73
Mean Education-Literacy Index	.47	74.47

TABLE 11.--Continued.

Factor (Variance) Variables	Highest Loading	Communality
V-A. Housing Characteristics (5.72%)		
House Type Index	.66	69.63%
Household Facilities Index	.71	79.54
Household Possessions Index	.73	83.26
Mean Year Hybrid Maize Adoption	.53	66.44
VI-A. Intensity Index (5.47%)		
Mean Acres Hybrid Maize per Farm	.82	73.67
Mean Acres Pyrethrum per Farm	.52	79.02
Tick Control Practices Index	.79	77.01
Income from Cash Crops	.56	68.96
VII-A. Keroka Concentration (5.46%)		
Mean Year Passion Fruit Adoption	-.85	78.97
Mean Passion Fruit Acres per Farm	-.88	85.00
Percent Passion Fruit Adoption, 1971	-.85	82.08
Population Density	-.54	67.07
VIII-A. Tea (4.07%)		
Mean Year Tea Adoption	.44	60.44
Mean Tea Acres per Farm	.73	77.23
Percent Tea Adoption, 1971[a]	.37	72.15
Mean Age Head-of-Household	.58	66.75
IX-A. Progressiveness Indices (4.04%)		
Crop Progressiveness Index	.80	74.99
Overall Progressiveness Index	.59	80.27
X-A. North-South Dichotomy (3.77%)		
North-South Coordinate	.57	83.12
Mean Acres per Farm	.75	76.88
XI-A. Information Availability (3.71%)		
Mean Number Demonstration Plots Visited	.64	64.13
Mean Number Formal Offices Held	.77	77.14
XII-A. Hybrid Maize (2.91%)		
Percent Adoption Hybrid Maize, 1971	.68	79.96
Mean Acres Local Maize per Farm	-.48	73.14
XIII-A. Traditional-Modern Dichotomy (2.52%)		
Mean Number of Local Cows per Farm	.52	61.27
Mean Number Children in Higher School per Household	-.56	72.16

[a]Second highest loading.

other variables the former loaded together on the same factor. Another measure loading on this factor is the local cow practices index, meaning that the farmers who tend to adopt grade cows will also take better care of their local cows. The moderately high loading of the variable measuring the number of children in higher school indicates the relative wealth of those farmers owning grade cows.

Factor III-A, Population Characteristics (8.71 percent of variance). Measures of population, that is, number of people on the farm, the number of adults and children, the number of the family members residing on the farm, and the number of children in primary school all load high on this factor. Moderate loadings are achieved for the age of the head and the number of pieces of land. These latter two are logical because the older farm heads would tend to have larger families and also more pieces of land since they probably inherited the land some time ago when more land was available; therefore some of them would have more than one parcel of land.

Factor IV-A, Cosmopolite Characteristics (8.57 percent of variance). The cosmopolite factor is a measure of information-seeking behavior. All of the indicators of change agent contract, formal membership behavior, attendance at demonstrations, communications behavior, education and literacy, and Farmer Training Center course attendance

load highly on Factor VI. The north-south coordinate loading is in opposition, indicating that as one moves southward in the study area there is a slight tendency for the information available to farmers to diminish.

Factor V-A, Housing Characteristics (5.72 percent of variance). The three measures of housing--the indices of house type, facilities, and possessions--load together on this factor due to the relatively small variability from one part of the study area to another. The variable measuring the mean year of hybrid maize adoption attains its highest loading on this factor, indicating a slight tendency for people with better housing to adopt hybrid maize earlier. However, due to little variability in adoption dates from one place to another, this variable is of minimal importance to the makeup of the factor.

Factor VI-A, Intensity Index (5.47 percent of variance). This factor is an indicator of intensity of use due to the high loadings of hybrid maize and pyrethrum acreage, and the high use of tick control measures. Farmers who have adopted the planting of hybrid maize in large amounts also tend to own more local cattle and use approved techniques of tick control. Also, there is a slight tendency for these farmers to have higher incomes.

Factor VII-A, Keroka Concentration (5.46 percent of variance). All of the variables measuring passion fruit and population density load very high on this

factor. This title was given because there is a very strong concentration of passion fruit growing in the area of Keroka and that same part of the district experiences the highest population density, thus the factor serves as another locational measure.

Factor VIII-A, Tea (4.07 percent of variance). The tea acreage variable is most closely related to this factor, with the mean year of tea adoption and the percent of farmers growing tea of lesser importance. Also achieving its highest loading is the mean age of the homestead head, indicating a possible relationship between older farm heads and tea adoption because older farmers have, perhaps, had a greater opportunity to have worked in the tea estates around Kericho, and therefore, because of that experience, are quicker to adopt tea as a cash crop.

Factor IX-A, Progressiveness Indices (4.04 percent of variance). The crop progressiveness index, the mean number of years before 1971 that the crop innovations were adopted, and overall progressiveness index, which is the crop progressiveness index plus the number of years prior to 1971 that grade cattle were adopted, align most closely with this factor.

The lack of relationship between this factor and the variables measuring the mean year of adoption for each innovation indicates that each is of relatively small importance to the progressiveness indices.

Factor X-A, North-South Dichotomy (3.77 percent of variance). The total number of acres per farm and the north-south coordinate (which increases in numerical value as one travels southward in the study area) are logically related to each other for the population density decreases somewhat as one travels in that direction. This relationship, however, should not be overemphasized because of the low explanation provided by this factor.

Factor XI-A, Information Availability (3.71 percent of variance). The two variables loading on this factor indicate a relationship between the number of offices held and visits to demonstration plots. The ineffectiveness of demonstration plots in encouraging adoption is evident from the fact that none of the innovation measuring variables load highly on this factor.

Factor XII-A, Hybrid Maize (2.91 percent of variance). This variable is not related to either the mean number of acres of hybrid maize grown by each farmer or to the mean date of adoption. Also, and quite significant, it does not relate strongly with any other variables. This would point to the lack of relationship between the percent of farmers raising hybrid maize and other variables.

Factor XIII-A, Traditional-Modern Dichotomy (2.52 percent of variance). This dichotomy indicates, possible, that people who raise more local cows are poorer and thus

cannot afford to send their children to high school. Or perhaps the greater numbers of local cows refers to traditionalism, so that secondary school is less important to such people. As the explanatory power of this factor is very low, these tendencies should not be regarded as important.

There is one principal conclusion that can be drawn from this factor analysis. For the most part the variables measuring the innovations either factored out as independent of everything else, or they loaded up in conjunction with locational variables due to the spatial distribution they take (i.e., Factors I, II, III, IX and XIII). When the innovation variables did load on the same factor as non-innovation or non-locational variables three characteristics stood out. First, the factor provided only about 4 to 6 percent explanation of variance. Second, the loading of the innovation variable was with only one exception, over .52. Third, the relationship is such that one cannot ascribe cause and effect, only a relationship.

The distribution of socio-economic and demographic variables therefore bears little relationship to the distribution of innovation adoption as it existed in 1971. If one can assume the present is reasonably similar to the past, then the lack of relationship between the variables measuring the innovations and the

other variables becomes important. The distribution of socio-economic and demographic characteristics is sufficiently random so that every area has about an equal number of innovators and laggards, thus no area can be expected to adopt sooner than others on this basis. We can thus conclude that the primary influences on the present spatial pattern are the random (or planned) placement of the original adopters and the spatial diffusion process generated on that basis, modified by physical, cultural and economic (market) features.

Factor Analysis B, 31 Variables

A second factor analysis routine was performed on the data matrix with all innovation measures removed. From the remaining 31 variables eight factors explaining 73.48 percent of overall variation were extracted. These eight factors correspond with those derived in the first factor analysis routine according to Table 12.

Rather than discuss each of the eight factors separately only the ways in which the second analysis differs from the first will be pointed out (see Table 13). The elimination of factors I-A, grade cattle; IX-A, tea; and XIII-A, hybrid maize, is due to the exclusion of the innovation variables from the routine. Factor IV-B (East-West Dichotomy) differs from Factor I-A only in the removal of the variables measuring coffee and pyrethrum. Factor VII-A, the Keroka Concentration, is primarily made

TABLE 12.--Factor Analysis B, 31 Variables Used (Total Explained Variance: 73.48%).

Factor (Variance) Variables	Highest Loading	Communality
I-B. Population Characteristics (15.15%)		
Mean Age Head-of-Household	.52	59.51
Mean Total Farm Population	.92	92.96
Mean Number of Adults on Farm	.84	84.60
Mean Number of Children on Farm	.87	86.20
Mean Number of Family on Farm	.91	87.27
Mean Number of Children in Primary School	.68	76.62
II-B. Cosmopolite Characteristics (12.00%)		
Mean Number Agent Initiated Contacts	-.86	83.06
Mean Number Client Initiated Contacts	-.88	82.98
Mean Number Demonstrations Attended	-.63	83.35
Mean Number Demonstrations Found Useful	-.62	82.42
Mean Number Formal Memberships per Head	-.67	68.43
Mean Communication Index	-.61	84.55
III-B. Information Availability (10.43%)		
Mean Number Demonstration Plots Seen	.77	65.02
Mean Number Formal Offices Held	.65	64.22
Mean Education-Literacy Index	.63	78.02
IV-B. East-West Dichotomy (9.66%)		
East-West Coordinate	.88	84.95
Elevation	.88	88.42
Annual Precipitation	-.67	75.77
Distance from Kisii	.68	70.58
V-B. Housing Characteristics (9.45%)		
House Type Index	.77	73.22
Household Facilities Index	.57	70.66
Household Possessions Index	.70	76.49
Mean Number Children in Higher School per Farm	.71	56.52
Mean Number Farmer Training Center Courses Attended	.45	54.80

TABLE 12.--Continued.

Factor (Variance) Variables	Highest Loading	Communality
VI-B. North-South Dichotomizer (7.15%)		
North-South Coordinate	.84	79.54
Annual Precipitation[a]	-.43	75.77
Population Density	-.70	54.02
VII-B. Land Holdings (5.08%)		
Mean Total Acres	.72	64.79
Mean Fertilizer Index	-.45	59.52
Mean Income	.55	63.65
VIII-B. Weeding Practices (5.03%)		
Weeding Practices Index	.71	70.74

[a]Second highest loading.

TABLE 13.--Comparison Between Factor Analysis A and B.

Factor Analysis "A" (77.73%)	Factor Analysis "B" (73.48%)
I. East-West Dichotomy (13.28%)	IV. East-West Dichotomy (9.66%)
II. Grade Cattle (9.49%)	
III. Population Characteristics (8.71%)	I. Population Characteristics (15.15%)
IV. Cosmopolite Characteristics (8.57%)	II. Cosmopolite Characteristics (12.00%)
V. Housing Characteristics (5.72%)	V. Housing Characteristics (9.45%)
VI. Intensity Index (5.47%)	
VII. Keroka Concentration (5.46%)	VI. North-South Dichotomy (7.15%)
VIII. Tea (4.07%)	
IX. Progressiveness Index (4.04%)	
X. North-South Dichotomy (3.77%)	VI. North-South Dichotomy (7.15%)
XI. Information Availability (3.71%)	VII. Land Holding (5.08%) III. Information Availability (10.43%)
XII. Hybrid Maize (2.91%)	
XIII. Traditionalism-Modernity Dichotomy (2.52%)	
	VIII. Weeding Index (5.03%)

up of measures of passion fruit adoption, but also consists of measures of population density and north-south measurement. The elimination of passion fruit measures allows the north-south dichotomy to be strengthened on the factor. Total acreage is the main component of Factor X-A, the North-South Dichotomy, and the coordinates are the second most important variable. Therefore, Factors VI-B, North-South Dichotomizer and VII-B, Land Holding Characteristics, correspond to that factor.

The Intensity Index, Factor VI-A, does not appear in Factor Analysis B due to the elimination of the main variables, dealing with hybrid maize, pyrethrum and tick control. Likewise, the Progressiveness Indices, Factor IX-A, were removed. Factor XIII-A, the Traditionalism-Modernity Dichotomy, disappeared because the variables load on a new set of factors (such as number of children in high school) or were removed (such as the numbers of local cattle). Lastly, the weeding index, which in Factor Analysis A loaded moderately with several of the innovations, factors out by itself because it no longer has anything to relate to.

Factor Analysis B Related to Innovation Adoption

The final step in the statistical analysis related the factor scores of the eight factors derived from the 31 non-innovation variables to the percent of adoption in

1971 for each of the six innovations. This was done by using a least squares multiple regression deletion routine with each innovation, in turn, as the dependent variable and the factors as the independent variables. The factors relating to the innovation distribution pattern in 1971 at a significance level of .05 or better are shown in Table 14. Beta weights are included to indicate the relative contribution of each variable to the amount of explanation provided by the combination of variables (the sum of squared beta weights is equal to R^2). It is significant that the East-West Dichotomy was the most important variable in four out of the six cases. This factor simply is a measure of those items of location, i.e., coordinates, distance from Kisii, rainfall and elevation, that differ from the eastern to western parts of the study area. Thus, no explanation of cause can be offered by this factor.

Housing characteristics were most closely related to the spatial distribution of tea and grade cattle adoption. This leads to the question of cause and effect. Because they adopted these innovations are the farmers better able to afford higher quality housing, or due to more wealth, as manifest by their better housing, are the farmers better able to afford to adopt these relatively expensive innovations?

The cosmopolite factor seemingly should correlate with the rate of adoption but it does not. In fact,

TABLE 14.--Multiple Regression and Correlation Variables Significant at .05.

Dependent Variable (R^2) Independent Variables	Beta Weights
Coffee Adoption, 1971 (R^2 = 0.73)	
Factor II, Population Characteristics	-.14
Factor III, East-West Dichotomy	-.81
Factor VII, Weeding Index	.20
Factor VIII, Housing Characteristics	-.12
Pyrethrum Adoption, 1971 (R^2 = 0.47)	
Factor I, Information Availability	.19
Factor III, East-West Dichotomy	.63
Factor V, North-South Dichotomy	.19
Tea Adoption, 1971 (R^2 = 0.38)	
Factor I, Information Availability	.24
Factor III, East-West Dichotomy	.37
Factor IV, Cosmopolite Characteristics	.19
Factor VIII, Housing Characteristics	.38
Passion Fruit Adoption, 1971 (R^2 = 0.11)	
Factor III, East-West Dichotomy	.24
Factor V, North-South Dichotomy	-.23
Grade Cattle Adoption, 1971 (R^2 = 0.46)	
Factor II, Population Characteristics	.21
Factor IV, Cosmopolite Characteristics	-.29
Factor VIII, Housing Characteristics	.58
Hybrid Maize Adoption, 1971 (R^2 = 0.20)	
Factor I, Information Availability	.22
Factor III, East-West Dichotomy	.39

there is either an extremely low correlation, as with passion fruit adoption at .0056, or a negative relationship, the highest being with grade cattle at -0.2920. This would seem to indicate that the more cosmopolite farmers are not likely to adopt grade cattle. But that proposition does not necessarily hold true, for the places where grade cattle were first introduced will have a profound influence on the subsequent adoption pattern, and those places are not necessarily related to the distribution of cosmopolite characteristics.

Some Internal Interrelations

A careful examination of the intercorrelation matrix reveals an interesting relationship for each of the six innovations between the mean year of adoption, the mean number of acres (or cattle) per farm, and the percent of farmers raising the item in 1971. The earlier the mean year of adoption, the greater number of acres (or cattle) each farmer will cultivate (or keep). The earlier an area adopted the greater the percentage of farmers raising the item. The higher the percentage of farmers raising the item in an area the higher the number of acres cultivated or cattle owned. Thus the original nodes will have the highest level of adoption, in terms of the percent of farmers adopting, and the greatest intensity, measured by the number of acres or the number of cows.

This relationship holds very well for coffee (see Table 15), passion fruit and grade cattle. For pyrethrum it holds fairly well, except for the relationship between acres per farm and the mean year of adoption. Tea exhibits a modest relationship between all three variables. So, for all of the cash crops and grade cattle the relationship holds to varying degrees. But for hybrid maize there is none. This can, perhaps, be explained by the fact that hybrid maize is not normally a cash crop, and as such market considerations do not enter into the farmers' calculations, therefore he will not be as cautious about adopting. Also, it has the most rapid rate of adoption, because it is a relatively simple change from local maize, so the relationships do not hold. In spite of the rapid rate of adoption the correlation of .23 between the percent of adoption in 1971 and the mean year of adoption suggests that the original nodes have the highest levels of adoption.

The relationship between the mean year of adoption, and the percent of adoption in a sampling area exists primarily because of the friction of distance. Awareness knowledge, that is, knowledge about the existence of the innovations in question is very widespread. But specific "how-to" knowledge is confined to those areas having greater experience with the innovation, therefore more farmers have adopted and each

TABLE 15.--Internal Intercorrelations, Mean Year of Adoption, Mean Acres per Farm, Percent Adoption 1971.

	Year Adopted	Mean Acres	Percent 1971	Year Adopted	Mean Acres	Percent 1971
	COFFEE			PYRETHRUM		
Year Adopted	--			--		
Mean Acres	.91**	--		.39**	--	
Percent 1971	.86**	.90**	--	.61**	.55**	--
	TEA			PASSION FRUIT		
Year Adopted	--			--		
Mean Acres	.54**	--		.79**	--	
Percent 1971	.51**	.60**	--	.68**	.74**	--
	GRADE CATTLE			HYBRID MAIZE		
Year Adopted	--			--		
Mean Acres or Number	.74**	--		.08	--	
Percent 1971	.67**	.69**	--	.23*	-.06	--

*Significant at .05 level.
**Significant at .01 level.

farmer uses it more intensively. Knowledge of exactly how one goes about getting material to start raising the crop (or how to acquire grade cattle), knowledge about horticultural methods, harvesting techniques and marketing procedures are progressively more important as one goes from innovator to laggard on the adopter category continuum (Rogers, 1971, pp. 259-261). Awareness knowledge depends on large numbers of farmers raising the item so that non-adopters can observe and ask questions about specific procedures. Thus the level of "how-to" knowledge varies greatly over space.

As an indication of the spatial behavior exhibited by Gusii farmers consider the following. The field survey data indicate that 61 percent of the farmers in the study area never travel to a market, for either buying or selling, that is over 4 km. (2.5 miles) away from their farms. Most of the time people travel to the nearest market, so 91 percent of the farmers report that they normally travel to a market located within 4 km. (2.5 miles). Also, the greater the population density of the area the closer the spacing of markets, therefore people travel even shorter distances. For example, in Kitutu East, the most densely populated location in the study area, 61 percent of the farmers travel to markets located within 2 km. (1.25 miles) of their farms. Using distance traveled to markets as a surrogate measure, one could assume that farmers would travel much shorter distances to visit another

farm for the purpose of acquiring specific "how-to" knowledge.

Strong distance friction would cause a very small Personal Information Field. Distance friction is, of course, caused by the fact that people walk most of the time. Virtually no farmers in the district have automobiles, few have bicycles, and bus transport is oriented to the larger towns only, the result being that most people walk on journeys of less than, say, a one-hour walk. In spite of the high local relief the area operates somewhat like an isotropic plain in that foot travel is nearly omnidirectional. The maze of footpaths is interrupted only by the steepest of relief features.

While awareness knowledge can travel from adopter to non-adopter and subsequently to other non-adopters, specific "how-to" knowledge generally moves from adopter to non-adopter only. Thus the lower level of knowledge is relatively unaffected by distance, but the higher level is very much retarded by distance, because "how-to" knowledge can diffuse spatially only as fast as adoption spreads.

The Accelerating Pace of Change

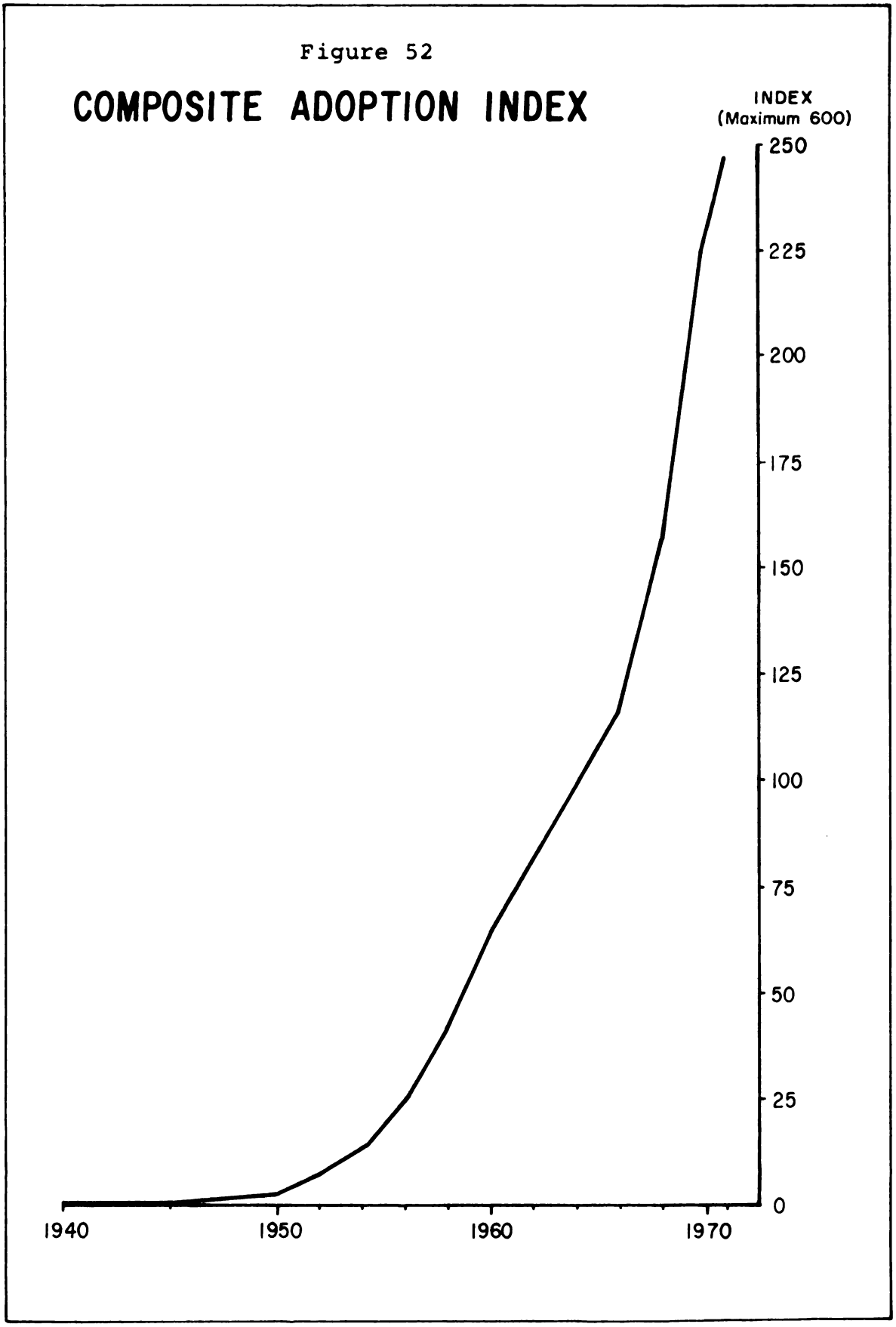
A question that could be asked in the context of this study is: "Has the pace of change increased over the years?" One might ask such a question after examining the graph showing the cumulative percent of adoption

for each of the six innovations. It appears that there is a steady increase in the adoption rate when one considers first coffee, then pyrethrum, and finally hybrid maize. Thus, over time, the length of the bottom end of the logistic curve shortens and the steepness of the central part of the curve increases. So from this inquiry one would conclude that the pace of change is quickening.

But when one considers the three newest innovations, tea, grade cattle and passion fruit, the picture becomes murky. For grade cattle and passion fruit, in particular, the lower end of the logistic curve seems to be even less steep than for the innovations introduced earlier. However, there is a fallacy in considering innovations separately, because innovativeness is a combination of all of these innovations, and therefore they should be considered in concert (Figure 52).

Simply adding together the percents of adoption for the six innovations during each time period will give a crude measure of the pace of change. This composite adoption index has a theoretical maximum value of 600, assuming that all farmers within the study area were to adopt all six innovations. Considering five-year increments from 1940 we find that there has indeed been a constant acceleration in the pace of change. From 1940 to 1950, a ten-year period, there was only a change of 2.7

Figure 52


COMPOSITE ADOPTION INDEX
INDEX
(Maximum 600)
250
225
200
175
150
125
100
75
50
25
0
1940
1950
1960
1970

in the index. Between 1950 and 1955, only five years, the index increased by 17.6, or 6.5 times as much as the previous time period. During the next five years, from 1955 to 1960, the increment was 44.0, or still over twice as much as the previous time period in spite of the increased size of the base. From 1960 to 1965 the rate of increase diminished somewhat as the growth was only 42.4. So, in spite of a declining relative rate of change during this time period, the overall change as measured by these innovations is still several times as great as it was during the 1940 to 1950 period. After 1965 the pace of change again quickens. The amount of increase from 1965 to 1970 is 120.1 on the composite adoption index for this five-year period. This is nearly three times the rate of increase for any other comparable five-year period. If the growth in the index from 1970 to 1971 is projected out to 1975 the rate would diminish only slightly from the 1965 to 1970 pace.

It is evident that one must consider the alternative items available for adoption, for given a selection of innovations the rate of adoption for any one item will most likely be slower. So if farmers, for example, did not have the alternatives of grade cattle or passion fruit adoption during recent years but only the adoption of tea, the adoption rate for tea would have been much higher. One can only reach the inescapable conclusion

that the rate of change has acceleratec considerably from the decade of the 1940's to the 1960's. The overall rate of change in the future seems to be more dependent on the number of innovations available for adoption rather than the speed with which one single innovation is accepted.

The Composite Adoption Index leads back to a question raised in the introduction to this dissertation. That is, does an accelerating pace of change, as measured by innovation adoption, lead automatically to an improvement in family welfare? If, for example, a farmer raises commercial crops to the exclusion of food crops, and then purchases an inferior diet, the family suffers because of the innovation. On the other hand, if the adoption of hybrid maize allows a farmer to produce an adequate amount of food on less land, and then uses the extra land to raise a commercial crop to earn money to purchase high protein supplements to the family diet, then the family is better off. The contribution of innovation adoption to improved family welfare is not measured here. The Composite Adoption Index only examines the pace of change, and not the consequences of change.

Generalizations About the Factor Analysis and Regression and Correlation Models

Factor analysis of the 57 variables measuring the innovations plus socio-economic and demographic variables showed that the innovations were quite unrelated to the

other non-innovation measures. The innovation measures either factored out by themselves or on the same factor as the locational measures. There was little relationship between innovation measures and the measures of communication behavior. Analysis indicated a strong interrelationship between the various measures of communication behavior. Variables measuring population are quite similar so they logically factored out together. Other indicators such as housing characteristics, and the number of children in high school are measures of wealth, so they emerge on the same factor. The second factor analysis, with the innovation measures removed, reveals that the basic dimensions are much the same, minus, of course, the innovations. For example, the factors measuring only an innovation were no longer present, and the geographic factors were minus the innovation variables.

The basic reason for the small amount of explanation provided by the variables used seems to be one of scale. When considering the study area as a single unit the patterns found match those found in other research. That is, the growth curves of adoption over time are completely normal and understandable and the relationship of the socio-economic and demographic variables to each other is completely logical. A problem, however, is encountered when one tries to relate the socio-economic and demographic variables for the entire study area to

the spatial diffusion pattern. An attempt at prediction of the spatial diffusion of adoption based on a knowledge of the spatial pattern of socio-economic characteristics is not substantiated because of a conflict in scale. Throughout the study area there is a relatively uniform distribution of socio-economic characteristics, so no one area stands out as being more likely to adopt earlier. Therefore the place of original introduction, whether random or planned, is the principal determinant of the early pattern of adoption. So a person residing at the locus of original introduction with the characteristics of a laggard may adopt the innovation at, say, time T plus 3, and another individual, residing a long distance away, with the characteristics of an innovator or at least an early adopter, may adopt at time T plus 6. Thus any attempt to predict when a person is likely to adopt must include the fact of propinquity to other adopters.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Only in recent years has the explosive nature of African population growth come to light. Kenya, for example, is increasing in numbers by 3.3 percent annually, a doubling rate of 21 years. An exponentially growing population such as this puts severe strains on the government to provide the services needed by the people, but more importantly it generates demand for meaningful employment at a faster rate than the economy can supply. Closely associated to the employment problem is that of migration. Wage rates are several times as high in the urban areas as opposed to rural areas, so large numbers of people migrate to the city to seek employment. Even though the probability of securing a job is low, the dramatic increase in income makes such an attempt rational. As a result of such conditions Nairobi has been growing by 9.5 percent annually and the African population of the city, that continues to make up a larger portion of the total each year, is expanding by 14.5 percent annually.

During most of the 1950's and into the 1960's development planners generally subscribed to the theory of advancement through industrialization, but unfortunately, it has not generated adequate employment opportunities. Manufacturing as an employment category has actually decreased over the past decade in Kenya. The so-called modern sector (i.e., in general terms, wage employment) has expanded slightly only because of a major increase in government employment. The output of industry, as measured by the value of the goods produced, is expanding by about 6 percent annually, in spite of declining employment. The reason is that owners seek to maximize returns per worker and per unit of investment. No mineral deposits of consequence have been found in Kenya.

Agriculture, therefore, is, and will continue to be, the most important sector for employment and export earnings. About one-third of the Gross Domestic Product consists of agricultural products, about 60 percent of commodity exports are raw or processed agricultural goods, and most importantly, three-fourths of the population derives its livelihood from the land.

The fastest growing portion of the Kenya economy is tourism. The annual increase in the number of foreign visitors to Kenya in recent years is approximately 25 percent. The projected foreign exchange earnings for 1974 are K£ 37 million (U.S. $95 million) which will

make tourism the single most important earner of foreign exchange, surpassed only by export categories such as agriculture and manufacturing. In terms of employment, tourism is not very important as the projected 1974 workforce is only 40,000, or slightly less than 1 percent of the total.

In agriculture there are two general ways to attack the dual problem of production and employment; opening new land and intensification of production on currently used land. The former has generally been abandoned due to a variety of reasons, the most important being the high cost of settling each family. Intensification involves the application of new technology, or simply old technology in a more concentrated form, to increase output per acre. Increased output per unit of labor is important, but since employment generation is a principal goal, efficiency takes a secondary position.

In order to intensify the farmer must accept a combination of new methods, technology and crops. The rate at which these innovations are accepted by the farmers largely determines the success of the intensification program. In order to understand the process of innovation adoption, with the ultimate aim of facilitating the diffusion of innovations, a whole area of academic inquiry has developed. Several broad categories of investigation are undertaken by diffusion researchers. They are:

(1) The communication network through which the farmer receives information about the innovations. (2) The personal characteristics of people who adopt at different times. (3) The characteristics of the innovations that influence the rate of adoption. (4) The growth of adoption over time. (5) The impact of organizations specifically engaged in the introduction of change. (6) The consequences, to the individual and to society, of innovation adoption.

Geographers are concerned with the spatial aspects of the diffusion process, that is, the manner in which the innovation spreads across the landscape and the combination of forces that facilitate, retard and modify that spread. Hagerstrand postulates four separate stages in which the innovation is introduced into an area, spreads outward rapidly, intensifies, and finally increased slowly up to the maximum acceptance level.

The central feature of the spatial diffusion model is the Personal Information Field. It refers to the declining probability of communicating about the innovation to another person as distance increases. Personal Information Fields can and do overlap with one another as the distance between adopters lessens. Therefore, in areas where the adoption rate is high the numerous overlapping Personal Information Fields will create a more intense Regional Information Field. The localized generation of

specific information (i.e., information of the type needed for a person to adopt) about a potential innovation is an important factor explaining the spatial diffusion process.

Kisii District, in southwestern Kenya, is 2217 square kilometers (856 square miles) with a population of about 675,000 people, most of whom are Gusii. The economy is based on a combination of small-holder cash crop and subsistence agriculture. A variety of food crops are grown for local consumption and several cash crops, such as coffee, tea, pyrethrum and passion fruit, are grown for export. There is little other economic activity in the district, save the provision of a small quantity of consumer goods.

The district ranges in elevation from about 1525 meters (5,000 feet) to over 2135 meters (7,000 feet), is cool year around, receives abundant rainfall that is reasonably well distributed temporally and spatially, and has good soils throughout. The landscape that results from the combination of intense cultivation, dense population, high altitude and abundant rainfall is not one that fits the typical stereotype of Africa.

Perhaps the most serious problem facing Kisii District is population growth. Currently portions of the district have over 580 persons per square kilometer (1,500 per square mile), and even the most sparsely populated areas, with the exception of the former settlement area,

have over 135 persons per square kilometer (350 per square mile). Add to this the annual growth rate of 3.6 percent for the district as a whole and one can easily see the population problem Kisii faces.

Six innovations are under investigation in this study. Coffee was first planted in the district in 1921, but it was not until about 1950 that it began to spread. Today a little over half of the study area has some coffee grown on it, but diffusion has essentially stopped, due to a ban imposed on additional planting. The ban, however, has not been strictly enforced.

Tea was first introduced in 1957 in the eastern part of the study area, because farmers in that part of the district had experience working with tea on the nearby estates. It spread rapidly to the west, but now the Kenya Tea Development Authority is attempting to restrict the spread of adoption, instead opting for more concentrated adoption.

In 1950 pyrethrum was first grown in the eastern part of the study area. It has spread to most of the study area, but remains concentrated in the east. The main reason for the lack of spread to the entire area was the prohibition on planting below 1890 meters (6,200 feet), which slowed the adoption rate in the western one-third of the study area. Now that demand has increased substantially pyrethrum is grown below that level.

Overall, adoption continues, but the slowdown at the top end of the growth curve is becoming faintly perceptible.

Passion fruit was introduced into the Keroka area in 1959, and today remains concentrated in the same place. After a series of difficulties, such as low price, disease and discouragement by the agriculture department, the crop started to gain acceptance in 1966. Presently the adoption rate is comparable to that for tea.

Grade cattle are gradually replacing the local breeds in Kisii. The cattle were introduced in a number of locations at the same time so the diffusion process is primarily characterized by intensification and infilling rather than an outward movement of a diffusion wave. In spite of the high cost of acquiring grade cattle the rate of adoption is quite high. The cost in and of itself is not a factor in the rate of adoption because very few Gusii farmers could afford to adopt without a loan. The hinderance to adoption therefore is the difficulty of securing a loan with which to buy the cattle. The profitability of grade cattle is obviously sufficient to justify the expenditure involved.

Hybrid maize has experienced the fastest adoption rate in the history of Kisii District. From its introduction in the early 1960's until 1966 the adoption rate was not very high, but in that year it began to be accepted with amazing speed. In 1971 only about 20

percent of the farmers had failed to adopt hybrid maize. The adoption rate has now slowed slightly as the upper part of the growth curve has been reached.

Table 16 is a summary of the principal characteristics of the diffusion of the six innovations being investigated here. All of the items in the table are presented in the analysis of the diffusion process in Kisii, but are included in tabular form here for the convenience of the reader.

A dissertation should seek to be unique and innovative if it is to add to the current body of knowledge. To that end, this dissertation has attempted to do several things that have heretofore seldom appeared in any research. The distinctions are as follows: (1) Innovations were examined as they diffuse through space as well as time. (2) The focus of the research was on an area in the developing world. (3) The unit of analysis was the spatial unit rather than the individual farmer. (4) Percent of adoption by area was used rather than individual discreet adoptions. (5) Spatial diffusion was related to socio-economic and demographic characteristics via factor analysis and multiple regression and correlation. (6) Computer maps and three-dimensional computer graphics were used to visually portray the spatial diffusion pattern. (7) An attempt was made to integrate the basic concepts of temporal and spatial diffusion.

TABLE 16.--Summary of Diffusion Characteristics.

Characteristic	Coffee	Pyrethrum	Tea	Passion Fruit	Grade Cattle	Hybrid Maize
Year of Introduction	1921	1950	1957	1959	1961	1958
Number of Originating Centers	3	3	2	1	7	9
Hagerstrand Typology (yrs)						
Stage I	1940-50	1950-52	1957-58	1959-68	1961-64	1958-66
Stage II	1952-62	1954-64	1960-64	1970-71	1966-71	1968
Stage III	1964-71	1966-71	1966-71	NA	NA	1970-71
Stage IV	NA	NA	NA	NA	NA	NA
Deviations from Hagerstrand	Stage II and III	Stage II and III	Stage II and III	Stage II	Stage II	Stage II and III
Mean Year of Adoption vs. % Adoption 1971	r=.86	r=.61	r=.51	r=.68	r=.67	r=.23
Mean Year of Adoption vs. Use Intensity 1971	r=.91	r=.39	r=.54	r=.79	r=.74	r=.08
% Adoption 1971 vs. Use Intensity 1971	r=.90	r=.55	r=.60	r=.74	r=.69	r=-.06
Marketing Location Important?	Yes	Yes	No	No	No	No
% Adoption 1971	42%	78%	32%	9%	11%	78%
Innovation Wave same as Morrill's	Different	Different	Different	Different	Different	Different
Socio-economic Variables Loading on Factor Analysis	None	None	None	Population Density	None	None

Conclusions

1. The spatial diffusion of agricultural innovations in Kisii is characterized by the following. (1) In the initial period there is little contrast between the adopting and the non-adopting areas as the former have achieved only a low percent of acceptance. (2) During the second period new diffusion nodes form in isolated locations and peaks of higher adoption appear above the general low level of adoption. (3) The valleys between the adoption peaks begin to fill in as the peaks reach 100 percent acceptance and spread out to form plateaus of saturation level adoption. (4) Finally, the gradient of the diffusion wave becomes progressively steeper as the distance from locations with no adoption to saturation adoption lessens.

2. The stages in the Hagerstrand typology of innovation diffusion are similar to those found in Kisii, with two exceptions. Stage II, the diffusion stage in the Hagerstrand typology is denoted by the development of new diffusion nodes and the leveling of regional differences. In Kisii new nodes appear but regional differences become more pronounced. Old and new nodes increase in adoption percent until they become

peaks of very high adoption levels that stand out above the surrounding area. Stage III, the condensing stage, is characterized by Hagerstrand as exhibiting equal increases in all areas. In Kisii this stage primarily involves filling in between the adoption peaks and the outward spread of those peaks to form plateaus.

3. There is a strong positive relationship between the mean date of adoption, the percent of farmers adopting the innovation and the intensity of use within the individual sampling areas. Thus, the first areas to adopt an innovation also tend to be the ones with the highest percent of the farmers who have adopted and where each farmer raises more acres of the crop (or keeps more grade cattle). The exception to this tendency is hybrid maize. The adoption rate has been much more rapid than for the other innovations because it simply replaces an old crop. It would tend to have more uniformity of acreage per farm because it is a food crop. Also, everyone raises local maize so the conversion is largely the result of seed availability.

4. The location of marketing sites for coffee and pyrethrum are important in understanding the present spatial pattern exhibited by these two

crops. In order for either a coffee factory or a pyrethrum cooperative marketing society to be built it is necessary to have enough production nearby to justify the expenditure involved. Frequently when a coffee factory was built the level of coffee adoption in adjacent areas would quickly increase. In 1959 and 1960 the pyrethrum societies were opened. Those areas located near the new cooperative marketing societies experienced a rapid decrease in acceptance. Today, areas with 100 percent adoption of pyrethrum are all located within a few kilometers of a cooperative marketing society.

5. The Gusii have exhibited a ready response to the profitability of innovations. Price declines, or an uncertain market future, have a noticeable effect on the growth curves of adoption. For example, the inflection in the pyrethrum growth curve that takes place in 1960 was caused by a drop in price. Passion fruit experienced a very low rate of adoption for several years until it became certain that the crop would be profitable to adopt.

6. With the exception of hybrid maize, all the innovations exhibit approximately the same rate of adoption. In the early 1950's there were only

two innovations available, but in the 1960's all six became available. The rate at which each individual innovation is accepted has not significantly increased in recent years. Therefore, the combination of all innovation adoptions added together is a measure of culture change. This is not to say, however, that change necessarily is for the better, for spatial innovation diffusion, rather than the consequences of innovation is the subject of this research.

7. Due to the very limited division of labor, both socially and spatially, each part of the study area is much like all other parts. That is, there is little range in the size of farms, size of families, levels of income, etc. from one place to another. Each sub-area will, therefore, have approximately the same distribution of adopter ideal types, from innovator to laggard. An innovation with no ecological limits or marketing location constraints could be introduced into any part of the study area with the same probability of success because no area seems to have greater receptivity to innovation adoption. Thus, the most important determinant of when an area accepts an innovation is the time when the innovation wave moves into the area.

8. Factor analysis reveals that the innovation measuring variables are structurally unrelated to the other socio-economic and demographic variables. The exceptions are the geographic variables, such as, distance from Kisii town, locational coordinates, precipitation and elevation. Pyrethrum and tea are related positively to each other while coffee is inversely related to both of these. Grade cattle and hybrid maize are not closely related to any of the other variables as they factor out by themselves. Passion fruit is related only to population density. The innovations are related in this manner because of their geographical distribution.

Recommendations for Policy Planners

The following recommendations will be confined to spatial considerations.

1. To reduce marketing costs individual cash crops should be confined to reasonably defined areas. Within those areas a high percent of the farmers should be raising the crop. Cash crop production areas should overlap, rather than be spatially exclusive, so farmers have the benefit of diversity in the event of a price decline.

2. Demonstration plots appear to be of minor importance in Kisii District, but have proved to be quite effective in other parts of the world. Plots should be strategically located where large numbers of people will see them. Also, they need to be properly marked and well maintained, and the number of plots should be increased.

3. Agricultural innovations should be introduced simultaneously at several places in a small area (about the size of Kisii District) so that numerous innovation waves can be generated. This will allow the build-up of specific "how-to" knowledge that will facilitate adoption.

4. Efforts of change agents should be concentrated around the points of original introduction to generate enough adoption for diffusion nodes to appear. The outward movement of innovation waves from several nodes will cause more rapid adoption than would occur if only one or two nodes existed. After the spatial spread is well developed only a minimal push from the extension services will be required.

5. Each individual farmer must make decisions as to the rational use of his limited resources. When competing alternative innovations are available for

adoption in an area farmers will be forced to decide between them. A farmer may decide to adopt only one, or he may utilize all available alternative innovations to a limited extent. Therefore, planners should be prepared to accept either a slower rate of adoption for each innovation, or a lower level of utilization. Intensive utilization and a high percentage of adoption for crop innovations simply may not be possible due to the scarcity of land.

6. Farmers at the laggard end of the adopter category continuum require more specific "how-to" knowledge and word-of-mouth information than others before they are willing to adopt. This kind of information seems to be more concentrated in areas of highest adoption. Therefore, change agents should suggest to laggards only those innovations that have achieved a very high level of acceptance in the immediate area.

7. If cash crop marketing locations are established before there is sufficient demand nearby farmers will be encouraged to adopt. The first years of uneconomic operation could be justified on the grounds that it encourages adoption.

Suggestions for Further Research

1. Innovations other than crops, such as fertilizers, should be investigated to determine the spatial diffusion pattern.

2. Other spatial diffusion studies should be undertaken in areas of peasant agriculture, but with low population density, for the purpose of comparing the diffusion pattern and the nature of the personal information field.

3. The spatial pattern of extension agent activity should be examined to see how they distribute their effort over the area assigned to them, and to evaluate the impact of concentrated versus dispursed efforts.

4. The relationship between the locations where an innovation is available to the farmer and the spatial diffusion pattern needs to be investigated.

5. Non-agricultural innovations should be researched to see if they diffuse spatially through a rural population in the same manner as agricultural innovations.

6. The "S" shaped growth curve should be aggregated at different levels to examine the impact of study area size.

7. The consequences of innovation adoption in terms of improved family welfare should be examined.

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Mr. N. N. Khaniri. Tea Officer, Kisii District. Location: District Agricultural Office, Kisii. Date: July 1, 1971.

Mr. Nathan Migire. Manager, Kisii Farmers Cooperative Union, Ltd. Location: Kisii Farmers Cooperative Union Offices, Kisii. Date: June 28, 1971.

Mr. James M. Ombui. Assistant Manager, Masaba Union Farmers Cooperative Society. Location: Masamba Union Farmers Cooperative Union Offices, Keroka, Kisii District. Date: June 27, 1971.

Mr. Michael Owen. Manager, Kenya Fruit Processors, Ltd. Location: His home near Sotik. Date: June 30, 1971.

Mr. Christoph von Tresckow. Manager, Small-Holder Credit Scheme. Location: District Agriculture Office, Kisii. Date: May 12, 1971.

APPENDICES

APPENDIX A

Location Sub-location Coordinates

Grid No. Interviewer Date

Year when each innovation was adopted

Name	Hybrid Maize	Coffee	Tea	Pyrethrum	Passion Fruit	Grade Cattle
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						
21.						

APPENDIX B

Location	Sub-location	Grid No	Coordinates	Farm No
Elevation	Rainfall	Distance	Interviewer	Date

Q1 Good Day, I am one of the officers going around in this Division asking a few farmers like yourself questions about farming matters. We need this information to help us plan better services to farmers. We would be grateful if you could help us with your answers. First, who is the head or owner of this farm and where is he?(IF NECESSARY,FIX APPOINTMENT. IF HEAD LIVES AWAY,PROCEED WITH Q1a)

Farm Head Male Fem Residence

Q1a Who is responsible for managing this farm from day-to-day? Name:

How related to the head? Head 1 | Wife 2 | Son/Dtr 3 | Fthr/Mthr 4 | Bro/Sis 5 | Rel 6 | Mnger 7 | Oth 8

		Sub-Loc	Loc	Div	Dist	Prov	Oth
Q2	Now, about land owned or rented by head...						
Q2a	How many pieces of land are owned/rented in this...						
Q2b	How many acres total are owned/rented in this ...						
Q2c	Is this land 1)Inherited 2)Bought 3)Rented 4)oth...						
Q2d	Is it 1)Adjudctd 2)Survyd 3)Registrd 4)Titled ...						

		Hybrd Maize	Local Maize	Coffee	Tea	Pyreth	Passn Fruit
Q3	Now, about crops grown on all land in this Division only						
Q3a	Have you ever grown						
Q3b	When did you first start growing...						
Q3c	Have you ever stopped growing...						
Q3d	(IF YES)When did you first stop growing ..						
	When did you last start again.. ..						
	How often have you stopped growing						
Q3e	Are you still growing						
Q3f	(IF YES)How many acres/trees are under ..						
	What spacing do you use						
	Do you use Chem Fert, FYM or None .						
Q3g	How often(per crop maize) Weed ..						
	(between long rains oth crops) Prune ..						
	do you ... ... Dust/Spray ..						

Q4 What kind of maize did you grow during this years long rains? Hybrid Local

Q4a And what kind did you grow during last year's short rains? Hybrid Local

		Cows	Bulls	Strs	Heifrs Calves	Pigs	Chcks Layrs	Chcks Table
Q5	Now, about grade livestock raised on land in this Division only							
Q5a	Have you ever kept							
Q5b	When did you first start keeping.. ..							
Q5c	Have you ever stopped keeping							
Q5d	(IF YES)When did you first stop... ...							
	When did you last start... ...							
	How often did you stop							
Q5e	How many.....do you have now... ...							

		Cows	Bulls	Strs	Heifers Calves	Sheep	Goats	Chks
Q6	And local livestock raised on land in this Division							
	How many.....do you have now... ...							

		Grade Cows	Local Cows
Q7	(IF EITHER GRADE OR LOCAL COWS KEPT)		
Q7a	How many of your cows are now in milk...		
Q7b	And how many of them are now dry		
Q7c	How many pints per day total do you usually milk		
Q7d	And how many of these pints do you usually sell.		
Q7e	Do you have 1)A Dairy Shed 2)Cleaning Stuff?		
Q7f	Do you own 3)A Pasture? Is it 4)Fenced? 5)Paddocked? ...		
Q7g	Do you provide your cows with 6)Fodders? 7)Concentrates?		
Q7h	Do you have your cows served by 8)A.I.? 9)Bull?		
Q7i	How often do you dip or spray your cattle?	Times per Month	

		Well	Raintank	River	Spring	Other (Spec)
Q8	Now about your water supply: Where do you get water for					
Q8a	Home use	1	2	3	4	
Q8b	Livestock	5	6	7	8	
Q8c	Irrigation... ...	9	0	x	y	
Q8d	When did you acquire your					

		Famly Mmbrs	Self Help	Risaga	Paid Cntrct	Paid Rglr	Ngesanglo	Oth
Q9	Now, about farm labor: What labor did you use between last long rain							
Q9a	Cash crops	1	2	3	4	5	6	
Q9b	Food crops	7	8	9	0	x	y	
Q9c	Livestock	1	2	3	4	5	6	

Q10	Where do you sell	Name of Market	SubLoc	Loc	Div	Dist	Prov	Elsewhere (Spec)
Q10a	Chicks/Eggs... ...		1	2	3	4	5	
Q10b	Milk...		1	2	3	4	5	
Q10c	Food crops		1	2	3	4	5	
Q10e	Meat...		1	2	3	4	5	
Q10f	Livestock..		1	2	3	4	5	

Q11	What kinds of farm records do you keep?	
Q12	Not counting extension officer, name 2 farmers in this area who you can trust to give you right information & advice about farming matters?	1) 2)
Q12a	And which two farmers in this area are usually ahead of other farmers when it comes to trying more modern ways of crop or animal husbandry?	1) 2)

		Agr	Vet	Adm	C Dev	Hlth	F P	Comrce
Q13	Which of the following officials visited this farm at least once since the long rains last yr?	1	2	3	4	5	6	7
Q13a	And which did anyone from this farm visit?	1	2	3	4	5	6	7

		Chief Baraz	Crop Demo	Anim Demo	H.Ec Demo	Cmrce Demo	Family Plning	Agric Show
Q14	Which of the following meetings did anyone from this farm attend at least once since the long rains last year?...	1	2	3	4	5	6	7
Q14a	Which were found very useful?...	1	2	3	4	5	6	7

Q15 Has there ever been a demonstration plot on any of your land? Yes 1) No 2)

Q15a Since Xmas last year, how many demo plots did you see/visit in this Dist?

Q15b How many times have you and others from this farm attended FTC courses? ____ times

		Kanu	Coop Soc	Local Counl	Maen-deleo	Sch'l Board	Hmbe Group	Chrch Group	4K Club	Other
Q16	Is anyone from this farm at present a member of ... (IF MEMBER)	1	2	3	4	5	6	7	8	9
Q16a	Is he/she an office-bearer?	1	2	3	4	5	6	7	8	9

		Daily or almost	Few times per week	Few times per month	Seldom	Never
Q17	How often do you Read or have read to you					
Q17a	Daily Newspapers?	4	3	2	1	0
Q17b	Mthly/Wkly Magazines?	4	3	2	1	0
Q17c	Listen to Radio...	4	3	2	1	0
Q17d	Visit Kisii Town	4	3	2	1	0
Q17e	Other Districts in Kenya	4	3	2	1	0
Q17f	Nairobi...	4	3	2	1	0
Q17g	Go to Church..	4	3	2	1	0

Q17h How long did you live, work, study, outside Kisii dist in your life?

Q18 What is Heads main occup? _____ Others? _____

Q18a What is resp main occup? _____ Others? _____

Q19 EDUCATION	H	R
None	0	0
Up to std 3	1	1
Up to Primary	2	2
Tech Training	3	3
Up to Form 2	4	4
Up to Form 4	5	5
Prof Training	6	6
Up to Form 6	7	7
Coll/Univ	8	8

LITERACY	H	R
None	0	0
Vermac	1	1
Swahili	2	2
English	3	3

SEX

Male	1	1
Female	0	0

MARITALS STATUS	H	R
Single	1	1
Married (Monog)	2	2
Married (Polyg)	3	3
Widowed	4	4
Separated	5	5

AGE
of Head _____
of Resp

BIRTH PLACE OF HEAD
In this Sub-loc ____
Elsewhere (Spec)

B.P.OF HEADS FATHER
In this Sub-loc ____
Elsewhere (Spec) ____

RELIGION

Q20 How many people live on this farm? ____ :Adults 16+? ____ :?Minors 15-? ____ :

Q20a How many of the Heads' direct family are on this farm? ____ :And Away? ____ :

Q20b How many of the Heads children attend school? ____ :Primary? ____ :Higher? ____ :

Q20c Who all help to pay school fees for N/A Head Wife Son/Dtr Fthr Mthr Bro/Sis Oth
children from this farm?... ... ... 0 1 2 3 4 5 6

		Coffee	Pyrethrum	Tea	Maize	P.Fruit	Milk
Q21	What is your ...						
Q21a	Co-op society...						
Q21b	Co-op/KTDA No...						
Q21c	1970 income from						
Q21d	(OFFICIAL INCOME)						

		WALLS			ROOF				FLOORS			WINDOWS	
Q22a	House type	Stone	Wood	Mud	Tile	Iron	Tin	Thatch	Cement	Wood	Earth	Glass	Wood
		1	2	3	4	5	6	7	8	9	0	x	y

		TOILET			COOKING			LIGHTING			FENCING		
Q22b	House facilities	W.C.	Pit	Nil	Stove	Jiko	Stones	Elec	Prfn	Other	Wire	Hedge	None
		1	2	3	4	5	6	7	8	9	x	y	

		Plow	Saw	Spray	W/Barrow	Tractor	Bike	Lamp	Clock	Radio	T.V	Car	Phone
Q22c	House old possessions	1	2	3	4	5	6	7	8	9	0	x	y