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Main factors affecting development and transfer of technologies for R&D institutions in Tanzania

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***Abstract*—Technologies are essential inputs in pursuit of the developmental goals of any country in particular the developing countries to achieve sustainable development and also have a crucial role to play in achieving the Millennium Development Goals. The majority of the local industries in Tanzania use turnkey plants and process machinery imported from abroad for specific production lines. The imported technology may not be completely fit to the local conditions and it is the duty of the R&D institutions to match it with the local needs and conditions. Therefore, one of the major corrective measures required is to promote technology development and transfer from local R&D institutions to industrial enterprises. This paper focuses on how technological capabilities were enhanced by R&D Institutions in the development and transfer of technologies and the results of the enhancement. The discussion of the findings is based on the preliminary data collected from questionnaires and interviews which was administered to R&D Institutions in Tanzania.**

Keywords—Technological capability, technology development and transfer, R&D institution

I. Introduction

In Tanzania there are various institutions established to administer technology development and transfer of machineries and equipment for agricultural and industrial processes. Most of these institutions are government parastatal organizations and academic institutions. The government parastatal organizations include Tanzania Industrial Research Development Organization (TIRDO), Tanzania Automotive Technology Centre (TATC), National Housing Building Research Agency (NHBRA), Tanzania Engineering Manufacturing Design Organization (TEMDO) and Centre for Agricultural Mechanization of Rural Technology (CAMARTEC). The academic institutions include University of Dar es Salaam (UDSM) and Sokoine University of Agriculture (SUA). The only national NGO charged with the development and promotion of Renewable Energy Technologies is Tanzania Traditional Energy Development and Environment Organisation (TaTEDO).

Tanzania, like many developing countries, the R&D institutions and technology development activities are public financed. The government is unable to meet its many obligations; consequently, the R&D activities suffer most. This is because the government does not attach sufficient importance to R&D as integral components of the development strategy. This is reflected well in the actual budget allocation for R&D activities. In a survey conducted by COSTECH [1], it is revealed that Government funding on R&D activities from 1995 to 2004 is only about 14%. The majority of funds come from foreign sources.

This indicates that national priority areas for science and technological research and development have not been adequately determined. Thus science and technology related institutions are not in a position to contribute significantly even in areas indicated by the state policies due to lack of adequate budgetary support from the Government. Their yearly budget reveals that the fixed cost is far more than that of programme budget.

II. National Policies on Development and Transfer of Technology

In recognition of the importance of technology development and transfer, the Tanzanian government has developed and continued to design and implement a number of policies. The main objective is to favour, on the one hand, the dynamics of small and medium-sized enterprises and innovative entrepreneurial companies, which contribute to increase employment, economic growth and economic dynamics and, on the other hand, technology development and transfer and eventually improving the technological innovations in the country. The notable policies include:

A. National research and development policy [2]

The Policy among other things, emphasizes that research undertaking in Tanzania should be directed towards addressing problems affecting our society, gaining knowledge, and building skills which will be of lasting benefits to the country. Furthermore, this policy put emphasis on innovation and commercialization of research results which are the key in bringing about economic growth while at the same time solving societal problems. Hence, this policy helps to promote

technology development and transfer from R&D institutions to the local industries in the country.

B. National public private partnership (ppp) policy [3]

The main objective of this policy is to promote private sector participation in the provision of resources for PPPs in terms of investment capital, managerial skills and technology. Specifically on technology transfer the policy states that: The Government in collaboration with stakeholders will encourage interventions for technological transfer including promoting R&D in PPPs. Technology transfer in PPPs will be encouraged as the process of sharing skills, knowledge, designs and management of various PPP contracts and other implementation aspects. This will be encouraged to ensure that scientific and technological developments are accessible to a wider range of users [2].

The National Science and Technology Policy [4]

The overall objective of the policy is to guide the country on building scientific and technological capabilities aimed at enhancing sustainable socio-economic development. The policy document asserts that science and technology should be applied to improve and sustain technological development in the country.

The government policies therefore aim at developing technological capabilities of R&D institutions to enable promotion of technology development in order to reduce reliance on imported technologies. However, [5] revealed that currently in Tanzania technology policies do not provide link between R&D institutions and industries. This leads local industries and enterprises to fail to innovate or upgrade technology in production.

III. Technology development concept

There has been recent and broad acknowledgement that innovation and technology are key performance drivers of the national economy, especially with the emergence of the knowledge-based economy [6]. [7] defines technology as a system of knowledge, techniques, skills, expertise, and organization used to produce, commercialise and utilise goods and services that satisfy economic and social demands.

However, [8], [9] and [10] defines technology in a greater detail in terms of the following elements:

a) Physical Facilities, which consists of object-embodied physical facilities such as tools, devices, equipment, machinery and instruments, which enhance human physical powers and control for carrying out transformation operations,

b) Human Abilities, which refer to human-embodied abilities such as skills, expertise and creativity, which are needed for the effective use of technical hardware in a transformation operation;

c) Documented Facts, which refer to record-embodied documented facts such as manuals, specifications, blue prints and design parameters, which are needed for carrying out the transformation activities effectively, and

d) Organizational Frameworks, which refer to institution-embodied organizations, which coordinate and facilitate effective deployment of physical facilities, human abilities, and documented facts in transformation operations.

The four constituents are complementary to one another and are required simultaneously for the production of goods and services. That means facilities need operators with certain abilities. Abilities have to be strengthened gradually from operation to improvement and generation of facilities. Facts representing accumulated knowledge need to be updated regularly, while the frameworks have to continually evolve to meet changing requirements. The use of our understanding of nature to develop a technical method for achieving a practical purpose and product is the application of technology in a particular physical form designed to carry out a specific set of functions.

Technology development in the context of this study can be defined as the process of creating technological solutions to problems or needs that currently do not have satisfactory solutions. The technical aspects must be developed to a point such that the technology is simple, friendly to the environment and rugged enough to be used in real-world applications. Additionally, the technical, social and economic advantages must be well established.

IV. Technology transfer

[11] pointed out that technology transfer implies the movement of technology from one entity to another, and if the transfer is successful, proper understanding and effective use of the technology by the receiving entity. If the receiver does not understand and use the technology effectively, the transfer is considered incomplete. So, it is application of technology and considered as process by which technology developed for one purpose is used either in a different application or by a new user.

Furthermore, [12] pointed out that technology transfer can serve as a tool for strengthening the local production system; providing information and training; serving as a stimulant for further development; facilitating a more competitive position in the international marketplace; and assisting in closing the gap between developed and developing nations. [13] observed that technology transfer process in Tanzania has been hindered by a number of constraints including economic, social, cultural, political and legal; the economic and social constraints being the major ones.

Technology transfer as used in this study refers to the process of getting new technologies readily

available on the open market. The technology must have moved beyond the laboratory testing and demonstration phases. It needs to be marketed to different sector entities willing to commercialize the technology.

V. TECHNOLOGICAL CAPABILITIES

An effective management of technologies and an appropriate choice of technology development approaches are important for the success of the technological efforts. An institution's technological capabilities are composed of a variety of sources of knowledge and experiences. Some of the capabilities are disembodied, such as new ideas and inventions. Others are embodied in equipment, machinery, and infrastructure, while still others are embodied in human skills.

The concept of "technological capability" was defined by [14] as "the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies". For the purpose of this study, technological capabilities are regarded as the effective use of the technical knowledge, skills and experience, not only in the procedures to acquire and develop new technology, but also to generate new skills and knowledge and improve the existing technologies, as well as transfer in response to the local environment.

VI. METHODOLOGY

Data collection was done from April 2009 to February 2010. Two types of primary data were collected: qualitative and quantitative. The instruments chosen to fulfill this requirement include structured interviews using questionnaires and in-depth interviews as both qualitative and quantitative information were required. Observations were also used as a supplement to drawing conclusion on how technologies were developed by R&D institutions, transferred to industrial enterprises. As many secondary data sources related to the subject areas covered by this study as possible also were used, including books, theses, journals, and electronic sources information.

The sample selected was 8 R&D institutions, and all responded to the questionnaires. This shows the questionnaire return rate 100%. The structured survey was employed and involved several steps from designing the questions to field work and assessing the reliability of the measurement used.

VII. DATA ANALYSIS

Data collected through the survey using questionnaires and interviews were prepared by coding and analyzing using SPSS programme.

VIII. DISCUSSION OF FINDINGS

A. *R&D funding*

Most of R&D institutions are reported to be modestly functioning due to financial constraints. This could be seen from their little R&D expenditure. The study revealed that only 12.5% of the responding R&D institutions spent average funds on technology development, while 25% had only little expenditure and 62.5% had significantly little expenditure during the period from 2008 to 2010. On Technology transfer, the results indicated that 37.5% of R&D institutions spent only little funds while 62.5% had significantly little expenditure as shown in Fig. 1.

B. *Government support in technology development*

Respondents were asked how often their institutions got government financial support for R&D activities. About 100% of the respondents indicated that sometimes got support as shown in Fig. 2. Therefore, the science and technology related institutions are probably not in a position to contribute significantly even in areas indicated by the state policies, such as technology development and transfer due to lack of adequate budgetary support from the government.

C. *Technology development and transfer*

Though the Government has upgraded its public investment in R&D from 0.3% to 1% of GDP as of the financial year 2009/2010 [15], the impact of this step has not yet yielded significant results. It was revealed that only 50% of the respondents had developed about 4 technologies, 37.5% had developed about 3 technologies while 12.5% had developed only 5 new technologies from 2008 to 2010 as shown in Fig. 3. On the other hand, 37.5% of the institutions had transferred 4 technologies while 62.5% had transferred 3 technologies over the same period as shown in Fig. 4. This is significantly not enough compared to the human resources and physical infrastructures available in the institutions.

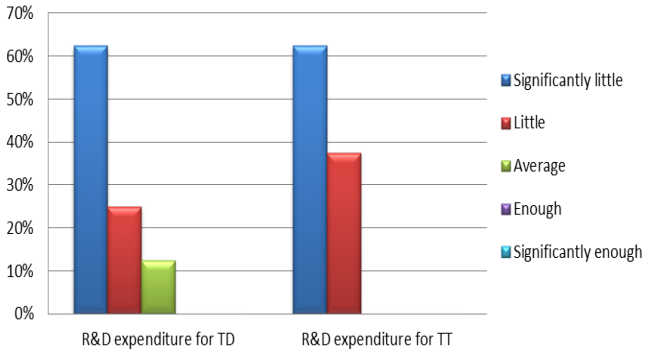

Fig. 1. Technology development and transfer expenditure from 2008 to 2010.

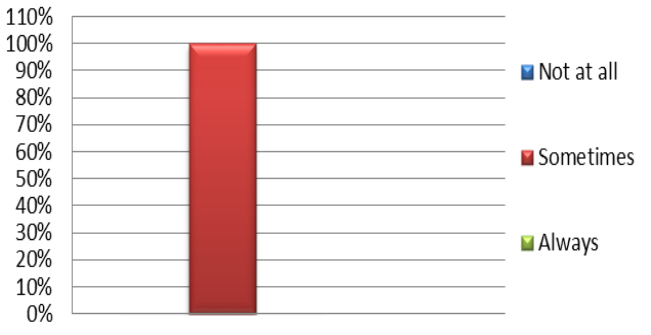

Fig. 2. Support from the government for R&D activity

D. Quantity and quality of technical facilities

Technology development and transfer is an area where a lot of investment is needed because it requires adequate infrastructure and long duration to develop and test technology. It was contextual to look at the investment made by the Government in R&D activities in the field of science and technology. It was observed that only about 25% of R&D institutions had adequate quantity of facilities while about 37.5% and 37.5% had fair and small quantity respectively as shown in Fig. 5. On the other hand, only 12.5% institutions had good quality facilities while about 37.5% and 50% possessed fair and poor quality facilities respectively as depicted in Figure. 6. This result indicates that R&D institutions have experienced the common problem of inadequate and inappropriate infrastructure like laboratories, workshops and libraries which should be adequately equipped with facilities and tools including equipment, machinery, chemicals, computers, reference books, journals and audiovisual equipment, to enable effective research and development work.

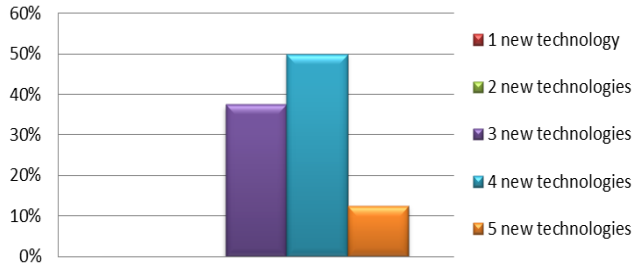

Fig. 3. Technology developed by R&D institutions from 2008-2010.

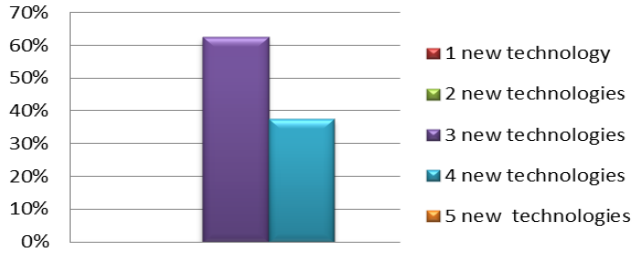

Fig. 4. Technology transferred by R&D institutions from 2008-2010.

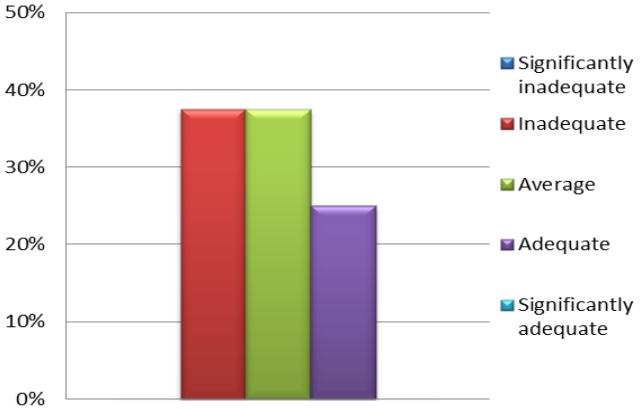

Fig. 5. Quantity of facilities for R&D activities

E. Technological capability

It was revealed from this study that most of R&D institutions (50%) had 11 to 15 engineers, 25% had 5 to 10 engineers and 25% had16 to 20 engineers. However, most of R&D institutions (62.5%) had less than 5 technicians while 37.5% had no any technician. It was also revealed that 37.5% of R&D institutions had less than 5 artisans, 12.5% had 5-10, 12.5% had 11-15, 12.5% had more than 20 and 25% had no any artisan as shown in Fig. 7. Based on the available technical staff, most of R&D institutions seemed to be capable of having significant contribution in technology development and transfer. However, there is a need to increase the number of competent and well-trained technicians and artisans.

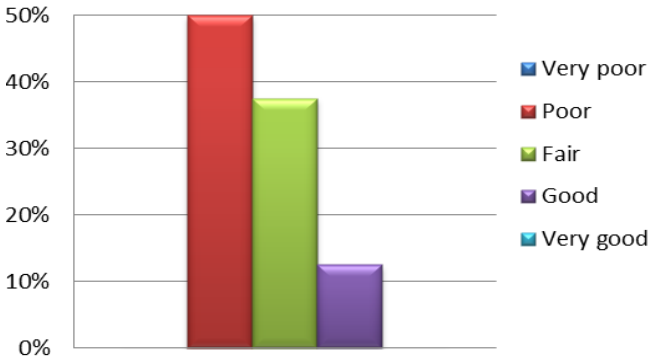

Fig. 6. Quality of facilities for R&D activities

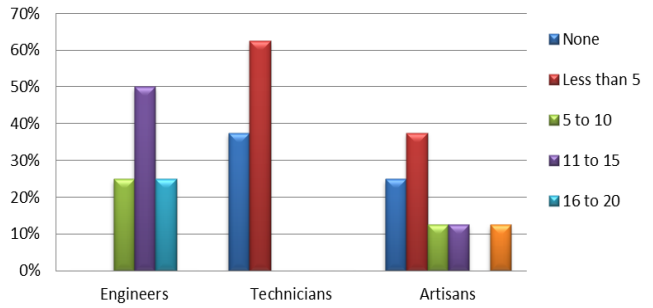

Fig. 7. Number of technical staff in R&D institutions

F. Weak linkage among R&D Institutions

This study observed that the links that exist among R&D institutions were seemingly weak. Where these links existed they were usually adhoc in nature, normally driven by necessity and often dictated by prevailing circumstances rather than strategic and deliberate planning. It was observed that only 25% of surveyed R&D institutions had good or fair linkage in technology development issues. The rest had poor collaboration. These results indicated that there is a need of strengthening technological linkage because innovators that leverage on knowledge and other resources or networks from multiple sources are among the most powerful agents of technological advance.

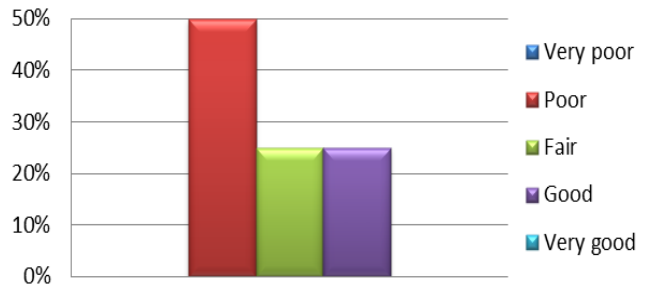

Fig. 8. Institution collaboration on technology development activities

IX. CONCLUSION

Encouraging local technology development can have both a direct effect on productivity and growth, especially as many of the benefits of R&D are likely to be local in nature, and an indirect effect by encouraging greater technology diffusion. Strategic alliances between public and private-sector entities must be established to expand the financial resources for R&D activities. The development of institutional mechanisms, such as competitive funds, could promote public-private interaction. Promotion of mechanisms that do not require new institutions, such as joint ventures, collaborative research, research levies, and contract research should be encouraged. Adequate and appropriate Technical infrastructure equipped with facilities and tools for carrying out research and development work effectively as well as increasing the number of competent and well-trained technicians and artisans is essential for R&D institutions in Tanzania.

Therefore, the success of industrial sector in Tanzania will in future depend largely upon the degree of which the country can develop, consolidate and strengthen technology development and transfer activities. This will help to accelerate the speed for industrialization as stipulated in the Tanzania Development Vision 2025 [16] and therefore increase its capability to solve basic industrial problems without relying on technological assistance from outside.

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