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ATPS Working Paper No. 19
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Published by: The African Technology Policy Studies Network
P. O. Box 62084
Nairobi, Kenya

Printed by: **Allied Printing Co. Ltd.,**
P.O. Box 73828, Nairobi Kenya

ISBN 9966-916-85-7

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Acknowledgements

We are greatly indebted to the IDRC and ATPS for enabling us carry out the study. Dr. Titus Adeboye, the ATPS coordinator, and his assistant George Githembe, kept us on track by providing invaluable advices as well as periodically reminding us of our schedule. We owe them many thanks.

Physical facilities and the conducive working environments at the Jomo Kenyatta University of Agriculture and Technology (JKUAT) and the Ministry of Research Technical Training and Technology (MRTT&T), our parent institutions of affiliation, made it possible for us to organize and analyze our data with relative ease.

This would not have been a study without the active cooperation of the directors and staff of the two research institutes we visited, the heads of departments and staff at the two universities we covered and the user respondents in our study. Our sincere gratitude to all of them.

During the period of the study we often spent long hours away from our families and thus denied them their rightful share of our companionship. Their understanding and endurance is highly appreciated.

The list of other people and institutions to whom we are indebted for their assistance, criticism and encouragement is quite long. We hope we will be pardoned for not mentioning by name all who contributed in one way or another to the successful completion of this study.

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Abstract

This report presents findings of phase I of a two-phase research whose main concern is investigating factors which influence the diffusion and adoption or acceptability of inventions and innovations made by Kenya's publicly funded research and development institutions. Phase I of the research was carried out to study the supply and demand of inventions and innovations originating from Kenya's publicly funded institutions, namely, the public universities and research institutes, as well as the demand for such innovations by the users.

The overall objective of this research is to identify policy interventions that could assist the technological process of diffusing and adopting local inventions and innovations.

Glossary of Terms

technology The application of knowledge to the production and distribution of goods and services. Technology is the conversion process that transforms the inputs of a business into outputs. More than simply machinery, technology also includes knowledge, tools, techniques and actions that are necessary to complete the transformation process. Often viewed as a major source of environmental change for business, technology consists of both inventions and innovations.

invention The creation of a new product or service that did not exist before.

innovation The modification and/or adaptation of a product or service; the introduction of a process or product that is new only to the given environment regardless of whether it has been used before anywhere. We believe that in innovation, the alteration of a product, rather than the creation of a new one, is almost always involved.

technological innovations Innovations adopted by entrepreneurial entities, as either intermediate or capital goods. Those innovations adopted by households as consumer goods will be referred to as consumer innovations.

adoption The acceptance of an innovation or invention by at least one user.

diffusion The process by which an innovation or invention is communicated through certain channels to reach and be adopted by many users.

objective The result which is expected. Objectives are, therefore, the broad aims of organizations and are related to the future since their attainment is distant in time and must be carefully planned. Planning in its turn is taken to be effectiveonly when it is supported by a network of appropriate policies.

policy The body of principles laid down to underline and guide the activities of an organization towards the declared objectives. A policy, therefore, means specific guidelines, methods, procedures, rules, and administrative practices established to support and encourage work towards stated objectives. It sets boundaries, constraints and limits on the kinds of administrative actions that can be taken to reward and sanction behaviour; it clarifies what should and should not be done in pursuit of the set objectives.

research and development Any creative and systematic activity undertaken to increase the stock of innovations or technology.

I. Introduction

In Kenya, publicly funded research has been undertaken for over 50 years. In recognition of the role of organized research and development (R&D), the country has established a number of research institutions. There are, today, five public universities:

- The University of Nairobi (UoN) - the oldest
- Kenyatta University (KU) - once a constituent college of UoN
- Moi University
- Egerton University and,
- Jomo Kenyatta University of Agriculture and Technology (JKUAT) - the youngest and once a constituent college of KU.

There are a number of non-university academic institutions commonly referred to as middle level colleges, including national polytechnics, that undertake some research, particularly innovational research. There are also lower level polytechnics that run practical programmes in innovations.

The country has gone further to establish specialised non-academic research institutes to cover various sectors of the economy. These include:

- The Kenya Agricultural Research Institute (KARI) addresses problems in the sector of agriculture.
- The Kenya Industrial Research and Development Institute (KIRDI) addressesproblems in the industrial sector.
- The Kenya Medical Research Institute (KEMRI) for the improvement of the health sector.
- The Kenya Forest Research Institute (KEFRI) addresses forestry problems.
- The Kenya Marine and Fisheries Research Institute (KEMFRI) promotes the exploitation of marine resources and the development of inland fisheries.
- The Kenya Trypanosomiasis Research Institute (KETRI) researches the effects of the tsetse fly on livestock and humans.

In addition to these institutions there are two Commodity Research Foundations namely, the Coffee Research Foundation (CRF) and the Tea Research Foundation of Kenya (TRFK). But unlike the previously listed institutions, which are funded through the exchequer, the foundations are funded through cess from commodity sales.

Kenya has, therefore, built enough public capacity to innovate and invent technologies to be diffused and adopted into the national economy. Although there are no clear records, it would appear that initially (largely in the 1960s and early 1970s), much of

research in Kenya, especially from non-academic institutions, concentrated on identifying and developing primary commodities to substitute imported consumer goods. The results became readily public and seemed to serve the long-term national developmental process.

Things are not quite the same any more. General observations indicate that most of today's research findings remain unapplied. The growing concern in recent years that the results of publicly funded research should be fully exploited and the society should derive maximum benefit from them is quite justified. Our belief, when we started this research, was that innovation and improved technical change in Kenya's economy should be the goal of Kenya's research institutions. Such a goal may best be realized by a combined effort between the research institutions and the users of their results. We have not changed our minds on this.

In phase I we carried out case studies of four Kenyan institutions involved in technological research and of the intended recipients of their results. The nature and extent of influence exerted by selected factors upon the entire process of invention-innovation-adoption was examined.

If results from the studied institutions are anything to go by, then many research and development (R&D) institutions in Kenya could be operating with very little interaction with the users of their results. Indeed efforts to work out modalities on how the users of research results can be involved in R&D carried out at the public research institutions do not seem to have succeeded. This has led to two glaring consequences: 1) some innovations and inventions made by the institutions do not address the real needs of the intended users, and 2) very many of these innovations and inventions (including those that do address the user needs) are never known by their intended users.

The general public "hue and cry" that the major roadblock to these efforts is lack of an exhaustively articulated government policy to effectively assist in linking researchers to the users of their results is apparently justified.

Our phase I findings do point to possible science and R&D policy interventions and how they may be expected to influence user-oriented R&D. However, conclusive policy recommendations can only be made after the completion of phase II, which is supposed to unveil the magnitude of innovations and inventions made by publicly funded R&D institutions.

Results emanating from the two phases of this research will add value to the academic field of technology transfer and diffusion and also to the national technology policy formulation efforts. We are, for example, confident that the inventory of innovations and inventions that we shall make in phase II will guide researchers in Kenya to "the way ahead" in research. It will help them avoid duplicating research and its associated drain on public funds, throw light on which areas are over- and which under- researched and finally enable incremental research by providing information on which research needs to be done.

This will be of great national importance particularly at this time when the country's planners are thinking of putting more emphasis on research and development to assist Kenya become a newly industrialised country (NIC) by the year 2020.

II. The Research Problem

The bottom line of the research is that most of the research results originating from publicly funded institutions do not end up in the hands of the users. Research institutions have continued to operate in isolation producing results that can not be accepted (adopted) by or diffused to the users. The overall effect has been that the government has continued to fund research institutions whose activities have resulted in the development of products and processes which could have been useful to end users but have remained shelved. This ties up large amounts of public funds. An investigation into factors that influence the diffusion of research results constituted a real research problem.

Social, scientific and development relevance of the problem

The problem as outlined above has social, scientific and developmental relevance. This relevance can be summarised in the commonly aired phrase "Technology and Development".

Indeed, science and technology stand at the centre of many critical issues facing the development of any society. Countless theoretical and empirical investigations have emphasized the crucial role that innovation played in fostering the development of today's developed nations. The same process is now seen as crucial to Third World development. There is a recognition that attempts to borrow and transfer technology from the North have not stimulated Third World development as desired.

The situation has been made even more grave by the fact that many countries of the North have put in place protective measures, especially in the area of intellectual property rights, in order to protect their domestic industries. This means that technology transfer capable of building domestic technological capabilities by the recipient Third World countries is limited. That then seems to explain the present emphasis in most Third World countries on endogenous technical innovation. The Schumacher (1973) idea of appropriate technology has formed much of the basis of technology policy formulation in many less developed nations.

A common criticism levelled against many Third World governments is that they pay no more than lip service to the need for accelerated endogenous technological development. The abilities of their own citizens for technological innovation that leads to entrepreneurship have not been exhaustively harnessed.

Third World researchers have been criticised for not researching exhaustively the field of local diffusion of innovations. Yet diffusion research can provide a theoretical understanding of human behaviour and accelerate technological change. It is a fact that left on its own, technological change in a developing nation can be strongly affected by

pressure of international economic competition. But not all these pressures are favourable to the weaker competitor, i.e the third world. Any study of attributes of technology with a view of identifying ways of assisting third world technological policies has, therefore, developmental relevance. That this research aspires to identify roadblocks to adopting local innovations means that it has social and developmental relevance.

III. Literature Review

Problems with the diffusion of innovations are now widely recognised. Getting an idea adopted even when it has obvious advantages is often very difficult. A common problem for many inventors/innovators, which is not exhaustively researched, becomes the issue of how to speed up the rate of diffusion of inventions and innovations. In other words, it is the problem of how to bring about change – and in this case technical and/or technological change – which is largely at the core of the science and technology policies of many countries.

Schumpter (1950) identified three phases in the process of technical change, namely, invention, innovation and diffusion.

Invention

An invention is the creation of any new idea and so the term is not restricted to advances in science and technology (Glaister, 1989). Glaister stresses that although it is usual to think of invention as the creation of a new product involving scientific advances or new product processes, invention also includes developments that do not incorporate any scientific advance. We view this to mean that inventions can occur even in the less advanced nations.

Another view is that an invention is a process by which a new idea is discovered or created. Adjeberg-Asem (1988) points out that an invention is the initial stage of an innovation process with the other stage being the prototype. When the prototype is introduced to the market then the invention becomes an innovation.

To Rothwell and Zegveld (1983), an invention is an act of technical creativity that involves the description of a novel concept that could be patented. An invention is not an act suggesting movement toward commercial exploitation.

The International Bureau of World Intellectual Property Office (WIPO) defines invention as a new solution to a technical problem. The problem may be new or old but the solution, in order to merit the name invention must be a new one. The problem must be a technical one. The word technical has different meanings depending on the context in which it is used. In connection with inventions technical implies that the invention must have practical uses, particularly in industry. It enables industry to make new products, or to make products in a more economical way (faster, more cheaply etc) or to improve existing products by making them more precise and yielding better results.

Today inventions are rarely a result of an accidental or an instantaneous stroke of genius. They are increasingly becoming the result of long, systematic, hard thinking and experimentation with the precise aim and hope of arriving at a new solution amount-

ing to an invention. In other words most of today's inventions are a result of methodical research.

Thring and Laithwaite (1977) assert that an essential part of an invention is the strong desire to produce a better solution to a human need and the ability to understand through the hands and eyes the way things work in space and time.

This focus on the human need was extremely useful for our research. We therefore designed a questionnaire to investigate whether or not Kenyan inventors gear themselves towards known local problems or invention for the sake of it.

Innovation

Glaister (1989) defines innovation as the commercial exploitation of the invention. He asserts that innovation includes the whole process whereby technologies and products are brought to commercial fruition. Thus an invention may be a scientific discovery while innovation is its economic application.

Rogers (1983) defines innovation as an idea, practice or object that is perceived as new to an individual or another unit of adoption. Thus it is an innovation if perceived so by the user. The idea of commercialisation is echoed.

Adgeberg-Asem (1988) views innovation as the introduction of a technical or mechanical process involving:

- Either a potential market or a basic scientific idea;
- The ability to practicalize the need or idea;
- Concretization of the above by producing an invention and creating a prototype or adapting an old idea to a new use;
- Tests of the new invention or idea that shows it workable and acceptable; and
- The introduction, usually on a small scale, of the invention into a market place.

These five involvements are echoed by Rogers (1983) who identifies five characteristics of innovation as perceived by individuals as:

- Relative advantage i.e. how better the innovation is than the existing (or alternative);
- Compatibility i.e how consistent the innovation is with the existing values and norms;
- Complexity i.e how difficult it is to understand and use the innovation;
- Triability, i.e. how easy it is to experiment on the innovation; and
- Observability i.e how easy the results of the innovation are observable or visible to others.

Our interpretation is that innovation is actually a process starting with an invention. For the innovation process to continue beyond the stage of invention it seems logical that action must be taken to apply the invention in a way that results in its successful utilization. This may mean that the attributes listed by Rogers ought to be incorporated in the innovation. They seem to us to be key in determining the rate at which the innovation can be adopted by the users.

In our study, we investigated those attributes that do (or should) influence the diffusion of locally made innovations and inventions. Specifically we sought answers to the question "what is the driving force for innovations and inventions in Kenya". The two dominant models applied in literature to this question are known as technology push and demand pull (or innovation-oriented and client-oriented, or top-down and bottom-up).

The technology-push (innovation-oriented or top-down) model assumes that discoveries in basic science or research and development lead to innovations that can successfully find their way to the market place. This is very much like saying supply creates demand.

Apologetics to this model include Clark (1985), Freeman (1982), Mansfield (1978) and Minasian (1962). The last two demonstrate that spending on research and development is related to economic output. This side of the debate has found support in many third world countries' national science and technology budgets.

Many of these countries' budgets seem to imply that large expenditures on R & D *per se* can lead to progress. Thus a lot of academic research is being funded in institutions with results more often than not left to gather dust on the library shelves.

The demand pull model emphasizes the market need. It is a reverse argument to the above model and ideally suggests that demand creates supply. It has come as a recent reaction to the technology push model and is best advanced in the developed nations. Thus three-quarters of innovations in the U.S. scientific instruments industry originate with the user as is the case in the U.K. medical instrument industry (Adjeberg-Asem, 1988). Supporters of this model argue that the needs of the user and the feedback from him should play a leading role before and after the launch of innovations.

Studies that support this model include that of Rothwell and Gardiner (1985). The underlying concept here is that an innovation is primarily a commercial rather than a research activity.

The two models – technology-push and demand-pull – should be considered two extremes each having its pros and cons. In Kenya no work known to us suggests which is the dominant model. To bridge this gap, we designed a questionnaire to investigate how Kenyan innovations actually come about – technology-push or technology-pull?

Diffusion and adoption

By diffusion is understood the process by which an innovation is communicated through certain channels over time among members of a social system (Rogers, 1983; Adjeberg-Asem, 1988). The four elements of a diffusion process are, therefore, innovation, communication channels, time and the social system. Many technologists think that advantageous innovations would sell themselves, that the obvious benefits of a new idea would be widely realized by potential adopters, and that the innovation would therefore diffuse rapidly.

Unfortunately, this is very seldom the case. Most innovations, in fact, diffuse at surprisingly slow rates. Literature is full of examples. One very popularly quoted example is that of hybrid corn seed which, despite its known advantages, took a very long time to diffuse and be adopted.

When one peruses the diffusion research literature one is impressed by efforts ex-

pended on studying differences in innovativeness (that is, determining the characteristics of different adopter categories). Relatively little effort has been devoted to analyzing "innovation" differences (that is, investigating how the properties of an innovation affect its rate of diffusion and adoption). A study of the differences can be of great value to change agents seeking to predict the reactions of their clients to an innovation and if need be to modify certain of these reactions even by the way they name an innovation and relate the new idea to existing beliefs.

Communication channels and social structures have been found to be key actors in the process of diffusion. Both of them determine the speed of diffusion and adoption. Mass media channels have been found to be rapid and efficient means of informing an audience about an innovation. Established behaviour patterns that are part of a social structure have been found to define a range of tolerable behaviour and serve as a standard for members of the system in accepting an innovation, hence the impact on speed of diffusion. Our study borrowed from these established theories and investigated them with Kenyan innovations.

Factors influencing adoption/diffusion of innovations

The adoption and diffusion of inventions and innovations is apparently influenced by a variety of factors. Blackledge (1979) includes among the factors that inhibit the diffusion the following:

- the absence of technical economic feasibility studies,
- market analysis to assess the product or process potential,
- unwillingness of the users of technologies to take risks on unproven technology,
- lack of adequate financing mechanisms; and
- the institutes' lack of capabilities to transfer completed research results as a package acceptable to the entrepreneur.

The factor relating to the inadequate funding for research and development has also been echoed by Alhassan (1994). He goes further to add more technology transfer inhibiting factors.
These include poor institutional arrangements and inadequate links between developers and users of technologies. Alhassan sees the lack of pilot plant facilities as a major constraint in the process of "packaging" research results for commercialisation.

An enabling policy has also been sighted as a major factor in enhancing the adoption and diffusion of innovations. Banerjee (1992) argues that since development of inventions has to take place within the framework of the economic and political set-up of a country, this very set-up becomes a function of a country's research and development base for the successful diffusion of innovations. Yossifor (1992) concurs with this view and asserts that a variety of instruments are necessary for the fostering of an enabling policy. These include fiscal incentives, preferential financing and provision of venture capital.

The need for an enabling policy for the transfer of technology has also been stressed by Nichol (1992), who asserts that the three factors necessary for diffusion of innova-

tions are:

- information about technical feasibility;
- nformation about demand for a new process or product; and
- investment funds.

The success of a diffusion process requires that these three factors. The enabling policy should facilitate these factors, since an unbalanced provision may not bear the desired fruits. Our research explored the status of these factors in Kenya.

Institutional arrangements and the diffusion of inventions

Institutional arrangements have been explored by Su (1987). He suggests that institutions engaged in R&D should be encouraged to adopt contracts with user organizations that would not only enhance the flow of innovations but also ensure that research institutions are financially self-sufficient. Su notes that experience with contracts between research institutes and user organizations serves to solve a multitude of outstanding problems of R&D. First, efforts of R&D are directed to high priority areas of economic development. Second, the alienation among organizations is lessened promoting cooperation and exchange of personnel for better utilization of resources. Third, R&D personnel are motivated by pertinent remunerative measures for capable workers.

Using the U.S. example, Ku (1992) narrates how competitiveness, innovation and technology transfer as a government concern can be useful. She informs us that in 1970 the US Government realised that government-owned innovations were not being developed by industry. As a result, in 1980, Public Law 99-517, Patent and Trademark Law Amendment Act of 1980 was enacted. The law was designed to encourage US universities to set up their own technology transfer operations and resulted in extensive technology transfer efforts by universities. In 1980 alone there were about 65 members of a small organization called the Society of University Patent Administrators (SUPA). Virtually a decade thereafter in 1992 the same organization which had renamed itself the Association of University Technology Managers, amd had grown more than tenfold to a membership of over 650.

Bekoe (1993) discusses the problem of African national research systems placing undue concentration on research (basic or applied) without adequate attention to development. This, he argues, is due to few systematic mechanisms for converting research results into practical commercial activity. Bekoe suggests that mechanisms similar to the National Research Development Corporation (NRDC) of India that specialize in buying the risks of application of research results should be established in Africa. While carrying out this study we had in mind Kenya's institutional arrangements and how they may affect the diffusion of inventions and innovations.

IV. The Theoretical Framework

The above reviewed literature gave us some very clear messages. First, any prospective adopter of technological innovations is likely to pose, among others, the following questions before deciding whether or not to adopt an innovation:

- what is the price of the innovation and what is my ability to obtain finances to acquire the innovation?
- What infrastructure will I require to effectively use the innovation and is it in place?
- Does the innovation assist me to do my tasks at a lower cost or at the same or proportionately the same cost?
- Does the innovation improve my quality and productivity?
- Does the innovation assist me do the needed tasks that I have been unable to accomplish?
- What is the skill requirement for using the innovation?

We believe that these and related questions reflect the perception of the innovation by the adopter and imply that certain technology characteristics such as those identified by Rogers (1983) are very important.

Second, in order for an innovation to encompass successful characteristics it should arise from a fusion of technical feasibility with the recognition of a need or demand and the availability of funds and other resources. It would seem that as a precondition for effective adoption and diffusion, an innovation must be adaptable to the needs and situations of potential users.

Concerning the two approaches to innovation research - the technology push and demand pull - are concerned we drew up a comparison matrix (Table 1).

We set out to answer the question - Which of these approaches is used at the Kenyan universities and research institutes? Past studies strongly indicate that successful innovations result from proper conceptualization of the process of innovation. We clarify this using an adapted model of such a process as shown in Figure 1.

Table 1. Comparison of the two common approaches to innovation research

	Technology push approach	Demand pull approach
Approach	Theoretical	Practical
Nature	Fundamental	Applied
Time Horizon	Future	Immediate
Base Studies	• Secondary data • Documents • Existing theories	• Primary data • Existing technologies
Researchers' motive	Academic pursuit	Fulfilment of felt need
Research motive	• Policy implications • Enrichment of theory	• Practical solutions • Increase/improve existing stock
Results	For the library	For the adopter

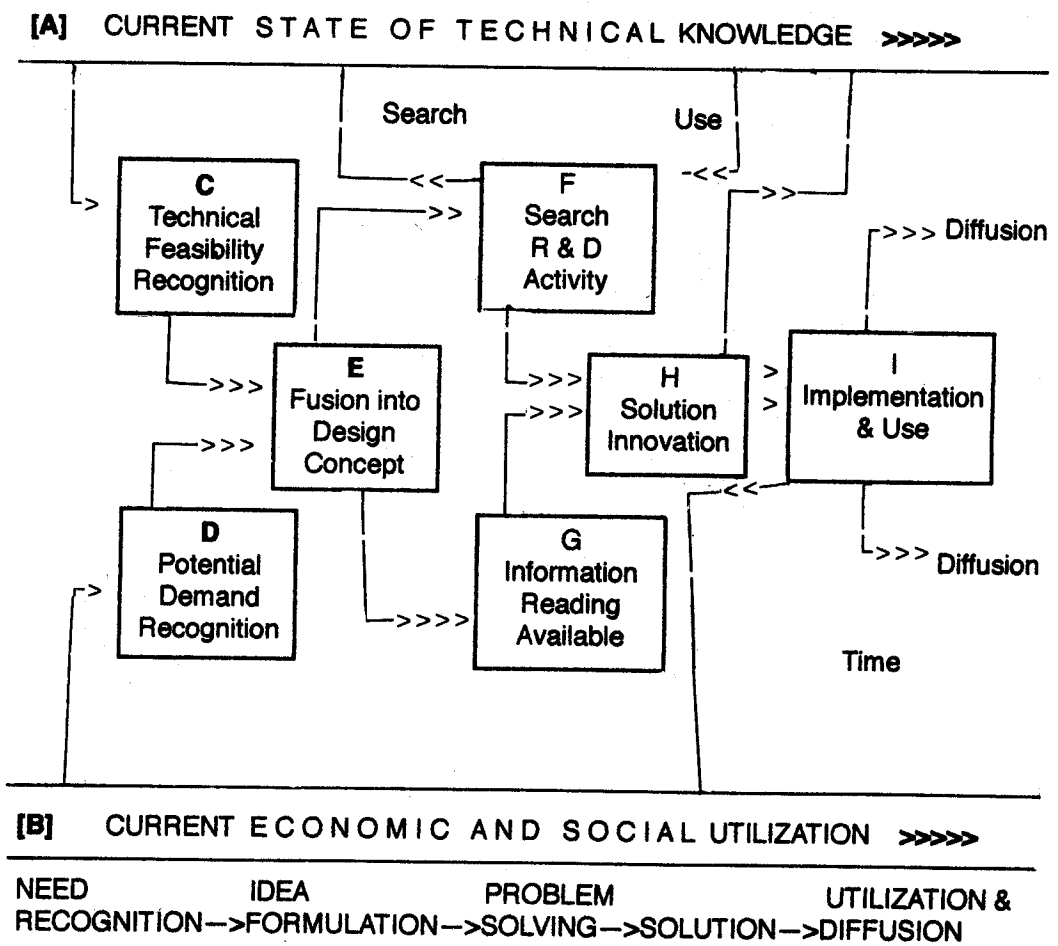

Figure 1. The desirable innovation model (adapted from Myers and Marquis, 1969).

The model shows that the process of successful innovations is sequential, starting with need recognition. Initially an innovation should be a result of two recognitions - the technical feasibility **[C]** of and the demand **[D]** for the innovation. The technical knowledge sphere **[A]**, e.g research institutions providing the environment to carry out innovations geared at meeting the demands of the socio-economic sphere **[B]**, e.g the intended users. Both spheres are dynamic as shown by the **>>>>>** signs.

A starting point for an innovation should be to identify a need. Next would be to ascertain that there is the technical feasibility necessary to provide a solution **[H]**. This should then lead to the formulation of a concept or research idea **[E]**. Search, research and development activities should thereafter follow **[F]**. The activities will, naturally, involve drawing from the current state of technical knowledge **[A]** in order to provide a solution (innovation) **[H]** to meet the identified demand **[D]**. The solution should be implemented **[I]** by the business(es) that provided the demand but with time be diffused into the economy. This should be a continuous exercise since technical knowledge and economic demands are dynamic. Our research tested this model with the innovational processes at the institutions we covered.

V. Research Objectives, Hypotheses and Questions

General objective

The general objective of the study was to investigate and explain why Kenyan innovations are not widely diffused and adopted in the country. The findings will form the basis of policy suggestions to enrich Kenya's science and technology policy.

Specific objectives for phase I

- To study the process of innovation - diffusion on a case study basis of two universities and two research institutes and the (intended) users of their technological innovations and inventions.
- To identify those inventions and innovations that have been successfully diffused and those that have not determine why?.
- To generate, from the findings, hypotheses on the attributes of innovations that would lead to their successful diffusion and adoption.
- To suggest policy measures that would accelerate local inventions and innovations.

Hypotheses and questions

To achieve the objectives of this study we intended to test the following hypotheses:

- Kenya has many endogenous inventions and innovations that have not reached the user. These are inventions and innovations made without being tailored to the needs of the intended user.
- Lack of proper institutional arrangements to link the research institutions with the users of their results has meant that users are not aware of what the institutions have, affecting the use of research results.
- Increased mobility of R&D personnel between research institutions and industry has not been exploited effectively.
- The attention paid to the organization of human resources (multi-disciplinary approach using experts from various sectors) during the important phase of technology development is inadequate.
- The concept of "intelligent imitation", which uses the cheaper and more effective method of technological development rather than being first innovators with the associated high learning costs, has not been a common practice in Kenya's research institutions.
- The lack of technology transfer units to process and disseminate R&D information is a hindrance to technology transfer.

The questions that we hoped to finally answer by this study were basically two broad ones: 1) which attributes of Kenya's inventions may influence their diffusion and adoption? (phase I) and 2) what inventions are there in stock for the user? (phase II).

VI. Phase I Methodology

In phase I, we had case studies of two universities and two research institutes together with their (intended) users of the inventions. Questionnaires for these respondents were designed and pre-tested before being executed: the university technician/lecturer; the university departmental head/institute director; the research officer at an institute of research; the industrial user; and the domestic user.

The questionnaires were designed to capture the issues related to the innovational and/or inventional process at the institutions in question. Principal investigators supplemented the questionnaires with qualitative interviews of key research personnel at both the research institutions and the user organizations.

In this phase only four institutions were covered – two universities and two research institutes: Jomo Kenyatta University of Agriculture and Technology, the youngest of the five public universities in the country established as a universities in the 1990s; and Kenyatta University, a former constituent college of the oldest public university in the country.

It was our intention to investigate whether time has had any effect on R&D policies at the Kenyan universities. We thought one old and one young university would serve this purpose. In the second place, if JKUAT is primarily a technology university, then KU has an entire appropriate technology unit. This would indicate how far the efforts to produce diffusible inventions and innovations have gone at these institutions.

JKUAT is basically a technology university, and a fairly one. All the 15 departmental heads and institute directors were included since they were manageable. In every department, ten lecturers/technicians were randomly selected, bringing to 165 (15 heads + 150 lecturers/technicians) the number of respondents from JKUAT.

Kenyatta University is quite large and has a number of faculties. Most involvement in technological research is within the Faculty of Science, which hosts the Appropriate Technology Centre (ATC). We, therefore, chose to cover all eight departments of this faculty. In every department, ten lecturers/technicians were covered totaling 88 respondents from KU.

Initially it was hoped that the heads of departments and lecturers would help us trace the users of their innovations. Unfortunately this did not work since there was no information of this sort. We therefore made a random selection of would-be users who included domestic and small-scale producers and interviewed them.

For the research institutes we selected one from the agricultural sector – KEFRI – and one from the industrial sector – KIRDI. Again this was by design, as these sectors form the backbone of Kenya's economy.

Fieldwork was undertaken from November, 1995 through April, 1996. The investigations were covered through search and analysis of both primary and secondary data. Face to face interviews and some observations were conducted.

VII. Field Work and Research Findings

Findings from the university departmental heads/directors

Tables 2(a) and (b) below show the magnitude of research being carried out at JKUAT and KU as of February, 1996. The sketchiness of the information, especially from KU results primarily from a combination of lack of records and a lax attitude by some of the respondents. Table 3 shows the research accomplishments at JKUAT since its establishment as a university, but there was no comparable information at KU. Table 4 shows the main sources of funds of R&D activities at JKUAT. Although records from KU could not be obtained, general interviews indicated that the university largely depends on government funds that are grossly inadequate. Tables 5 (a) and (b) show some of the inventions and innovations at JKUAT and KU.

Only 40% of the departments covered from both universities said they had R & D policies. The same proportion indicated they were aware of an overall university R&D policy. Objectives for some departmental policies included:

- to further knowledge on plants
- to promote research geared to promoting the welfare of Kenyans
- to innovate and produce for industry
- to develop the natural resources
- to advance basic and applied research

The 40% that indicated they were aware of a university R&D policy in their respective universities did not agree on the objective of the policy. Differing objectives were given by different departmental heads in one and the same university:

- to encourage creativity
- to promote and disseminate information
- to advance applied research for national development
- to develop staff

Departmental heads and directors were almost unanimous in saying academic-oriented research was the most popular due to the apparent universities' emphasis on academic research and publications when it came to staff promotions. The heads were unanimous that only a few of their staff do actually engage in research work. The major reasons were lack of motivation, facilities, funding and lack of time due to a high teaching load. Those doing research do so for either self-satisfaction or in pursuit of promotion. The most mentioned promotional methods of university innovations were semi-

nars and conferences. The media and private contacts were least mentioned.

Lack of financial resources and an appropriate university and national policy hinders commercialization of innovations the most.

Do the departmental heads think innovations originating from their departments (albeit few) are more compatible with local values and norms; less complex; easier to be tried and maintained by users and more efficient? The unanimous answer was yes. Only 25% of the departmental heads indicated that they were aware of university-industry links. About half of these indicated that the links were only starting and could not be evaluated. The actual nature of links varies from joint research to mutual secondment of staff to mutual staff attachments. It was clear, however, that most of these links were initiated on an individual staff basis. Every head of department thought the universities could encourage either user-oriented or any other research amongst its staff with motivational packages.

What, in the opinion of the heads, should be the major components or focus of a university R&D policy? Answers to this question varied greatly. Some thought the whole process should start with recruiting only committed staff. There was also the feeling that designing a university R&D policy should be a joint effort by the researchers and the administration as opposed to the current practice of the administration designing it alone.

A number of heads felt the emphasis of university R&D policy should be placed on applied research geared at enhancing the quality of life for Kenyans, on research for problem solving. There were those who strongly felt that the policy should emphasize the interests of academic staff and national development.

Findings from the university lecturers/technicians

Only 22% of university lecturers claimed to be aware of national amd university R&D policies. None thought there was a departmental R&D policy in their departments. Those who were aware of policies thought that them too broad, unfocused and largely unimplemented.

All the lecturers surveyed indicated that in every department, staff carrying out research at are fewer than those not carrying out research, and academic research dominated. Many reasons were given for lack of research enthusiasm among staff. Key ones, which we verified as accurate, were:

- inadequate funding
- inadequate research facilities
- heavy teaching loads
- lack of immediate material (financial) rewards

Orientation towards academic research is generally explained by the fact that the universities do put more emphasis on this aspect of research in their staff promotional requirements.

Of the lecturers and technicians surveyed, 44% claimed to have innovated either a gadget, formula, model or written a book. Forty-four per cent claimed the motive for their innovations was to solve a felt need since they had actually carried out needs assessment studies. The rest indicated theirs were academic research aimed at gaining

points for promotions. None of the researchers claimed to have undertaken a systematic procedure of exploration, product development, pilot testing, field evaluation and market survey while carrying out the innovation. Although 20% of the lecturers claimed that their innovations had reached the market they (lecturers) were unable to trace them on the market. Records regarding the trajectory of innovations out of the university are nonexistent. Innovations did not reach the market for various reasons: lack of funds for promotion; poor promotional infrastructure; and lack of policy and commitment from the university.

About 40% of the lecturers surveyed claimed they were aware of university-industry R&D links, and that virtually all these links were with individuals. The only popular university-level links mentioned were training programmes the university offers to some firms.

Findings from would-be users of university innovations

The questionnaires for heads of departments and lecturers were designed to capture information on the users of university innovations. Specifically we sought to know the innovations that have reached users, their purposes, the users' names and addresses, and years sold. This information would have assisted us to trace the users and interview them. If there are any university innovations that have reached the users then no records are available to trace them.

Not wishing to stop at this we made intelligent guesses of the would-be users of university innovations and interviewed them. We randomly chose inhabitants of the environs of JKUAT, some small-scale operators in Nairobi, some individuals and a few industries. Most of our interviewees (who requested anonymity) had no idea which innovations the universities produce. To most the university is for academics. Many small-scale operators do their own innovations and improvisations but would have been happy to get assistance from the university. The industrialists interviewed thought that university researchers have until now remained somewhat passive to the needs of industry and have created suspicion about their competence and reliability.

A number of domestic users echoed the view of the industrialists and thought university researchers are passive to socio-economic development. The university was accused of not being mindful of the needy in this country.

There were those would-be users who complained that the only time they learned about university innovations was when the universities exhibited at the Agricultural Society of Kenya (ASK) shows. Indeed there were those who complained that even after placing orders at the exhibitions the universities did not deliver.
than in applied innovational research geared towards end-users.

The overall number of the accomplishments as shown in Table 3 may appear impressive given that the main objective of the university is to pursue academics. The fact that these accomplishments have not reached the users is, however, worrying given that public funds, however meagre, have been expended to generate them.

Table 4 shows that universities are largely dependent on external donations. It would appear that without these external sources there would be no R&D activities at the university. The indication could be that although the Government of Kenya talks well of R&D activities it has not seriously considered allocating adequate funds for them.

Table 2(a). JKUAT departments and staff carrying out research as at February, 1996.

Department	Esta-blishment	On Innovation Research	% of Dept. Total	On Academic/ Policy Research	% of Dept. Total
Agri. Engin	24	0	0	15	62.5
Horticulture	17	2	11.8	7	41.2
F.S. & P.H.T.	13	0	0	2	15.4
Architecture	25	0	0	7	28
Mech.Engin	19	7	36.8	5	26.3
Civil Engin	31	7	22.6	0	0
E. & E.	19	0	0	14	73.7
Maths	31	0	0	0	0
Botany	14	4	28.6	2	14.3
Zoology	14	0	0	3	21.4
Biochemistry	6	0	0	1	16.7
Physics	12	0	0	1	8.3
Chemistry	19	0	0	2	10.5
I.H.R.D.	15	0	0	2	13.3
Engineering W/Shop	39	6	15.4	0	0
Total	293	13	4.4	84	28.7

Source: Authors' field survey.

Table 2(b). KU departments and staff of the faculty of science carrying out research as at February, 1996.

Department	Esta-blishment	Applied Research	% of Dept. Total	On Academic/ Research	% of Dept. Total
Biochemistry	-	-	-	-	-
Botany	26	4	15	16	62
Chemistry	-	-	-	-	-
Geo-Physics	-	-	-	-	-
Maths	-	-	-	-	-
Physics	-	-	-	-	-
Zoology	62	4	6	29	47
Atc	17	16	94	1	6
Total	105	24	23	46	44

Source: Authors' field survey.
KEY: (1) Teaching + Technical staff; (-) No information availed

Table 3. JKUAT research accomplishments for the 1991-1994 period.

Department	Number Of Researches
Agriculture Engineering	4
Food Science & Post H. Tech.	1
Horticulture	6
Architecture	2
Civil Engineering	6
Electrical Engineering	4
Mechanical Engineering	0
Biological Sciences	2
Physical Sciences	1
Maths & Computer Sciences	3
Board Of Post Graduate Studies	1
Inst. Of Energy & Env. Tech.	0
Institute Of Hum. Res. Dev.	1
Centre For Biotechnology	1
Total	32

Source: From the office of the DVC R. P. and E. - JKUAT

Table 4. Research funding at JKUAT, 1990-1995 (Ksh. '000)

Donor	'90/'91	'91/'92	'92/'93	'93/'94	'95/'96	Total
JICA	1 111	935	955	1 940	2 866	7 807
GOK	0	286	65	384	0	735
Others	7	576	1 898	2 058	0	4539

Source: As table 3.

Table 5 (a). Selected researches/innovations by JKUAT departments.

Research/ Innovation	Initiator	Motive	Initial Needs Study	Adopted/ Diffused?
R/fruits	Indiv. staff	A.A.Need	yes	adopted
Mushroom production	Individual staff	A.A.Need	none	develop. stage
Flowers production	Individual staff	academic	none	no
Horticul. production	Individual staff	academic/ awareness	yes	adopted
T/culture	Indiv. staff	academic	none	no
C/cutter	E.W.S.O	A.A.Need	partial	adopted
Sisal de- corticator	Student	academic pursuit	none	develop. stage
C/car	group	prestige	none	no
Posho mill	students	academic	none	no
R/thrasher	Student	academic	none	no
B/thresher	E.W.S.O	A.A.need	partial	no
Yoghurt	Department	academic	none	no
Tomato jam	Department	academic	none	no
P/flour	Student	academic	none	no
Amaranthus flour	Staff	academic	none	no
Trailer	E.W.S.O	A.A.Need	partial	adopted
Water pump	E.W.S.O	A.A.Need	partial	adopted
Chain link maker	E.W.S.O	A.A.Need	none	no
Juice extractor	Student	academic pursuit	none	no
M/sheller	Student	academic	none	no
Drought resistant tomato variety	Staff	academic	yes	test stage
Sugar cane varieties	staff	A. A. Need	yes	with farmers

Source: Authors' field survey

KEY: R/fruits - ripening fruits; T/culture - Tissue culture; C/cutter - Chaff cutter; C/car - Charcoal car; R/thrasher - Rice thrasher; B/thresher - Bean thresher; P/flour - Potato flour; M/sheller - Maize sheller; E.W.S.O. - Engineering Workshop Objective; A.A.Need - Address a need

Table 5(b). Selected researches/innovations by KU departments

Research Innovation	Initiator	Motive	Initial Study	Adopted Diffused
Diagnostic kit	Staff and student	academics	no	no
Chemotherapeutic agents	Staff	academics	no	no
Prototype vaccines	Staff	academics	no	no
Various plant species	Staff	research	-	-
Biocontrol for plant diseases	Staff	user need	yes	yes
Charcoal jiko	Staff	user need	yes	yes
Sisal-cement roofing material	Staff	user need	no	yes
Solar crop drier	Staff	academics	no	no
Water pump	Student	academics	no	no
Solar cooker	Student	academics	no	no

Source: Authors' field survey.

Table 6. The characteristics of selected JKUAT innovations (*)

Innovation	Relative advantage	Compatible	Complex	Triable	Observable
Hand tractor	Yes	Yes	No	Yes	Yes
Chaff cutter	Yes	Yes	No	Yes	Yes
Charcoal car	No	No	No	Yes	Yes
Posho mill	Yes	Yes	No	Yes	Yes
Bean thresher	Yes	Yes	No	Yes	Yes
Trailer	Yes	Yes	No	Yes	Yes
Water pump	Yes	Yes	No	Yes	Yes
Chain L. cutter	Yes	Yes	No	Yes	Yes
Juice extractor	Yes	Yes	No	Yes	Yes

Source: Authors' field survey.
(*) This table takes into consideration only the supply-side opinion. Lack of funds inhibited the researcher from interviewing the adopters of these innovations.

Interpretations

It is quite clear from Tables 2(a) and 2(b) that not many of the universities' staff undertake research. The few that do so choose to be involved more in academic research

The prevailing number of unadopted inventions and innovations revealed by Tables 5(a) and 5(b) is worrying. Apparently many inventions and innovations are generated without needs assessment. For the few that address felt needs there is no effective mechanism of making them reach the intended user. Table 6 reveals that a good number of these innovations and inventions have a number of advantages for the economy. It might mean that creating awareness about them is all that is needed.

The fact that only 40% of all the departments surveyed said they had departmental R&D policies with the same proportion indicating that they were aware of an overall university R&D policy suggests that if there are these policies then little communication about them to staff has been made. Indeed even those departments indicating awareness of these policies had different interpretations of them. No effort has been made to articulate the universities' R&D policies.

An analysis of responses from departmental heads reveals that universities in Kenya have continued to emphasize academic research and publications as yard sticks for promotions. This has made academic research the most popular type of research carried out by lecturers and technicians.

Further analysis of responses from departmental heads indicates that due to inadequate motivation, facilities, funding and heavy teaching loads, few of their staff actually engage in research. The few that engage in research do so for either self-satisfaction or in pursuit for promotion. This would indicate that if there is any R&D policy at all then it does not adequately address the motivation, facility, funding and teaching load issues.

Innovations originating from the universities are mainly promoted via university seminars and conferences. The media and private contacts are least used. Lack of finances and an appropriate policy seem to have greatly hampered commercialization of university innovations.

As indicated in Table 6, some innovations originating from the university (albeit few) are compatible with local values and norms, not complex, easy to be tried and maintained by users and supposedly efficient. This would mean that if ways and means of making then reach the user can be found they could easily be adopted.

That only 25% of the heads interviewed indicated that they were aware of university-industry links would mean that not a lot of effort has been made to link the university to industry. This is changing, however, with JKUAT establishing a number of these links.

Findings have revealed that only 22% of lecturers and technicians interviewed claimed they are aware of a national R&D policy. The same proportion claimed they are aware of their university R&D policy. None thought there was a departmental R&D policy in their departments. This, as with departmental heads, means that if there is any policy at all then it has not been adequately communicated to staff.

It could be this lack of R&D policy or lack of its awareness that seems to partially explain the fact that very few lecturers carry out research as indicated by Tables 2(a) and 2(b). One would think that a comprehensive policy would articulate the rewards and motivate lecturers to actively involve themselves in both academic and user-oriented research.

Poor university-industry links seem to explain why very few innovations have reached the industrial user, and why most of our user interviewees had no idea which innovations the universities produce. It is not surprising that industrialists interviewed thought that university researchers are somewhat passive to the needs of industry and that a number of domestic users echoed the view of the industrialists and thought university researchers are passive to socio-economic development of this country.

Factors influencing diffusion and adoption of inventions and innovations from universities

The above findings and their interpretations seem to point to three broad mutually complementary factors that influence the diffusion of innovations and inventions from Kenyan universities: economic, technological and university specific factors.

Economic factors. These are mainly, though not exclusively, objective as far as the universities are concerned, and are largely external: funds, infrastructure and the competitiveness of the innovations.

R&D funding by universities is grossly inadequate. Even at national level, R&D budgetary allocations are extremely meagre (about 0.5% of GNP). The inadequacy of research funds means that research projects are often underfinanced, affecting the quality of the whole process of research. Though inadequate, funds for carrying out research at the universities are often forthcoming. But funds for carrying out commercialization activities of the research results are never forthcoming. It is no wonder that the old story of university research results "gathering dust on library shelves" persists in Kenya. The R&D promotional, distributional and marketing infrastructure is dearly missed in Kenya. There are few institutional arrangements at national level to support the promotion, distribution and marketing of innovations. The fact that quite a number of innovations from universities have not been adopted and diffused is partially explained by the fact that many are not competitive. Both technological and university specific factors explained below do contribute to this uncompetitiveness.

Technological factors. This category of factors is partially objective and partially subjective as far as the universities are concerned. In other words they could be external or internal to the universities. They include: research facilities, appropriateness of the innovations, technology transfer experience, and innovational approach.

Research facilities at the universities are inadequate and many are obsolete. This contributes to inappropriate innovations that are unadaptable.

It may be argued that universities have rich experiences of transferring technology to industry via supplying industry with the much needed skilled manpower. Unfortunately this appears to be about all in the area of technology transfer. Concrete hardware innovations originating from the universities seldom reach industry because universities have not cultivated strong formal university-industry links. Without such links the innovations have an extremely narrow avenue for reaching industry.

The majority of researchers at the university do not carry out any needs assessment studies before they innovate. This is tantamount to saying that they believe in supply creates demand. However, for an innovation that does not address a specific need to be successfully adopted, a good deal of promotional and marketing is needed. Unfortunately, as noted above among the economic factors, there is very little technology promotion and marketing infrastructure, both nationally and at the university. This makes it extremely difficult for a university "technology-push" innovation to reach the user.

University-specific factors. This category of factors is largely subjective, purely a question of the R&D managerial atmosphere at the university. Included in this category is the entire spectrum of motivational factors, including material rewards for researchers, promotion criteria for staff and teaching load.

Very often research projects are underfinanced. There are no in-built financial rewards for researchers in an already underfinanced project. The researcher would expect to be rewarded separately yet there are no funds at the university set aside for this purpose.

The university management sees research as part of employment terms and conditions, hence lecturers doing research are accomplishing these terms of employment. The normal salary and the possibility that the researchers will later use the results to argue for promotion suffice as rewards. This thinking does hold credence in developing nations where salaries are low and material rewards are regarded as ideal motivators.

It is not difficult to explain why many of the lecturers doing research tend to choose purely academic areas hoping to publish their results in international. Inclination towards academic research penalizes efforts to innovate for local needs. Kenyan universities emphasize publications in refereed journals for staff promotions. In Kenya a refereed journal is synonymous to an international journal given the scarcity of local refereed journals in a number of academic disciplines. Cases were unveiled during our research where lecturers who came up with useful endogenous/indigenous innovations for local use could not be promoted on their bases because the results were not published in "reputable" journals by the definition of the university administration. Publications in local journals and papers were not considered toward promotions. Sadly, not many reputable journals, by the university administration definition, would accept the endogenous/indigenous innovations because they lack international relevance and application. All this discourages efforts to research local problems. Heavy teaching and/or departmental administrative loads leave very little time for research. University administration does not deem it necessary to reduce the load of lecturers doing research. Add to this the fact that there are no material rewards after a successful research and you have your answer to why not many lecturers are involved in research.

Discussion

This discussion is done against the backdrop of pertinent issues and promises raised in the literature review. Our literature review identified key factors that tend to be universal and that block the adoption and diffusion of innovations and inventions.

- absence of technical economic feasibility studies (including market analysis) by innovators
- lack of appropriate institutional arrangements including lack of innovator-user links
- inadequate financing
- lack of capabilities to transfer
- unwillingness of users to take risk

To summarise, we conceptualised a model to suggest that successful innovations are a result of the fusion between technical feasibility, investment funds and demand recognition. To support our conceptualized model, we adapted a known model by Myers and Marquis (1969) (see Figure 1).

Not many university researchers undertake needs assessments for their projects, nor

feasibility studies before research is done. This means that many innovations are produced without a recognition of demand. The fact that there is lack of appropriate institutional arrangements, including lack of innovator-user links has also been proved and so has the issue of lack of finances. With very few innovations reaching the users, it follows that the university has not built adequate technology transfer capabilities. We cannot say that we have proved that Kenyan users are unwilling to take risk. On the contrary, the Kenyan user has been denied a chance to take the risk. He has not even been made aware of the innovations that the university offers.

Not every university innovator gears themselves towards known local problems, since a number of researchers engage themselves in purely academic exercises. The driving force for innovations at the university is academics and to some degree prestige. We would therefore propose that many university researchers are technology-push oriented. Universities tend to use mainly seminars and conferences to diffuse their findings, which are largely academic-oriented.

This discussion has pointed at the university research policy. Although Kenyan universities have been in the forefront in advocating the design of appropriate innovations they do not seem to have clearly understood university policies to support this advocacy. If there is an R & D policy at the university, then many at the university are either unaware or ill-aware of it.

There is actually some confusion at the university on what a research policy should be and what research objectives should be. A remote argument is that both the objectives and policy are in the province of "direction". They should, therefore, be seen as so inevitably interrelated that one should always be considered in the context of the other. It would appear that what we have at the university in relation to inventions and innovations can be likened to objectives unsupported by a clear policy (refer to our definition of terms).

For example, the JKUAT Engineering Workshop, which has a rich innovative potential, has as one of its objectives "to encourage innovative ideas in the design and development of products for use by the small-scale enterprise (SSE) sector operatives."

This objective does not seem to be well supported by an appropriate policy, i.e., a set of rules, procedures, regulations. For the Engineering Workshop, for example, an R&D policy (which is either lacking or unclear) would articulate, among others, the following issues:

- the rules for running the workshop with clearly spelled out issues such as the degree of authority and responsibility of the workshop manager and his chain of command.
- the products to be made, who should determine them and how
- the proportion of the workshopand staff hours to be devoted to academics and to producing for the SSE sector
- the motivational package for the innovating staff
- the promotional methods and distribution channels for the innovations
- the rules in relation to the intellectual property issues, e.g., ownership of patents of innovations by staff

VIII. Conclusions and Recommendations

Kenyan universities have good potential to produce adoptable and diffusible innovations. But for the successful diffusion and adoption of university innovations there has to be a comprehensive R&D policy. The process of formulating such a policy could be both top-down and bottom-up. For example national priorities could be spelled out from the top, i.e., by the government funds designated to them. The universities, on the other hand, could identify their individual capabilities and sieve out from the national priorities what they could and could not do.

We believe there is room for cost-sharing between the government and the university to finance R & D. A university policy that encourages links with industry and promises rewards for the researchers could in itself be an avenue for raising R&D funds. The university could shift some of its emphasis on rewarding from purely academic R&D on to industry-applied R&D. It then could designate a part of its R&D funds for feasibility studies, say in the form of industry needs assessment researches (INARs). Researchers would then be funded to do industry-specific INARs whose results the university would use to entice funding from industry. It should be remembered that a number of industries we visited during our research complained that university researchers have remained passive to the needs of industry. Industry-specific INARs would identify specific needs that would form proposals to specific industries, thus an opportunity for fundraising from industry.

Research findings from the institutes

Unlike universities whose main mission is academics, research institutes in Kenya were set up expressly to carry out research that would supply tangible results to meet the nation's demand. With this in mind, this study approached the issue being investigated, i.e. factors that influence adoption and diffusion of innovations from the research institutes, through studying the demand and supply aspects of the innovations.

Supply study

The instrument for the supply study was the institute questionnaire that was sent to the Kenya Industrial Research and Development Institute (KIRDI) and the Kenya Forestry Research Institute (KEFRI). The results (Tables 7 and 8) indicate a sample of 21 innovations from the institutes. We have analyzed these, focusing on the technological capability of the institutes to generate innovations for adoption. The institutes' level of technological capability is expected to be reflected by the initiation of the innovation, funds availability, period of development of the innovation, the development stages the

innovation went through, completeness of the innovation and the current status of the innovation.

initiation. The majority of the innovations were developed at the initiative of either the researcher at the institute or the institute itself. A smaller number of these innovations were initiated by the user. The inference to be drawn here is that there was no demand pressure from the users for the development of the majority of the innovations.

period of development. Results indicate that the innovations took between 2 and 11 years to complete. We did not uncover any direct inputs and contributions from potential end-users and especially profit-making users. Clearly, such users would not have waited for so long to get the results. It is, therefore, not surprising that adoption of these innovations is rather low.

availability of funds. Results gathered show that a good majority of innovations were developed with government grants. The few innovations registered are a reflection of the scarcity of these funds (the government of Kenya spends about 0.5% of her GNP on R&D).

development stage. The conduct of R&D should be submitted to the following stages of development: exploratory research, product or process development, pilot testing, field evaluation, and market survey.

This criteria is essential for results of significant value to the end-user. It helps to give a complete techno-economic picture of the innovation, which is an essential element in adoption and diffusion. Results of our analysis indicate that very few of the innovations met the above criteria, consequently, a low rate of adoption can be expected.

completeness of the innovation process. We gauged the completion of the innovation via the following indicators: written technical report, published papers, developed prototypes AND patents granted

current status of adoption. Analysis shows that although the institute says that most of its innovations have been adopted, their usage seems to be limited to the sponsors who could have adopted them for lack of alternatives. Widespread diffusion into the economy is not apparent.

Demand study

The instrument for the demand study was the "user" questionnaire which was sent to 15 recipients of innovations identified under the supply study. Only two users – Sabuni Nyumbani, who manufactures caustic soda using a process developed in KIRDI; and Afri-Gums, who manufactures gum Arabic powder using a process also developed in KIRDI – had responded by the time this report was compiled. These users indicated that they had adopted the innovations and were willing to adopt more. The main reasons for satisfaction were given as:

- Locally developed innovations are relatively cheaper than imported ones.
- Advice from local sources of innovations is cheap and readily available.
- The innovations adopted have not developed any defects during use.

Factors influencing adoption of innovations and inventions from research institutes

The following are the factors that emanate from the supply and demand studies.

Insufficient demand. Out of a sample of 21 innovations from the two institutions studied, only three – making up about 14% – have been adopted by more than one end-user. Detailed analysis of the responses, mainly from the institutes, revealed lack of demand attributed to promotional problems as an influencing factor. As a result of lack of effective promotion, many potential end-users know nothing or so little about the innovations that they cannot make use of them, hampering diffusion.

Researchers in the field who have the ability and are willing to improve the innovations for better performance and faster diffusion are also not aware of them. Dissemination and follow-up activities have only been done in a perfunctory way and have thus not created the desired awareness of the existence of the innovations. It appears that the two institutions have adopted in-house research and expect it to flow to potential end-users. Effective promotion of sponsored research would ensure a wide application of the innovation and thus a payback of the investment.

Uncompleted innovations. Properly completed innovations are those that are patented and/or a market survey or field evaluation has been successfully carried out. None of the innovations from the two institutes had been patented. Although market surveys and field evaluation were reported to have been carried out for most of the innovations, it was not possible to gauge the level of success of the two exercises. Technical reports, prototype development and published papers, which are used as the main indicators of completeness by the institutes, have their own shortcomings. They are actually most useful for academic purposes. Most innovations in the institutes are not completed to a degree that would convince the end-users of the possible gains of adopting such innovations, contributing to the low adoption rate.

Inadequate financing of research. Tables 7 and 8 below show that most of the in-house research that depended on Government funding took up to 11 years to complete. Such innovations would get into the market when the demand for them had ceased. It is important to note that in Kenya national expenditure on research has, for a long time remained at 0.5 per cent of GNP. When research funds reach the institutes of research about 90% goes to pay personnel emoluments rather than for actual research. This expenditure is unlikely to produce returns of economic significance.

Lack of involvement by end-users. In the absence of demand pressure from users of innovations, the innovative activities are often random since the demand is often replaced by the perception of individual researchers. When this happens the research output is unlikely to have appreciable economic or social pertinence. This situation is compounded by poor institutional capabilities for evaluating innovations to assess their economic implications. It would be accurate to state that in-house research without direct inputs and contributions by potential end-users will rarely have commercial relevance and therefore will not be adopted.

Lack of adequate competence. The diversity of in-house research is an indication of lack of priority setting. Although each of the two institutes has a mandate, priorities must be set in order to build the institutes' competence. Incompetence in research will make it difficult to obtain firm commitments on delivery dates for services and the ser-

vices will often be shoddy. Such results will make the end-users have less confidence in the institute.

Table 7. KIRDI innovations and their adoption status.

Innovation	Initiator	Funding	Dev. stages	Complete-ness	Dev. period	Adoption
L.V.C.N	R	GOK	PD, PT, MS	TR, PP, PRT	5 years 80-'88	by one user
Q.F.W.K	user	user	PD, FE	PRT	2 years 93-95	spons.
S.S.P.A	inst.	GOK	ER	TR	11 yrs 80-'91	no
C.S.F	user	user	PD	TR	2 years 86-88	spons.
N.P.S.L	inst.	GOK, UNIDO	ER,PD, PT, FE, MS	PRT	2 years 86-88	widely
S.D.P	inst.	GOK,	ER,PD, PT,FE, MS	PRT	5 years 85-'90	inst.
R.T.P.P.	user	user	PD	TR	2 years	spons
E.G.O.	user	user	ET,PD	TR	1 year	spons
W.R.S.G.	user	user	PD	TR	1 year	spons
E.G.C:	user	user	PD	TR	1 year	spons
P.D.L.S.	user	user	PD,PT	PRT	1 year	spons
V.S.G.	user	user	PD,FE,PT	PRT	1 year	spons
G.A.P.P	user	user	ER, PD	PRT	2 years 86-87	spons

Source: Authors' Field Findings.

KEY FOR TABLES 7 AND 8:

L.V.C.N. - Lacquir vanish from cashew nut liquids.
Q.F.W.K. - Quick Firing Wood Kiln
S.S.P.A. - Small Scale Power Alcohol Production
C.S.F. - Caustic Soda Flakes
N.P.S.L. - Nile Perch Skin Leather Processing
S.D.P. - Sorghum Dehulling Process
G.A.P.P. - Gum Arabic Powder Production Process
P.E.W.C. - Plantation Establishment without Total Cultivation
I.N.F.T. - Inoculation of Nitrogen Fixing Trees in Nurseries
P.M.C.A. - Integrated Process to Manage Cypress Aphid
B.R.D.P. - Bamboo Resources Development Process
R.T.P.P. -Rosin and turpentine production from pine-oleoresin
E.G.O. -Extraction of garlic oil
W.R.S.G. -Production of water resistant glue from starch
E.G.C. - Extraction of glue cassava
P.D.L.S. -Piercing die for louvre separator(an electrical fitting device)
V.S.G. -Variable speed grider
P.P.E. - Technique for propagation of Populus Elicipolia

C.M.E.G. -Clonal multiplication of eucalyptus Grandis and Eucalyptus Saligna
B.S.C.D. -Briquettes from saw and charcoal dust
P.L.I. -Production of laminated items
B.H.M.P. - Brachylaena Huilleusis (Muhugu) Management Process
UNIDO - United Nations Industrial Development Organization
IDRC - International Development Research Centre
EEC - European Economic Community
ODA - Overseas Development Authority
INST. - Institute
GoK - Government of Kenya.
SPONS. - Sponsor (of innovation)
R-Researcher PD- Product Development MS-Market Survey
PT-Pilot Testing ER- Exploratory Research TP - Technical Report
PRT-Prototype PP- Published Paper FE - Field Evaluation

Table 8. KEFRI innovations and their adoption status.

Innovation	Initiator	Funding	Dev. stages	Complete-ness	Dev. period	Adoption
P.E.W.C	R	INST.	ER,PT, FE	TR	5 years ' 90-'95	no
P.P.E.	R	INST	ER,FE	-	2 years	no
C.M.E.G.	R	INST	ER,FE	TR	2 years	widely
B.S.C.D.	R	INST	ER,PD, PT,MS	TR	5 years	yes two clients
P.L.I.	R	INST	ER,PD, PT,MS	TR,PRT	4 years	yes one client
I.N.F.T	INST.	EEC, ODA	ER,PT, FE	PP,PRT	3 years ' 93-'95	no
P.M.C.A	INST.	GoK	ER	NOT YET	6 years	no
BRBPR	INST.	IDRC	ER, PB, FE, MS	TR, PRT	8 years	yes, two clients
BHMP	R	GoK, ODA	ER, PD, FE	PP, PRT TR	2 years	yes, one client

Source: Authors' Field Findings.
Notes: see Table 7

X. Conclusions and Recommendations

In this study we have been able to draw attention to and/or capture some important factors that influence the adoption and diffusion of innovations from two universities and two R&D institutes. The findings would be expected to reflect, to a large extent, the factors that influence the adoption of innovations in other national research institutions. It would be presumptuous, however, to put forward highly articulated policy recommendations at this stage. We believe there are a number of other issues that need to be understood before a comprehensive set of policy recommendations can be drawn. This does not, however, mean that we cannot make a start at drawing some recommendations.

One thing is clear – a good picture of the factors that influence the adoption of innovations nationwide is necessary. Such a picture would emerge if an inventory of innovations of the other national research institutions is carried out. It is for this reason that we start our recommendations with a proposal to carry out a nationwide inventory of innovations and inventions.

Inventory of Kenyan innovations and inventions

This inventory would become an important database from which policies could be drawn to guide future and further researches. It would, for example, indicate what is done where, the current stage of innovation, and suggestions for further development.

Industry technology needs assessment

Many innovations from R&D institutions are not adopted because they are not demand-driven. Would-be users have complained of researchers being passive to their needs. Innovations from R&D institutes whose research was sponsored had a higher chance of adoption than those doing only in-house research.

Continued R&D that does not address felt needs is a drain on public funds that should be avoided. This then warrants industry-specific technology needs assessment exercises. They would provide information that would be availed to R&D institutions to use for tailoring their research efforts to felt needs and enhancing the demand-pull approach to innovation.

R&D institutes should be encouraged to emphasize collaborative research where the sponsor is involved in the initiation, development and funding of the research.

An enabling R&D environment

The government, the universities and R&D institutes need to create favourable con-

ditions for indigenous innovations. Key elements of such an environment should be:

i) *A fund for rewarding successful R&D and financing activities that commercialize innovations*. Included in commercialization activities should be client-familiarizational-cum-promotional seminars and extension services that would move innovations to the doors of the users. We are recommending that the government increases the total funding for research from 0.5% of GNP to 1 per cent of GNP with all additional funds being devoted to operational expenditure only. The additional funds could also be raised by R&D institutions floating research proposals to Government, commercial, professional and industrial agencies in the country who are willing to collaborate with the institutes in research.

The agencies would indicate their willingness to collaborate in the development of an innovation and their financial contributions. A proposal that fails to attract enough positive response from the agencies would be enough indication that the innovation emanating from it would not be adopted. Such research proposals would either be dropped or shelved.

ii) *Creation of a mechanism to obtain patents, find developers (manufacturers) and entrepreneurs*.

One sees three sets of inventories in this arrangement: an inventory of needs (see recommendation 2 above), an inventory of innovations (see recommendation 1 above) and an inventory of entrepreneurs and manufacturers. Camouflaged in this recommendation is the need to create relevant university-industry links.

iii) *Establish university/institute-specific motivational measures:*

a) University promotions based on locally relevant R&D and local publications even if not necessarily in so-called reputable journals, honoraria for successful completion of research, off-loading of staff involved in research.

b) Sound business practices during the development of innovations.

Institutional arrangements for effective adoption of innovations

The role of marketing of innovations is more entrepreneurial than research oriented. This tends to suggest the potential need for a central marketing organisation to bridge the gap between the generators and the end users of innovations. It is therefore recommended that an innovations marketing organisation be established to:

- search for, evaluate and select commercially oriented innovations from research institutes, universities and polytechnics.
- do the necessary market research and techno-economic feasibility studies on the innovations.
- further develop and package (in collaboration with research institutions) the innovations to meet specified needs of the end users.
- promote and sell innovations to as wide a spectrum of end users as possible.
- give assistance (financial and/or technical) to the end users in the implementation phase of the adopted innovations.

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ISBN 9966-916-85-7