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SOCIOECONOMIC CONSTRAINTS TO THE ADOPTION, AND DIFFUSION OF
CHEMICAL FERTILIZERS AMONG SMALL-SCALE FARMERS: A KENYAN CASE STUDY.

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ABSTRACT

Many developing countries are today actively searching for ways and means of raising the level of agricultural output (particularly of food), productivity, farm employment and incomes especially within their rural small-scale farming sectors in which the majority of their populations is located. This search process has identified chemical fertilizer use, among other things, as one of the most potent modern agricultural production technology which, together with other complementary inputs such as high-yielding varieties, pesticides, herbicides etc, is capable of meeting the above objectives. Yet even though fertilizers have been on the market in these countries for many years, their adoption by small scale farmers remains very limited. This limited use of such a high potential technology raises the question: What factors constrain the widespread adoption of fertilizer use among small-scale farmers in developing countries?

The study proposed in this paper is aimed at identifying and quantifying, where possible, the socioeconomic and other factors that constrain the adoption of fertilizer use by small-scale farmers in Kenya. The study is based on a random sample of between 200 and 250 farmers located in Kirinyaga District in Central Province.

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AMONG SMALL-SCALE FARMERS: A KENYAN CASE-STUDY

INTRODUCTION AND GENERAL BACKGROUND TO THE PROBLEM

Recent agricultural growth and development literature as well as programs of national governments and aid agencies, have increasingly shown a growing awareness of the need to focus attention on raising living standards of the masses of people living in the rural areas of the less developed countries. This growing awareness has unfortunately not been matched by an equal degree of agreement among students and practitioners of economic growth and development concerning the nature of the process(es) or means through which these standards of living are to be raised.

Meanwhile, and in spite of this apparent lack of an agreed theory and practice of agricultural and rural development, the problems confronting the masses of rural people in the LDCs have continued to grow both in number as well as in complexity (1). And today, the problems of LDCs, compounded as they are by their ever rising populations, are being discussed more in terms of rising and largely unmet food and other basic needs than in the lubric term of "standards of living" (2).

By far, the largest number of people of the LDCs live in the rural areas and for most of them, agriculture or farming constitutes the principal occupation as well as source of their livelihood. Much of this agriculture however, is based on traditional and mostly archaic production technology which renders such farming extremely unproductive and therefore incapable of adequately responding, in a sustained manner, to the ever increasing need for food (quantity as well as nutrition-wise), employment, and income generation (3).

Thus, for the agricultural sectors of the LDCs to meet both the needs of the rural people as well as those of the rest of their economies, particularly with respect to food supply, the technology underlying such agriculture has to be transformed. Such a transformation has necessarily to be multidimensional. It has to include the introduction of, for instance, what might be called "hard" technology, e.g., new and improved inputs such as high yielding seed varieties (HYVS), fertilizer, pesticides, etc., and also "soft" technology such as better farm practices, better and higher levels of skills, knowledge and organization both at the micro (farm level) and macro levels of agricultural production, marketing and distribution. Such multifaceted transformation should ideally be carried out simultaneously and for better impact on agriculture, specific knowledge regarding each facet or dimension and its relationships with other facets is necessary.

This study aims at investigating factors which facilitate or impede the transfer of new technology-- specifically fertilizer from institutions which undertake its research, development (R & D) and marketing, to its ultimate users --the farmers. The motivation to study these factors stems from the following considerations: (i) Various agro-economic studies carried out in the area of food and other crop production (4), have identified fertilizer usage as one of the key components to any strategy aimed at increasing agricultural output and productivity as well as farm incomes and farm employment in general, as well as increase in food production, And besides, as J. Chanmugan /5/ notes, ... high natural soil fertility is a rather rare phenomenon anywhere in the world, and few soils can be cropped economically for more than a few decades continuously without requiring supplementation with essential plant nutrients; (ii) Several adoption and diffusion studies carried out in both developed as well as in the less developed countries have indicated that, where a new input such as chemical fertilizer becomes available for the first time in an area, some farmers adopt its usage relatively earlier than others and that while other farmers do follow these first adoptors overtime, there still remains a relatively large number of farmers who never adopt such an input even where available information appears to suggest that such farmers could benefit from such adoption /6, 7, 8, 9/. And at any rate, differential adoption of such a high potential innovation introduces serious income inequality since its use has the potential for increased yields, land-substitution (up to a point) and employment and income generation. Attributes such as these, are particularly relevant in small scale farming characterized by poor yields, land shortage, underemployment or unemployment as well as low incomes. Those who are earlier to adopt, gain "a windfall profit" if the innovation is successful and such profits are likely to put them a step ahead of late adoptors. Those who do not adopt at all never get to share any benefits associated with such innovations even though a lot of public resources may have been invested in making such innovations available to farmers. Consequently, for a society that aims at transforming its agriculture in an equitable way, such observed differences among adoptors and non-adoptors and between early and late adoptors, run contrary to such aims. Thus, an investigation such as this one aimed at identifying and measuring first, the effect of those factors that facilitate or impede the adoption of a given innovation by an individual farmer and secondly, the effect of those factors that lead to differential adoption at the community level, should be of interest to those concerned with raising the levels of agricultural productivity, employment and incomes in an equitable way. In this connection, it might be helpful at this point to briefly discuss how Kenya - the location of this study - fits into the problem context discussed above and how the country can benefit from the findings of this study.

Kenya

As a member of the so called less developed countries, Kenya has had a growing interest as a nation in ways and means of bettering the lot of her predominantly rural population which is dependent for its livelihood on agriculture--principally mixed farming. Such interests can be traced far in the history of organized government in Kenya /10/. However, real attempts to operationalize and institutionalize such interests, particularly as far as small scale peasant farming is concerned, could be said to have begun in 1954 when the then colonial government accepted and began to implement recommendations contained in the Swynnerton Plan /11/ which among other things, called for a crash program aimed at modernizing small-scale agriculture which hitherto had received little or no attention from the government. Before the Swynnerton Plan, government activities in agriculture were limited to the development of large-scale farms owned by white settlers who had a lot of influence in government circles. This bias against the African agricultural subsector started to be reversed with the acceptance of this Plan, and the period between 1954 and 1963 saw a lot of positive government activities which included; the setting up of a countrywide extension agency, research stations charged with the production and/or adaptation of new technologies suited to the resource endowments of small-scale farmers, etc., as well as the now famous land adjudication, consolidation and registration program.

With the achievement of independence in 1963, the new government decided to follow basically the Swynnerton Plan except this time, more vigorously. Thus, over the past 20 or so years, Kenyan small-scale agriculture has achieved quite a lot, particularly with respect to the setting up of new institutions charged with the responsibility of assisting small-scale producers. Such achievements, however, have had unbalanced income distribution impacts on a regional as well as at the farm household levels. In addition to such income distribution impacts, another serious development has been the overemphasis that has been placed at the development of traditional export crops such as coffee, tea, pyrethrum, passion fruits, etc., at the expense of development in food crops (with the exception of maize where research in crop breeding, agronomy etc., has produced locally adapted hybrid, synthetic and other varieties which have had some significant impact in yields in those areas of the country where farmers have adopted them). In general, one can say that such developments have benefitted mostly the so-called "progressive" farmers and the majority of the "less progressive" have, as it were, "been left behind" /12/.

Meanwhile, the problem of poverty compounded by an ever growing population /12/ has continued to get worse and to become less and less tractable. Already there is a growing concern with the country's ability to feed its growing population now and in the future. At the same time, unemployment and underemployment, both in the rural and urban areas, appear to deteriorate each year and rural incomes may be decreasing instead of increasing and its distribution is getting even worse /14/.

In the face of these problems, the government of Kenya has been and continues to be vigorously involved in attempts to seek solutions. Such recent rural development programs as the Special Rural Development Programme (SRDP), as well as recent shift from SRDP-type models to "District Planning," etc., are evidence of this constant search for solutions. In addition, the government appears to have also recognized, like other LDC governments, the potency of fertilizer in the solution of problems related to increasing output of food and other agricultural products; income; employment; as well as equitable distribution of the fruits of such increased output. As a result of this concern, the government has over the past few years been attempting to design policies, programs and projects aimed at increasing the availability and use of fertilizers by all farmers and especially the small-scale peasant producers /15/.

Yet, like other less developed countries, Kenya suffers from a dearth of policy relevant information and knowledge regarding the various factors that influence the adoption and diffusion of and the expansion of demand for innovations such as fertilizer-use, particularly at the small scale farm level. This type of information and knowledge, is particularly pertinent at this point in Kenya's agricultural development characterized by increasing investments in chemical fertilizer and other farm inputs' manufacturing capacity as well as increased investments in other areas such as in marketing and distribution infrastructure, extension, credit, research and farmer training services, etc. At the same time, the country is characterized by low rates of adoption, diffusion and levels of use of these inputs /16/. These considerations, convince us that Kenya can benefit from this and other studies aimed at contributing relevant information and knowledge on the types of factors that facilitate and/or impede the adoption, diffusion and expansion of levels of use (demand) of modern agricultural technologies with the potential for increasing yields, substituting for scarce land, increasing farm employment and farm incomes.

In the previous sections, we have discussed the need for developing countries in general and Kenya in particular, to find ways and means of raising the level of agricultural output, productivity, farm employment and farm incomes especially within their small-scale farm sectors in which the majority of their population is located. We also noted the fact that, there is increasing pressure on land in most of these areas due to rising population and that while available land per family gets ever smaller, its natural fertility is declining fast due to many years of continued cultivation without supplementary supplies of plant nutrients. Given these considerations, we isolated fertilizers as one of the most potent modern agricultural production technology which together with other complimentary inputs, can go along way in meeting the needs mentioned above and also arresting the declining soil fertility.

Yet the above factors notwithstanding, the rates of its adoption and diffusion (in terms of number of farm units initiating its use), levels of use (in terms of the quantities each adopting unit uses per season), remains relatively low. And this is inspite of the fact that chemical fertilizers have been available in the country for a long time now. This is a serious paradox which we would like to investigate.

THE OBJECTIVES OF THE STUDY

1. To investigate within a selected small-scale farming district in Kenya, the process and pattern of adoption and diffusion of chemical fertilizer use from a sample of farms and to identify the economic, social, institutional, physical and other constraints that impede this process. More specifically, the focus will be on the following questions:

- (1) What factors account for the variation in the time of initial trial of fertilizer usage among a sample of farmers?
- (2) What factors account for the variation in the time of adoption (sustained use) of fertilizer usage among a sample of farmers?
- (3) What factors account for the phenomena that some farmers within the sample will have tried this innovation while others, will not have tried it even after a long period of time in which the innovation has generally been available in the locality?
- (4) What factors account for the phenomena that among those who have tried fertilizer usage, some have gone to full adoption while others reject it?
- (5) What factors account for the phenomena that among those who have adopted fertilizer use, some use more each season than others even though they may be applying to it to the same crops and to equal areas of land?

- (6) What factors account for the phenomena that among adoptors, some may be using fertilizers on their traditional (tree) cash crops--tea, coffee, etc.--and not on their food crops especially maize even though research indicates significant crop response to fertilizers among these food crops?

2. In addition to the above questions, we also seek to understand the role of technical and other organizations which operate within the small scale agricultural sector and how their operations in general, constrain or facilitate the transfer of agricultural technology from its original source to its ultimate users. In this connection, some of the questions we would like to address include:-

Are there, for example, some operating procedures employed by these organizations which preclude or preempt the opportunities for small scale producers to avail themselves of these modern technological innovations? If so, how can such procedures be modified to make them more responsive to the needs and problems of small scale farming as practiced within the context of a semi-market economic system in which such agriculture operates?

E. Review of Literature

The phenomena of the adoption and diffusion of new ideas or innovations has for many years interested scholars from a wide range of the disciplines of the Social Sciences. The phenomena has been studied by economists, sociologists, geographers, communication scientists, and others. Yet, contrary to what one might expect from such a widely studied topic, there is yet, according to observers of this field, to emerge a systematic and comprehensive body of knowledge which can be put to use by those in government as well as in the business world who may want to employ such knowledge to increase the rate of adoption and diffusion of useful and/or profitable innovations /17/. This outcome of past adoption studies have resulted in dissatisfaction among scholars interested in this aspect of agricultural transformation. For example, Mosher /Introduction to Byrnes, 1968, 18/ had this to say about this state of affairs:

In few areas of research related to agricultural development have the traditional divisions among academic disciplines been more disastrous than in studies of the adoption of improved practices by farmers. Whether the persons making such a study be an agronomist, an economist, a sociologist, a communication expert or an anthropologist, the tendency has been for each to "explain" farmers' behavior predominantly in the light of the variables traditionally dealt with by the academic discipline represented by the investigator.

And, as Roling /1970: 71-72, 197/ has observed,

...much energy (has been devoted) to the study of the diffusion of innovations among farmers. This devotion has led to the development of an impressive body of findings, especially in the United States. One cannot, however, escape the feelings that a stalemate has been reached. Adoption studies are completed one after the other, the list of variables related to innovativeness is regularly expanded, but the findings have not been integrated into a more general theory of human behavior. This has halted the qualitative progress of research. Many phenomena are left unexplained, cannot be interpreted, or seem incorrectly interpreted.

The above two commentaries are offered merely as examples of the kind of dissatisfactions that are emerging from review of a large body of adoption and diffusion studies of general agricultural production technologies or consumer products carried out to date in the industrialized and market oriented societies of Western Europe and North America. However, Barnes /20/ has recently carried out a comprehensive review of similar studies carried out in developing countries with special reference to the adoption and diffusion of fertilizer usage among peasant farmers and he comes out as dissatisfied as Mosher and Roling in terms of serious shortcomings in methodological approaches, models, findings etc. Unlike the other two however, Barnes goes much deeper in his reviews pointing out these shortcomings and suggesting possible paths researchers interested in this subject matter might take.

From a quick glimpse of these types of reviews and some of the actual studies themselves /21, 22/ one comes out with the feeling that one of the major problems with past studies in this area has stemmed from disciplinary boundaries that researchers have, consciously or unconsciously, elected around the process of diffusion and adoption of new ideas--be they in agricultural production technology, manufacturing or in consumer products. Yet intuitively and from some of the "explanatory" variables identified in these studies, the adoption and diffusion of a new idea, e.g. a producer or consumer good, appear to be in essence a non-disciplinary specific phenomena which is likely to be influenced by economic, social, physical and other factors or variables. To the extent that this observation is true, to place disciplinary boundaries around such phenomena on a largely apriori basis, is likely to lead to strong, discipline-oriented and therefore possibly biased methodological approaches, specific models and findings. In the final analysis, such differences results in conflicting "explanations" of the nature and dynamics of these processes--an outcome which leaves practitioners confused and unable to apply such findings effectively.

Barnes identifies for instance, five major methodological approaches and specific models contained therein, which have been employed in the past in the study of the adoption and diffusion of fertilizer usage among farmers in developing countries. ^[23] These include:

1. the "price-induced" adoption/diffusion approach,
2. the "outward" (spatial) adoption/diffusion approach,
3. the "Downward" ("trickle-down") adoption/diffusion approach,
4. the "Upward" ("two-way communication" or "development from below") approach and
5. a group of approaches which do not fall neatly under any of the other four.

The first approach for example has been employed mostly by economists ^[e.g. Griliches, 24]. Within this approach, relative prices and their movements through and over time, are posited as the key determinants of the adoption and diffusion processes of a new input (innovation) such as fertilizer. In the second approach-employed mostly by geographers, spatial distance, is posited as the key "explanatory" variable that controls the diffusion and/or adoption of a new idea. The third approach - most popular with sociologists and communications experts - posits the "trickle-down" mechanism as an explanation of the flow of new ideas from their sources to their ultimate users. ^[Rogers, 25]. In connection with this methodology, it might be interesting to note that, this is the mechanism which has been used as a theoretical underpinning of extension workers operation model in many developing countries. Extension workers, the bearers of information about a new idea are advised to contact either the local opinion leaders or so called "progressive" farmers first - introduce the new idea to them and then hope that these group will over time diffuse the new idea to the other members of the community or village. Where such models have been used however, the result has been disappointing to say the least. After many years of availability of the new idea, it is found that only some farmers in the community have adopted it and that those who adopted it earliest have moved very far in terms of income distribution and that original goals of agricultural transformation with equity are simply frustrated.²⁶ The fourth approach is among the most recent. Central to this approach is the notion that research and development of new technology for farmers should begin with an assessment of farmers' felt needs, wishes and resource endowment and that only after such an assessment should researchers and other scientists attempt to discover and develop technology for solving the problems of such people.²⁷ This makes sense particularly in view of past experience where technology has been developed from simple and paternal assumptions regarding peasant farmers' needs.

Unfortunately, the approach does not provide a strategy as to how this is to be accomplished. Neither does it address the central issue: will farmers adopt the technology even if it has been developed with consultation with some of them or with their leaders? Also, it does not provide a theory of adoption. The fifth approach includes for instance, field "experiments," tree modelling and multivariate analytical models. Field "experiments" attempts to find out experimentally, the variables that influence adoption and diffusion of a new idea. Given time and resources, this is probably the best approach towards understanding the dynamics of the adoption and diffusion of new agricultural production technology. Unfortunately, even apart from constraints of time and resources, there are serious experimental problems associated with it including difficulties associated with the fact that, one is not certain as to what is to constitute the "treatment" particularly in cases where one is dealing with a "package" of a technology including say high yielding seed varieties, fertilizers, cultural practices, credit, training etc.²⁸ Tree modelling on the other hand, is an attempt to understand farmers decision making where alternative choices, consequences and their probabilities are known or can be assessed to give normative rules as to how farmers confronted with such choices ought to proceed. The multivariate analysis models have been developed to analyze data on adoption of innovations. These statistical models may be used and have been used within the other four methodological approaches but in the context they are used here, the one advantage with them is that unlike in approaches (1) - (4) discussed above, these multivariate models do not place any particular emphasis on any individual independent variable or set of variables as is the case with the other approaches. This makes them suitable in approaching a multidimensional subject matter such as the adoption and diffusion of new technologies where important independent variables are likely to come from the economic, socio-political, physical environment, etc.

There is obviously a great deal more that can and ought to be said about the various methodological approaches and models that have to-date been used to study the phenomenon of adoption and diffusion or spread of new agricultural production technology either in developed or developing countries. But due to constraints of space and time, we will not expand on this here. However, a general remark that would appear not too far fetched is that the disciplinary boundaries that researchers have placed on these processes have resulted in the kind of "explanations" about the mechanisms of adoption and diffusion that appear to have close analogy to the story told by the blind men about the shape of the elephant after they had been given an opportunity to examine one.

The above comment notwithstanding, however, it is clear that the explanations of adoption and diffusion of new technology given by those who have approached it as a price induced phenomena; a spatial-distance related phenomena; as a communication-through-opinion-leaders phenomena, etc. contain independent variables which are necessary but not sufficient to a full explanation of the phenomena, particularly, when such explanations are taken in isolation. Relative prices of both the inputs and output and their movements over time may or may not be crucial to the adoption diffusion of a new idea. So is spatial distance to the markets or to sources of the new technology or information about them. Social interaction through which information about the new technology may be diffused again may be crucial or just minimally important in determining the adoption and diffusion of such technology. In other words, we cannot on an a priori bases rule out any of these variables. What we can do, and we intend to do, is to develop a conceptual and operational framework which takes into account as many of these variables and then attempt to assess their influence on these two processes in a specified economic-socio-political and physical environmental context. In other words, we are looking for an integrated approach that attempts to bring together economic, socio-political, environmental (physical) and other variables which on the one hand explains the process of adoption of a new technology and on the other hand, its spread or diffusion in a given community.

The search and development of such an integrated approach to the phenomena of adoption and diffusion of a new agricultural production technology such as fertilizer usage among small scale peasant farmers, is a central focus of this study. It is our hope that such an approach could lead to the identification of key variables that government and other organizations interested in speeding up the adoption and diffusion of such a yield increasing, land augmenting and potentially income and employment generating technology, can manipulate.

Next, we discuss briefly the kind of integrated conceptual framework we have in mind.

Methodological Approach

One of the principal premise on which this study is based is that, the adoption and diffusion of new agricultural production technology such as fertilizer usage by farmers and as seen in the context of a society undergoing rapid transition from a traditional to a market-oriented economy, is a multi-dimensional phenomena influenced in part by Socioeconomic, agroclimatic as well as institutional variables. If our premise is basically sound, then it follows that, to seek an understanding of this phenomena, it is necessary to isolate key variables from each of these dimensions and relate them into a coherent framework within which the phenomena can be best understood. Before laying down such a framework, we will first introduce some of the key concepts around which such a framework is to be built. These include:

1. The concept of Innovation. For our purposes, an innovation is "an idea perceived as new by members of a social system."²⁹ Seen in this light, fertilizer usage is an innovation if and only if, it is perceived as a new, previously unheard of input. Such an input or innovation may have been in existence for a long time in another part of the larger society and as such, may not be perceived as new in that part. However, it will be an innovation to the part of society which is just becoming aware of it's existence for the first time.
2. Adoption. This is one of the concepts whose definition has caused a lot of controversy in the literature.³⁰ Abstracting from such controversy, we define adoption for our purpose, as a decision by a farmer or a farm family to acquire and use a new idea - such as fertilizer usage, for the first time. Accordingly, adoption is a micro level process which in the final analysis, works through decisions made by a farm manager or management unit. The same is true in the case of rejection.
3. Diffusion: Diffusion is a macro (societal) level process involving on the one hand, the flow of information about the existence of a new idea and on the other, the spread of use among members a community of the object (s) in which the new idea, such as fertilizer, may be embodied. In this connection, the diffusion process is likely to be strongly influenced by activities of business, government and other social organizations whose activities impinge on the operations of the farming community.

Following from the above definitions of the concepts of innovation, adoption and diffusion, we present below a schematic view of the relationships between an innovation such as fertilizer-usage and its adoption and diffusion by farmers. The variables involved can be grouped into three sets: (1) a set of independent variables that influence the probability that a farmer or management unit will or will not become aware of the existence of such a new technology; (2) a set of independent variables which influences the ability of a farmer or management unit to evaluate the new technology for attributes such as compatibility with existing production process or its relative advantage over an already known substitute etc., and (3) a set of independent variables which influence the ability of a farmer or management unit to implement either on a full scale or trial basis the new technology. The first set of variables can be said to constitute an awareness dimension, the second set an evaluation dimension and the third set, an implementation dimension. Hypothetically, constraints to awareness leads automatically to non adoption. One cannot adopt what one is not aware of. Similarly, constraints to evaluation, may lead to non-adoption or if it leads to adoption, the adopting unit is likely to make mistakes either with the choice itself or with later attempts to implement the choice. This is because such a choice would be based on incomplete or incorrect information about the new technology. Finally, even if a potential adopting unit becomes fully aware of the existence of a new technology, obtains as much information about it as possible, it may not adopt if it is unable to marshal the necessary resources - either owned or institutionally supplied - for the implementation of the decision to adopt. In other words, constraints in either of these dimensions of an innovations' adoption and diffusion will lead to non-adoption or incorrect use.

Below we present a schematic view of the relationships between these dimensions and variables contained within each viewed as constraints to an innovations' adoption and diffusion. These variables have been borrowed from the various methodological approaches mentioned earlier as well as from a general examination of the findings of studies based on such approaches.

Variables in group (a) address the question of awareness, those in group (B), the question of evaluation and those in group (C), the question of ability or inability to implement a favorable decision from (B).³¹

A) Potential Constraints on Communication of a new idea—eg Fert. usage.

B) Potential Constraints on Evaluation of a new idea before a decision to adopt or reject.

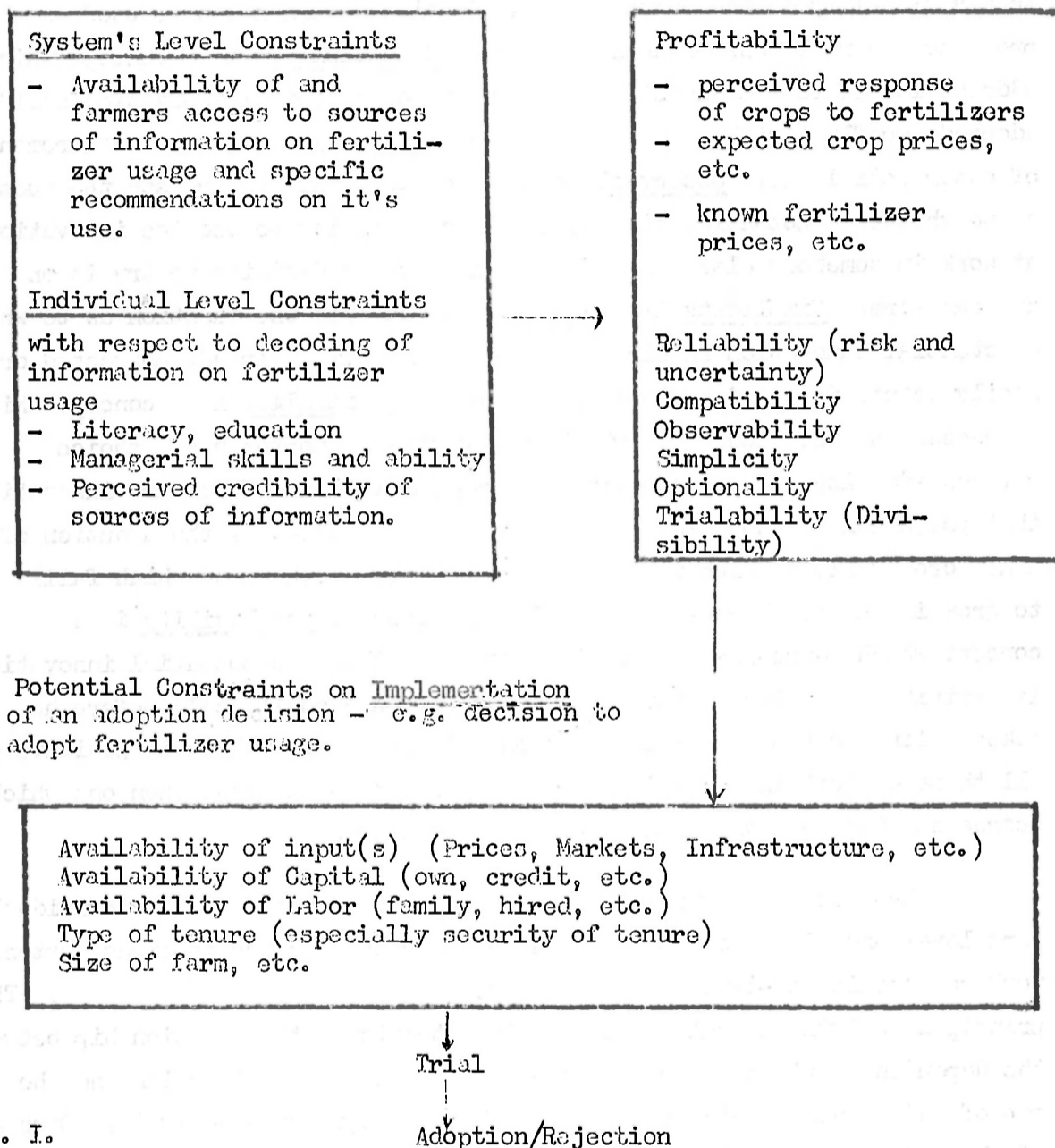


Fig. I.

Variables in group A and C are more or less self-explanatory. Some of those in group B however, needs some explanation. Briefly, profitability is simply the relative advantage (in monetary or nonmonetary terms) of a given technology over another. One could refer to this as a favourable benefit-cost ratio where the benefits and costs are in both monetary and nonmonetary terms. Reliability is the degree to which a farmer adopting a new technology can depend on it in terms of yielding consistent results from one period to another. An unreliable innovation is one which for

instance gives one result this time and a different result the next time and the adopter does not know a priori which result to expect. Accordingly, such variability in the outcome of an adoption decision can be used as a proxy to the riskiness of an innovation. Compatibility is a concept which address itself to the question of whether the potential innovation would if adopted, conflict with the existing operations and/or resource requirements of other activities. Observability is a concept which addresses the question as to whether a potential adopter has an opportunity to see the innovation at work in somebody else's farm before he makes a decision to try it on his own farm. Simplicity is a concept that address the question as to whether a potential innovation requires knowledge and skills already possessed or easily acquired by it's potential adopters. Optionality is a concept which addresses the question as to whether a potential adopter has a choice between adopting and not adopting a given innovation. There are innovations that potential adopters may have no realistic choice-e.g. the adoption of a new crop variety which is supposed to replace another one which fails to grow in an area because of a soil bone disease. Triability is a concept which addresses the question as to whether the potential innovation is divisible - so that a farmer can adopt it on a small scale before he makes a final choice for full adoption. An innovation which is positive on all these evaluation variables is more likely to be adopted than one which scores negative on some or all of these variables.

Data on these variables is being collected both at the individual farm level and also from other secondary sources research stations, extension workers, credit institutions, businessmen etc. The principal analytical tool to be used in determining the relationship between the dependent variables fertilizer-use (adoption) and diffusion and the set of independent variables will be multiple regression analysis. Some of the independent variables will enter the regression equations in the form of indices. We have in mind for instance- a knowledge/skill index which will be formed of items such as level of education, degree of literacy, contact with extension services, mass media consumption, membership in social organizations, attendance of farm demonstrations, farmer training courses and previous job experience in farming; a purchasing power index formed from such items as ownership of various assets including shares in companies, extra pieces of land that can be mortgaged for credit, livestock and cash crops etc.

I am also exploring the possibility of combining profit and multiple regression analysis.

G. Field Research Procedures

1. Location

The proposed farm-level investigation of the factors that influence the diffusion/adoption of and ultimately the demand for fertilizer among small-scale farmers in Kenya, is located in Kirinyaga District in Central Province. The district had an estimated population of 217,000 in 1969-70³² which today has probably risen to about 250,000. With an average of six persons per farm household, this works out to roughly 42,000 individual farm households.

In 1969, the district had an estimated availability of good agricultural land equal to about 100,000 hectares or about .5 hectares per person. All land in the district has been adjudicated, surveyed, consolidated and registered, and owners have been issued individual free-hold title deeds to their land.

Farming in the district is on a small scale level. Most holdings are below 10 hectares. Major cash crops include coffee, tea, and maize. Other crops, mostly for food, include beans, various millets, vegetables and bananas. There is no irrigation on these farms, although there is a government managed rice irrigation scheme (Mwea-Tebere) which is not included in our sample.

Basically there are three ecological zones: (1) the so-called high braken zone, also known as the "Kikuyu-grass-tea" zone and consists of farms located above 6,000 feet above sea level; (2) the star-grass zone, also known as the "coffee-banana" zone which is located between an altitude of 5,000 to 6,000 feet above sea level; and finally (3) the dry grassland or Savannah zone which comprises land falling below 5,000 feet above sea level. There are opportunities for using fertilizer in all zones — either on the traditional export crops or in food crops — mostly maize and bananas.

2. Sampling techniques

We intend to use the land registers kept in the District Land Registry as sampling frames from which we shall draw a random sample of between 200 and 250 farm holdings. Within each farm unit, we will identify the head of the farm household and defining him or her as the

farm manager or decision maker, we will interview him using a structured and partly precoded Interview Schedule of an optimum length. Each interview will be planned to take between one and two hours.

3. Analysis of data

After the Questionnaires have been checked and corrected for possible errors and omissions, the data will be coded and then punched into computer cards or tape and will then be analysed at Michigan State University.

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14. International Labor Organization (ILO), "Employment, Incomes and Equity: A Strategy for Increasing Productive Employment in Kenya." ILO, Geneva.
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16. FAO estimates that Kenya in the period 1970/77 was using only 32.4 kg. of N, P₂O₅, K₂O per hectare of arable land and only 5.0 kg. per capita. This is in comparison to developed countries like the USA or Europe which used 68.5 kg. and 169.6 kg. per hectare of arable land respectively and 54.6 and 54.0 kg. per capita over the same period. See Report on the FAO/DANIDA REGIONAL SEMINAR ON PLANNING AND ORGANIZATION OF FERTILIZER USE DEVELOPMENT IN AFRICA - held at Nairobi, Kenya, 1-16 Dec. 1972. p. 16.
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29. Rogers, E.M., op. cit.
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31. We have borrowed some of the concepts used here from Kelly Barnes' review manuscript, referred to earlier.
32. International Labor Organization (ILO). "Employment, Incomes and Equity: A Strategy for increasing Productive Employment in Kenya." ILO, Geneva.

TABLE

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