ECA FINAL REPORT

Advancing Technology Transfer for Sustainable Development in Africa: Kenya's Case

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National Consultant /Principal Investigator (PI)
Mr. Richard Mavisi Liahona
Geo-Exploration Directorate
Ministry of Energy
Box 30582, Nairobi
Cell Phone: +254 720 877502

Co-Investigators (CoI)
Dr. Frank Sawanga Ndakala
State Department for University Education & Research
Ministry of Education
P.O. Box 30568 00100, Nairobi

Collaborating Institutions
Ministry of Education,
National Commission for Science, Technology and Innovation
Commission for University Education
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Glossary

AI	Artificial Intelligence
AND	Automatic Digital Network
ASFV	African Swine Fever Virus
AU	African Union
BPT	Business, Professional and Technology
CBC	Competency-Based Curriculum
CEO	Chief Executive Officer
CGIAR	Consultative Group for International Agriculture Research
CIMMYT	International Maize and Wheat Improvement Centre
CoE	Centre of Excellence
CoI	Coinvestigator
COPI	Communities of Practice and Innovation
CUE	Commission for University Education
DCS	Distributed Control System
DeKUT	Dedan Kimathi University of Technology
EASTECO	East Africa Science and Technology Council
ECA	United Nations Economic Commission for Africa
ECF	East Coast Fever
ECOSOC	Economic and Social Council
EV	Electric Vehicle
FDI	Foreign Direct Investment
FGD	Focus Group Discussion
FT	Financial Times
GoK	Government of Kenya
HCDA	Horticulture Crops Development Authority
HT	Hot Temperature
ICIPE	International Centre for Insect Physiology and Ecology
IIATA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Organization
IoT	Internet of Things
IPR	Intellectual Property Rights
ISIC	International Standard Industrial Classification
JICA	Japan International Cooperation Agency
JKUAT	Jomo Kenyatta University of Science and Technology
KALRO	Kenya Agricultural and Livestock Research Organization
KEMRI	Kenya Medical Research Institute
KeNIA	Kenya National Innovation Agency
KENET	Kenya National Education and Research Network

KenGen	Kenya Electricity Generating Company Limited
KEVAPI	Kenya Veterinary Vaccines Production Institute
KIPI	Kenya Industrial Property Institute
KIPRA	Kenya Institute for Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
MoALF	Ministry of Agriculture, Livestock and Fisheries
MSE	Medium and Small Enterprise
MTP	Medium-Term Plan
NACOSTI	National Commission for Science and Technology Innovation
NIS	National Innovation System
NMR	Nuclear Magnetic Resonance
NRF	National Research Fund
OPGW	Optical Wire Ground
PDC	Polycrystalline Diamond Compact
PI	Principal Investigator
PLC	Kenya Power Company Limited
PPA	Power Purchase Agreement
PPE	Personal Protective Equipment
PV	Photo Voltaic
R&D	Research and Development
REC	Regional Education Conference
RTO	Research and Technology Organization
SA	Strategy Alliance
SHEP	Smallholder Horticulture Empowerment Project
SPSS	Statistical Package for the Social Sciences
SPV	Special Purpose Vehicle
STATA	Statistical data
STI	Science, Technology and Innovation
TA	Technology Acquisition
TILH	Transformative Innovation Learning Histories
TIP	Transformative Innovation Policy
ToR	Terms of Reference
TT	Technology Transfer
TTO	Technology Transfer Office
UN	United Organization
UNCTAD	United Nations Conference on Trade Development
UoN	University of Nairobi
WBG	World Bank Group
WEF	World Economic Fund
WHO	World Health Organization
WTO	World Trade Organization

Summary

The United Nations Economic Commission for Africa (ECA) commissioned study on Advancing Technology Transfer for Sustainable Development in Africa reveals some major barriers to the transfer of technologies in Kenyan Universities, Research and Technology Organization (RTOs), and firms. The study also suggests a number of policy interventions that could spur technology transfer. A team of researchers conducted a survey of 30 purposefully selected universities, RTOs and 5 business firms to understand the mechanisms, policies, and resources available to transfer research outputs to the market and key barriers to technology transfer. In addition, the researchers used the Transformative Innovation Learning History (TILH) methodology to develop a detailed case study to provide further insights into key institutional arrangements that facilitate or hinder technology transfer.

Key Findings

The five key barriers to the transfer of R&D outputs to the market in Kenya included low collaborative support of technology development among universities, firms and RTOs; lack of budgetary allocation for developing partnerships, stagnation of technology acquisition activities; lack of awareness of government incentives and limited sources of R&D funding. Although most organizations had Technology Transfer (TT) strategies (as strategic plans, policies, or guidelines) the implementation is hampered by insufficient funds, lack of prioritization and weak coordination of TT activities a cross the sectors.

Most organizations reported having R&D budgets, mostly funded by the government and donors. The average funding from abroad was 49%. About 63% of the foreign budgetary support was for Universities, and 37% for RTOs. However, for most organizations, there was lack of budget allocation for collaborative technology development and partnerships.

The survey reveals that the most commonly used mechanisms for TT were licensing technology and intellectual property rights ownership. A majority of the organizations had active technology licenses (≤ 20). Only 5% of the organizations had granted licenses to other parties. Likewise, a majority of the organizations had patents (≤ 15). A single organization had applied for 50 new patents. Other mechanisms of TT including spin offs and join ventures were not common. Generally, technology acquisition activities had stagnated in most of the organizations. Only a few of the organization reported a 50% increase in technology acquisition activities, which could be attributed to inadequate funding.

Regarding R&D incentives and motivation, a few organizations reported having received government incentives in the form of cash, grants, subsidies or tax relief. However, 58% of the organizations, were not aware of any government incentive. The common motivating factor

for TT activities for most organizations were to safe guard intellectual properties, to advance human and institutional capabilities, to become a global technology leader and to earn revenue from the technology.

Policy Recommendations

There are a number of interventions that Kenya can take to address barriers to successful TT. The government should develop a central coordination framework to support the implementation of policies that promote R&D and TT across many sectors. The framework should standardize technology niche management issues, benefits sharing, rewards and incentives across all sectors. The above interventions may help to motivate the private sector and philanthropists to invest in R&D.

The government and international development partners should support the establishment of sustainable financing for Research and Innovation through national granting agencies including the National Research Fund (NRF) and the Kenya National Innovation Agency (KeNIA). Innovative resource mobilization schemes with potential to encourage more arbitrageurs to participate in public funded research should be established.

Kenyan organizations should develop co-creation programmes to promote R&D and TT. Such programmes will help to build cooperative innovation and entrepreneurial culture. Therefore, organizations should build their capacities on knowledge co-creation, co-production and co-implementation of TT activities.

Contents

CHAPTER ONE

1.0. Background

The United Nations Economic Commission for Africa (ECA) was established by the Economic and Social Council (ECOSOC) of the United Nations (UN) in 1958 as one of the UN's five regional commissions. The mandate of ECA is to promote the economic and social development of its 54 member States, foster intra-regional integration, and promote international cooperation for Africa's development.

The mission of ECA is to deliver ideas and actions for an empowered and transformed Africa; informed by the 2030 Agenda and Agenda 2063. The mission is guided by ECA's five new strategic directions through six thematic areas that include: a) Macroeconomic policy and governance; b) Regional Integration and Trade; c) Private sector development and finance d) Data and statistics; e) Technology, climate change, and natural resource management; f) Gender, Poverty and Social Policy and; g) Economic development and planning.

To attain the its goals on technology, ECA engaged national consultants in selected African countries including Kenya, to survey firms and institutions with a focus on acquisition technology as well as the national support measures to encourage technology upgrading, development and diffusion. In Kenya the focus was on preferred modes and channels of technology acquisition by firms, the impact of technology transfers at firm-level and the government support measures useful to firms or encouraging technology transfer both from abroad and within the country. The assessment covered market and non-market-based technology transfer processes, policies encouraging technology acquisition and the role of academia and Research and Technology Organizations (RTOs) in technology development.

1.1. Purpose and objectives

The purpose of the work was to support the ECA-led research to identify potential areas that enable Kenya to better target her efforts to achieve the desired outcomes and areas that may be neglected (e.g., environmental, gender and common infrastructure) but are key to achieving sustainable development.

The work assessed the effect of the practices and measures on technology acquisition and impact on economic, social and environmental impacts in three communities: 1) Firm level practices on technology transfer, 2) Practices of academia and research and technology originations (RTOs) on diffusion of publicly funded technologies and 3) public sector support for technology acquisition by firms and other institutions.

The final national report provide evidence to aid national and regional efforts to strengthen institutional arrangements to drive technological and non-technological innovations at firm levels; enhance diffusion of public funded technologies and; encourage entrepreneurship to boost job and wealth creation, and competitiveness in trade.

1.2. Terms of Reference

The Terms of Reference (ToRs) addressed undertaking the survey covering firms, RTOs and related institutions, and national policies, strategies and measures that may encourage firms to acquire technology. In addition, the ToRs involved participating in the design and use of methodologies for analyzing the national datasets, both qualitative and quantitative.

Specifically, the ToRs included the following:

- Designing and administering questionnaires to assess technology transfer at firm-level, by RTOs and national policies and strategies in Kenya
- Undertaking quantitative and qualitative analysis of data from the survey
- Reviewing of existing and emerging trends, legal policies, regulations, administrative processes and infrastructure designed to promote technology transfer
- Identifying and reviewing institutional requirements at firm, RTOs and other players
- Preparing the national draft report
- Drafting and submission of the final report with supplementary raw data.

1.3. Methods

A team of three people including the Principal Investigator (national consultant), co-investigator and one focal person per participating firm, RTO or university undertook the assessment. Two structured questionnaires one targeting universities and another targeting firms and RTOs, were designed by ECA staff and customized by the survey investigators, before focal points used them to collect data from consenting key informants in the firms, RTOs and universities. During the analysis, identifiers of the respondents to the questionnaire were maintained in strict confidentiality. Several online and where applicable physical meetings were held to explain the contents in the questionnaires and where appropriate clarity was sought through follow-up phone calls.

The investigators undertook desk-top research to review existing and emerging trends, legal policies, regulations, administrative processes and infrastructure designed to promote technology transfer. The desk-top analysis was based on the three policy approaches including, the R&D policy, Science or Technology policy and the Innovation policy. After establishing the general trends of technology transfer in the country, the investigators identified potential case studies for further development.

The Kenya Electricity Generating Company (KenGen) Research and Innovation Department was identified as the case study with the highest potential for transformative change, using a lens of Transformative Innovation Policy (TIP). The KenGen case-study was further developed using the Transformative Innovation Learning Histories (TILH) Methodology.

1.4. Work Plan

The adopted work plan for the work is shown in **Annex I**. The work plan is what was eventually implemented as several changes were made to the original plan especially due to delays in data collection and as the survey progressed.

1.5. The Final Report

The report presents the survey report (chapters two to six), desktop review report (**annex II**), and case study report (**annex III**).

CHAPTER TWO

2.0. Background

The following five chapters (2,3,4,5, and 6) of the report presents details of the survey commissioned by ECA and implemented by a national consultant. The surveys covered firms and institutions with a focus on acquisition technology as well as the national support measures to encourage technology upgrading, development and diffusion in Kenya and internationally.

2.1. Introduction

For many countries accessing new and improved technologies greatly drives national and regional development. Technology Transfer (TT) remains important in global competitiveness, but some global and regional agreements restrict access to technologies thus slowing down the development of firms, industries, institutions and nations (Shmeleva et al., 2021).

Through TT new technologies move across boundaries (international) or domestically from one sector or firm to another(Pandey Shreya, 2020). Technology Acquisition (TA) and technology application in different fields contribute to the development of new and improved products and services as in the case of incremental development of Nuclear Magnet Resonance (NMR) originally used in space science (Baker, 2000). TT entails the movement of knowledge, skills, know-how, technologies, intellectual property or capabilities between entities in the industry, academia, government to meet societal needs. Common TT activities can include intellectual property rights (IPR), technology assessments, innovation surveys, marketing, startup establishment and resource mobilization (https://www.twi-global.com).

According to the triple helix theory, innovations emerge at the interface among government, academia, and industry (Galvao et al., 2019). In that interaction, government and academia act as sources of new ideas which are then transferred to the industry and society. In technology frontiers' where the triple helix is working, new technologies are discovered and developed for use by the rest of the world. However, in most developing countries including Kenya, triple helix is not working because of inherent weaknesses in the interaction between academia and industry. To strengthen the weak linkage between academia and industry the United Nations Economic Commission for Africa (ECA) has been implementing to measures to support strong collaboration between universities and the industry in commercializing new ideas. To achieve the goal, ECA has designed a regional study on advancing technology transfer for sustainable developing targeting Egypt, Ethiopia, Ghana, **Kenya,** Senegal, South Africa and Zambia.

The focus of the study was on exploring technology transfer from academia to industry with the specific research question being: *how effectively are technologies being transferred from universities to industry within the context of existing legal, policy and institutional frameworks*? The study assessed how firms and institutions acquire technologies as well as the existing national support measures that encourage technology upgrading, development and diffusion.

While governments and universities in Africa are largely engaged in research commercialization, industry has a bias for technology transfer. Although research commercialization and technology transfer are used interchangeably, the two terms slightly differ. Research commercialization involves the converting of scientific innovations into products and services that can be marketed (Harman & Harman, 2004) while technology transfer is the movement of ideas from the research laboratory to the market (Thore, 2002). According to Thore (2002), there are three steps leading from research to commercialization activities and application of a novel technology that include:

- Transfer of the technology to an interested business party either by the institution itself or with the help of a third party.
- Further development conducted by the recipient or transferee; and this can involve anything from modifications to the technical and business activities.
- The process of technology transfer, which includes the launch of the final outcome: for instance, a product.

All parties in technology transfer get motivation to acquire technology through a variety of reasons. According to Ford and Probert (2010), four reasons motivate firms and institutions to acquire technology (Ford & Probert, 2010). They include, the need to develop technological capabilities, to develop strategic direction, to gain efficiency improvements, and as a response to their competitive environment. Firms and institutions may have the internal capabilities and resources to develop the technology required to support their strategies, but eventually they may opt to acquire it from an external source (Stock & Tatikonda, 2008).

TT can be achieved through different ways including recruitment of experts, carrying out collaborative work or purchasing the business that holds the exploitative rights of the technology (Ranft et al., 2002; Cetindamar et al., 2010). Common sources of technology include customers, providers, competitors, universities and public research institutions(Arranz & Fernandez de Arroyabe, 2008). In addition, technology acquisition from external sources can be governed by different mechanisms including corporate venture capital investments, non-equity technology alliances, joint ventures, minority holdings, and mergers and acquisitions (Van de Vrande et al., 2009).

Types and magnitudes of international financial flows and innovation policies drive TT. However, many innovation policies are based on the supply-driven concept that promotes competition between nations and supports Research and Development (R&D) in policy-making, without considering other available options of innovation policies. A historical analysis of policies reveals three models of innovation policies that have been influencing how technology is transferred between firms and between nations. The models include R&D and Regulation, the National System of Innovation and Entrepreneurship, and the emerging Transformative Innovation policies (Schot & Steinmueller, 2018).

2.2. R&D and Regulation

Under this model, countries develop innovation policies that provide incentives for the market to produce socially and economically desired technologies (R&D) (Schot & Steinmueller, 2018). They are implemented through subsidies and measures that enhance the 'appropriateness' of innovation (IPR). To identify which areas, need support, foresight has to be developed. To manage negative externalities, various forms of technology assessment have to be developed, and to protect society from negative impacts, regulations are put in place. The approach identifies the most important element of technological innovation as the discovery process (invention) and gives rise to the linear model in which technology is the application of scientific knowledge (Schot & Steinmueller, 2018).

2.3. National Systems of Innovation & Entrepreneurship

Policies that fall under this model aim to maximize the use of knowledge production, support commercialization, and bridge the gap between discovery and application (Schot & Steinmueller, 2018). Various forms of learning at the centre of this model include linkages between various actors, absorptive capacity and capability formation of firms, and entrepreneurship. The policies focus on technology transfer, building technology platforms and technology clusters to stimulate interaction and human capital formation. In addition, in this model, foresight, technology assessment and regulation are add-ons to the core activity of promoting innovation.

2.4. Transformative Innovation Policy

To avoid externalities of innovation or negative impacts overtaking the positive contribution of an innovation, this model focuses on transformative change. The power of innovation is mobilized to address a wide range of societal challenges including inequality, unemployment, and climate change (Schot & Steinmueller, 2018). It emphasizes policies for directing socio-technical systems into socially desirable directions and embeds processes of change in the society. Transformative innovation Policy (TIP) explores changes in the socio-technical system to transform governance, the market, civil society, science, and to promote responsible research and innovation (Schot et al., 2018). Finally, the model has a more constructive role for foresight to shape the innovation process from the outset and on a continuous basis.

So far, from information available in literature, technology acquisition follows a linear process and that a number of factors may affect the outcomes. However, even if African countries including Kenya continue to implement incentives that support technology transfer, there is scarce evidence to indicate how the process of technology transfer is evolving in Kenyan firms, Research and Technology Organizations (RTOs). In addition, there is no clear evidence that specifies the relevance of certain factors including legal, policy and regulatory support over the stages of technology acquisition. Therefore, to understand technology acquisition and technology transfer, these knowledge gaps need to be addressed.

2.5. Problem Statement

Many African countries including Kenya lack the capacity to efficiently manage technological change, and particularly to integrate proven productive technologies in its industry and agriculture to enable its goods and services to compete in the world market (UNECA, 1995). Kenya relies heavily on technologies developed abroad to meet her development needs – be it new seed breeding technologies for agriculture, digital technology platforms, renewable energy technologies or new vaccine production technologies for COVID-19. Unfortunately, developed countries at the technology frontiers discover and develop most of the technologies that the rest of the world use. As such, technologies are highly guarded by the owners and often protected by developed countries. If technology is thus neither free to acquire or accessible to all that can afford to pay and use it, how about poor countries like Kenya who cannot afford such technologies? It is obvious that poor countries are living at the mercy of technology frontier countries. As a result, home countries of technology developers and owners tend to control which technology that may be available for sale to poor countries. Operating under such context, Kenya gets loans as a means of accessing technologies for her own use.

Technology developers may also take positions to pursue or prohibit a given technology within their control. Therefore, firms and institutions face different barriers and opportunities in accessing and using technologies. Governments of technology developers may ensure certain technologies are accessible to a limited number of firms or institutions (e.g., nuclear, digital, biotechnology etc.) or available to all with limited controls (UNCTAD, 2021). What is obvious, however, is that countries growing at a rapid rate generally register increased acquisition of technologies which they need to continuously grow and improve productivity and efficiency of their firms and institutions, and enhance delivery of services (e.g., China, Japan, Korea and Ireland). Technology transfer therefore remains a key element of national competitiveness, global and regional agreements and the main reason a ban to access technology could slow down development of the targeted industries.

Although Kenya is the sixth most competitive country in Sub-Saharan African, according to the Global Competitiveness Report 2019, there is little local data on how technology contributes to Kenya's competitiveness (World Economic Forum, 2019). Worse still, Sub-Saharan Africa ranks as the least competitive region, with Mauritius at the lead followed by South Africa and Chad holding the last position in the world. Kenya lacks data that can inform policies that improve its standing in the global competitiveness.

The good news is, developed countries have committed to enable developing countries access technology as key enabler of competitiveness in trade, development aspirations and meeting global commitments such as those of Climate Change. These commitments are noted in the various multilateral environmental, cooperation and trade agreements (e.g., those of WTO, WHO, Montreal Protocol, Paris Agreement, 2030 Agenda and Agenda 2063 as well as almost all RECs)(AU, 2017; United Nations, 2015). The aim is to support developing counties to strengthen the science-policy interface through evidence-based policymaking, support for research and development, particularly harnessing science, technology and innovation, promoting voluntary technology transfer on mutually agreed terms, leveraging technologies to promote inclusive digital economy and connectivity and build resilience across sectors. To align to these commitments, African countries have provided generous incentives such as financial incentives and, tax and non-tax incentives as well as accelerated support (e.g., rapid licensing, import and export facilitation). These incentives encourage domestic firms to import, upgrade, undertake development and application of advanced technologies as well as attract technologically advanced firms and skills, encourage investment in research and development (R&D), and facilitate the linkages between knowledge producers (e.g., universities and R&D institutions) and the productive sector (e.g., industry, societies etc.). In spite of all the incentives, studies on the outcomes of legal, policy and regulatory interventions are scarce. This study will therefore assess the advancement of technology transfer for sustainable development, at firm level, in research and technology organizations, universities and national legal and policy frameworks.

2.6. Overall Goal

The overall goal is to strengthen national institutional arrangements to drive technological and non-technological innovations at firm levels, enhance diffusion of public funded technologies, and encourage entrepreneurship to boost job and wealth creation, and competitiveness in trade to achieve sustainable development. Specifically, the research focuses on three communities: 1) Firm level practices on technology transfer, 2) Practices of academia and research and technology organizations (RTOs) on diffusion of publicly funded technologies, and 3) Public sector support for technology acquisition by firms and other institutions. The research also looks at the effect of both practices and measures on technology acquisition and economic, social and environmental impacts.

2.7. Main Objective

The main objective is to identify potential economic areas that Kenya should prioritize to achieve sustainable development.

2.7.1. Objectives

The specific objectives include:

1. To undertake a review of existing and emerging trends, policies, regulations, administrative processes and infrastructure designed to promote technology transfer.
2. To assess the impact of emerging national and international trends and institutional changes likely to have a negative or positive impact on technology transfer.
3. To identify and review institutional requirements at firms, RTOs and other players for the successful transfer of technologies in Kenya.

2.8. Expected Outputs

1. Report on review of technology transfer policy framework in Kenya.
2. Report on technology transfer trends and impact in Kenya.
3. Report on selected technology transfer case study.
4. National report on practice and hurdles for technology transfer

CHAPTER THREE

3.0. STUDY DESIGN AND METHODS

3.1. Study Design

The survey was conducted using a survey tool developed by the United Nations Economic Commission for Africa (ECA). The survey tool collected data on institutional technology transfer strategy and activities, technology transfer partnerships, licensing of technology, business, professional and technical (BPT) services in support of technology transfer, capital goods purchased for successful application of technology, geographical spread of technology transfer partners, technology acquisition and deployment, access to government incentives for technology transfer and motivations and challenges to technology transfer activities.

To identify potential economic areas that Kenya should prioritize to achieve sustainable development, the researchers carried out a national survey of firms and institutions with a focus on acquisition of technology as well as the national support measures that encourage technology upgrading, development and diffusion. This survey employed a descriptive research method, which is a process of collecting data to answer questions concerning the current status of technology acquisition in Kenya (Gay, 1981). Using this design, information was collected from firms, Research and Technology Organizations (RTOs), Public Universities, and government offices across the country. Purposive sampling technique was employed in selection of public and private universities with elaborate research portfolios and with a higher propensity to undertake research and technology transfer activities. On the other hand, a census of all key public research institutions was carried out. The sample for firms was obtained from the Kenya National Bureau of Statistics business frame based on ISIC Rev. 4 classification(UN, 2008). Both qualitative and quantitative information was captured to supplement each other, minimize subjectivity and enhance objectivity. Qualitative information included design, techniques and measures that do not produce discrete numerical data while quantitative information included designs, techniques and measures that produce discrete numerical data.

Considering that Technology acquisition is interdisciplinary, several methods were utilized so as to ensure the inclusion of both the science and business disciplines. The data collection methods adopted included interviews, questionnaires sent as Word document attachment through email, and virtual Focus Group Discussions (FGDs). The survey tools were sent by email to the Vice Chancellors of Universities, Directors of research institutes and Chief Executive Officers of business firms requesting them to designate appropriate individuals to coordinate data collections across the institutions. The instructions were given to ensure that appropriate, well-informed persons were assigned the duty of providing the data. Certain specific criteria and mechanisms of transfer were selected from existing literature as discussed in literature review.

3.2. Study Settings

The survey assesses technology transfer at firm-level in the industry; both public and private Research and Technology organizations (RTOs) including research institutes and universities and government ministries, Department and Agencies handling national policies, strategies and measures that may encourage firms to acquire technology.

3.3. Sample Population

The study statistically sampled small, medium and large top firms drawn from the Kenya National Bureau of Statistics (KNBS) Statistical Business Register based on ISIC Rev.4 as presented in **Table 3.1** (UN, 2008).

Table 3.1: Sample based on ISIC Rev. 4 comprising of five (5) top firms from every large, medium and small enterprises

No.	Description		Firm Categories			
			Large	**Medium**	**Small**	**Total**
1.	Section A: Agriculture, Forestry & Fishing		7	1	6	14
2.	Section B: Mining and quarrying		3	1	2	6
3.	Section C: Manufacturing		15	12	22	
	Division					
	10	Manufacture of food products	7	6	7	20
	11	Manufacture of beverages	1	1	4	6
	13	Manufacture of textiles	2	0	1	3
	20	Manufacture of chemicals and chemical products	1	1	3	5
	21	Manufacture of pharmaceuticals, medicinal chemical & botanical products	2	2	1	5
	22	Manufacture of rubber and plastics products	1	1	4	6
	27	Manufacture of electrical equipment	0	0	1	1
	29	Manufacture of motor vehicles, trailers and semi-trailers	1	1	1	3
4.	Section D: Electricity, gas, steam and air conditioning supply		1	0	1	2
5.	Section F: Construction		4	6	24	34
6.	Section G: Wholesale and Retail Trade, Repair of motor vehicles & motorcycles		10	15	50	75
7.	Section J: Information and Communication		3	0	11	14
8.	Section K: Financial and Insurance Activities		6	4	19	29
9.	Section Q: Human health and social work activities		7	7	15	29
Grand Total						**252**

The business firms sample comprised of large, medium and small enterprises representing 39 %, 38.7% and 15.1% respectively which collectively translates to 17.1% of the overall population.

The study was also conducted in both public and private universities (RTO's) with elaborate research portfolios and key public and private research organizations as presented in **Table 3.2**. Purposive sampling technique was employed in selection of public and private universities with elaborate research portfolios and with a higher propensity to undertake research and technology transfer activities. On the other hand, a census of all key public research institutions was carried out. The sample for firms was obtained from the Kenya National Bureau of Statistics business frame based on ISIC Rev. 4 classification.

Table 3.2: Universities, and Research and Technology Organizations

No.	**Category**	**Target Number**

1.	Public Universities	16
2.	Private Universities	10
3.	Public Research Institutions	8
4.	International Research Institutions	4
Total		**30**

3.4. Data Collection Tools and Procedure

Both secondary and primary data were collected in the study. Secondary data was sourced from online, print-outs, journals, websites, books, articles and through phone calls. Primary data was obtained using a questionnaire. Two questionnaires were used where the first questionnaire targeted universities and research institutes and the second one firms.

3.5. Case selection and Development

The process started by identifying firms or institutions committed to technology transfer activities using the firm's website, professional networks involved in co-development activities, and successful innovations exhibited in conferences and science congresses. The selected case studies was developed further using Transformative Innovation Learning Histories(Douthwaite & Ashby, 2005).

3.6. Statistical Analysis

The analysis of data collected was conducted on the basis of objectives of the study. Both descriptive and regression analyses were utilized and data presented in tables and graphs. The regression analysis involved a logit model with the binary choice model that include continuous and discrete variables. The descriptive statistics analyses were conducted using the SPSS programme, while the diagnostic tests and logit regression analyses were done using the STATA programme.

3.7. Evaluation and Outcomes

The project has generated new knowledge on challenges and barriers to technology acquisition and aims provide guidance to national and county governments, policymakers, and statistics offices to ensure sustainable development. This report will be presented to stakeholders to further input and relevant suggestions that will be included in the final report. The results and policy recommendations emerging from the project will be delivered by the end of the project and presented to ECA as per TORs.

CHAPTER FOUR

4.0. SUVERY FINDINGS

4.1. Response Rate

Twenty-four (24) questionnaires were received from 290 institutions and business firms contacted, representing a response rate of 8.3%. Three quarters (75%, n=12/16) of the public universities, 10% (1/10) of private universities, 87.5% (n=7/8), none of the international research institutions (n=4) and only 1.6% (n=4/252) of business firms responded.

It should be noted that the respondents were required to respond within two weeks with an extra one week for follow up. Despite the time given and extensive follow up engagement through telephone calls, emails and in some cases virtual meetings, there was still no significant progress realized in enhancing the response rate after more than twenty (20) weeks. Generally, even those institutions that responded took longer than expected to provide their responses sighting data and information access due to lack of reliable information management systems. Business firms were largely lethargic to the survey resulting in a very low and statistically insignificant response rate.

4.2. Limitations of the Data

Whereas there is a sense of representation among universities and research institutions given the relative number sampled and the guiding criteria used in their selection, there is really no representation among surveyed business firms due to the low response rate. Though the survey had targeted 252 business firms across key sectors in order to establish technology transfer trends and practices, the final response of 4 firms offers a limited basis to provide an informed view of the performance of the business sector on matters technology transfer as envisaged.

While 24 (20 RTO's and 4 business firms participated in the survey, not all questions were answered by the entities that participated. The number of entities which responded to a particular question is provided in parenthesis next to each statistic. Further, it was not possible to verify the accuracy of the data provided through on-site visits to each participating entity. This was further complicated by the fact that the data provided appear to lack a centralized system that is verifiable but rather was assembled from disparate sources spread over various departments for example finance, human resources and research. The entities have not organized their resources in such a manner that it is possible to easily isolate resources and information pertaining to technology transfer. It should also be noted that despite requiring the institutions to designate appropriate individuals (focal points) to coordinate data collection, it was not possible to establish to what extent the process maintained the accuracy required since efforts to seek further clarification did not bear fruits and there what was submitted at first instance was deemed to be final.

4.3. Descriptive Analysis

4.3.1. Description of the Institutions

The survey covered Universities, Research and Technology Organizations (RTOs), and firms. Universities and RTOs (n=24) included private (10%) and public institutions (90%). None of the institutions were affiliates or branches of other institutions. All (100%) institutions were found to be independent and were engaged in various research activities.

One quarter (25%, ¼) of the firms (n=4) constituted non-profit making and a subsidiary of a parent company in the same home country. Three-quarters (75%, ¾) constituted independent profit-making firms. One firm ((25%, ¼) for profit making, was listed on the stock market in 2006.

Universities and RTOs indicated the common area of research and technology was agriculture, environment and health (**Figure 4.1**) while firms described their main areas of focus as electricity, health and telecommunication.

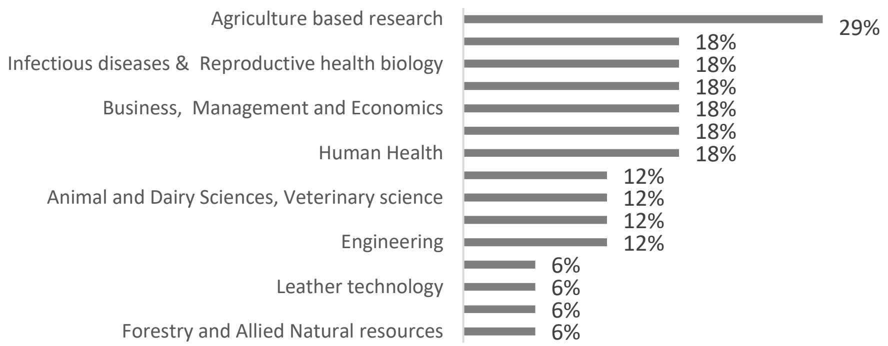


Figure 4.1: Main areas of Research and Technology for universities and RTOs (n=16)

4.3.2. Full-Time Employees

Full-time employees for Universities and RTOs comprised of researchers, technicians and research managers (**Figure 4.2**).

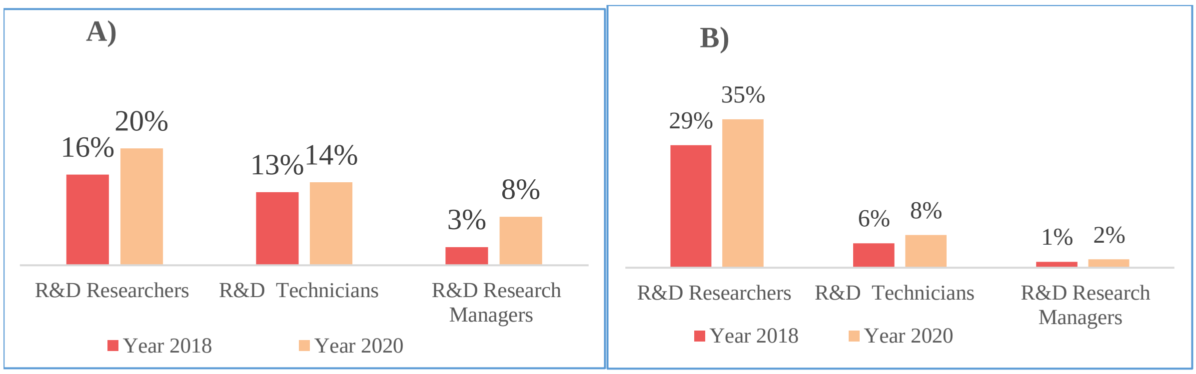


Figure 4.2: R&D managers, Researchers and Technicians as a proportion of the total employees per RTOs (**A**) and as a proportion of the total employees in 2018 and 2020 in universities (**B**).

The proportion of R&D researchers, technicians, and managers increased by 4%, 1%, and 5% respectively, in relation to the total employees per institution (RTO) between the years 2018 and

2020 (**Figure 4.2. a**). The proportion of R&D researchers, technicians, and managers increased by 6%, 2%, and 1% respectively, in relation to the total employees per institution (Universities) between the years 2018 and 2020 (**Figure 4.2. b**). In the case of firms, full time employees ranged between 50 and 1,736 in year 2018 and 12 and 2,208 in year 2020.

On average, thirty-one percent (31%) of full-time R&D employees in 2020 were female and 69% were male in universities and RTOs (n=18). On average, thirty percent (30%) of full-time R&D employees in firms were female while 70% were male. Whereas 18% of the FT R&D employees in RTOs possessed PhD, while 49% of employees in universities had similar qualifications as indicated in **Figure 4.3**.

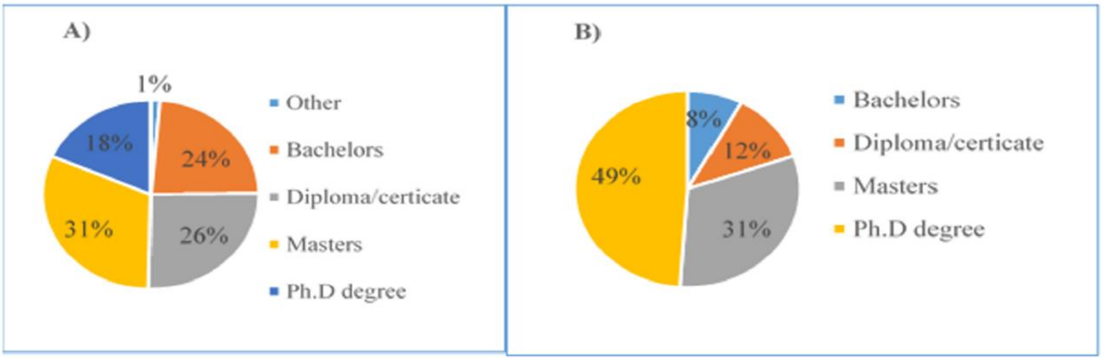


Figure 4.3: Academic Qualifications of FT R&D employees in RTOs (A) and Universities (B) in 2020.

Two firms (50%, 2/4) operate in other countries, in Middle East and Asia. Since 2019, about 25% (1/40) of firms, export products to other African countries.

4.3.3. R&D Budgets and Funding

Average funding and budgets decreased by 11% and 8% respectively, among universities and RTOs between the years 2018 and 2020. The minimum R&D budget allocated per institution increased by 47% between 2018 and 2020. However, the minimum R&D funding per institution decreased by 38% between 2018 and 2020. The maximum budgets and funding per institution remained unchanged at 0% between 2018 and 2020.

The average R&D budget and funding received per institution were **USD 9,359,915** and **12,173,020** respectively in 2018. Similarly, the average R&D budget and funding received per institution were USD 8,574,920 and 10,880,176 respectively in 2020 (**Table 4.1**). Sales revenue declined between 2018 and 2020, among firms. Firms received maximum sales revenue of **USD 34,000,000** and **32,000,000** in 2018 and 2020, while minimum sales revenue was ***USD 1,754,385*** and ***1,234,000*** in 2018 and 2020. Firms reported (0%) of Sales outside their country to Total Sales Revenue in 2018 and 2020.

Table 4.1: Change in R&D budgets and funding between 2018 and 2020, among universities and RTOs (n=15)

	R&D Budget per institution in 2018 (n=15)	R&D Budget per institution in 2020 (n=15)	R&D Funding in 2018 (n=15)	R&D Funding in 2020 (n=15)
Average (USD)	9,359,915	8,574,920	12,173,020	10,880,177
Minimum (USD)	66,000	97,148	145,313	89,845
Maximum (USD)	85,000,000	85,000,000	90,000,000	90,000,000

Three-quarters (75%) of the universities and RTOs reported having dedicated teams that handle TT issues including licensing, industry liaison, and knowledge exchange. Of these, 80% had full-time staff dedicated to handling TT issues. The highest number of TT staff per institution was 42, and the lowest was one (1) staff member. Furthermore, two-thirds (67%) of institutions with staff dedicated to TT also had TT budgets. In 2020, the lowest budget per institution was ***USD 2,000***, and the highest budget *was* **USD 10,000,000.** Half of the firms (50%, 2/4) had dedicated Research and Development (R&D) team or unit. The first firm had an R&D budget of **USD 3,600,000** in 2018 and **USD 3,200,000** in 2020 while the second had budgeted **USD 5,600** for R&D in 2020. In addition, the firm reported having a team of 15 members a dedicated team/ unit for handling TT issues, in year 2018 and 2020.

R&D funding by sources for universities and RTOs show that the average R&D funding from abroad was 43% among universities and RTOs while funding from the Government accounted for 38%. Notably, sources from own funding was at 18% while industry as a source of funding accounted for 1% (**Figure 4.4**). Of these, 63% of the institutions are Universities, and 37% are RTOs.

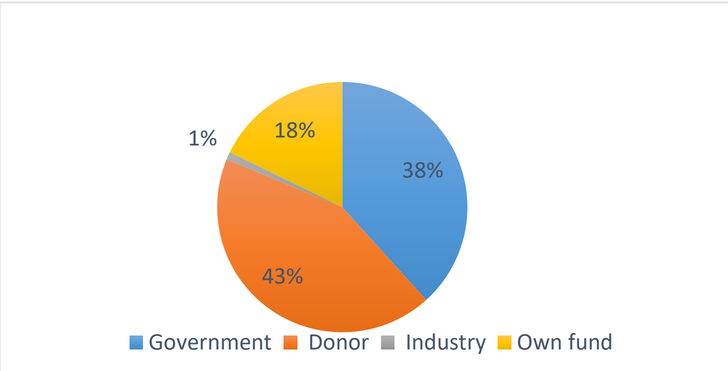


Figure 4.4: Sources of R&D funding for universities and RTOs (n=13).

4.4. Formalized Technology Transfer (TT) strategies

Generally, 70% of universities and RTOs have either a strategic plan, policy, or guidelines pertaining to technology transfer. Approximately 71% of universities have TT strategies compared to 29% of RTOs. One quarter (25%, ¼) of the firms have a formalized TT strategy, done in the year 2017. Common TT strategies reported include:

- Manufacturing contracts
- Formalized TT strategies
- University strategic plan and outreach policy and community engagement strategy
- Universities engage industry and entrepreneurs during trade fares and exhibitions.

- Universities work with various county governments in cascading of technologies especially in agriculture.
- Hosting international centers for innovation.
- Intellectual property management policy
- Incubation Policy
- Common manufacturing facilities and
- IP Policy.

Three-quarters of the universities and RTOs (75%) reported including TT outputs as a performance appraisal criterion of the R&D staff of the institution. In addition, 60% reported having a monitoring and evaluation system in place for TT activities**.** Forty-five (45%) reported that they regularly conducted satisfaction survey on TT partners **(Figure 4.5**).

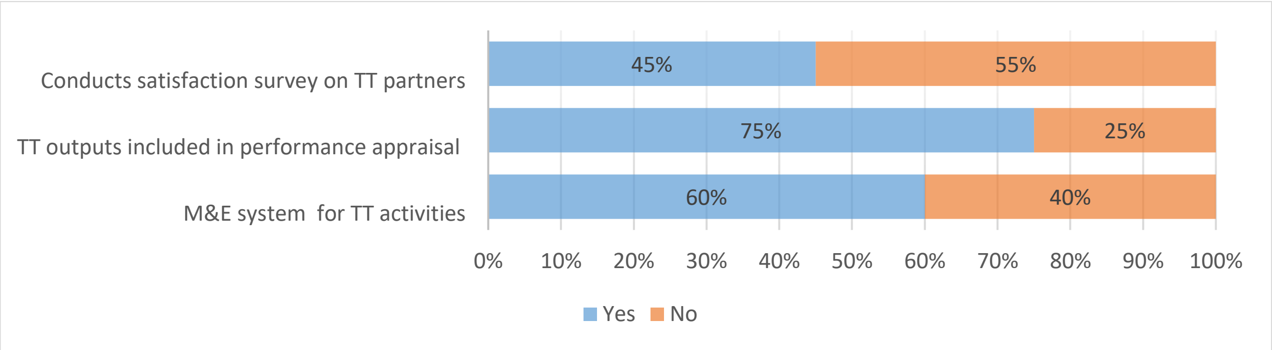


Figure 4.5: Proportion of universities and RTOs with integrated TT outputs (n=20).

The firm indicated that they have TT activities in their monitoring and evaluation system and that TT outputs are included in the performance appraisal system. None of the firms reported having conducted satisfaction survey on TT partners.

4.5. Technology Collaborative Partnerships

In 2020, about 30%, (6/20) of the universities and RTOs had budgets for developing technology partnerships. The average allocation for the institutions was less than USD 100,000. The minimum allocation per institution was USD 1000, and the maximum allocation was USD 3,000,000. Between 2018 and 2020, 35 percent of the universities and RTOs increased their budgets to support TT partnerships, 25% had a decrease while 40% did not experience any change.

The number of partnerships ranged from 10 to 12. Private sector firms had the highest partnerships (50), while higher education institutions in other countries were the second highest partners for universities and RTOs in Kenya (**Figure 4.6**).

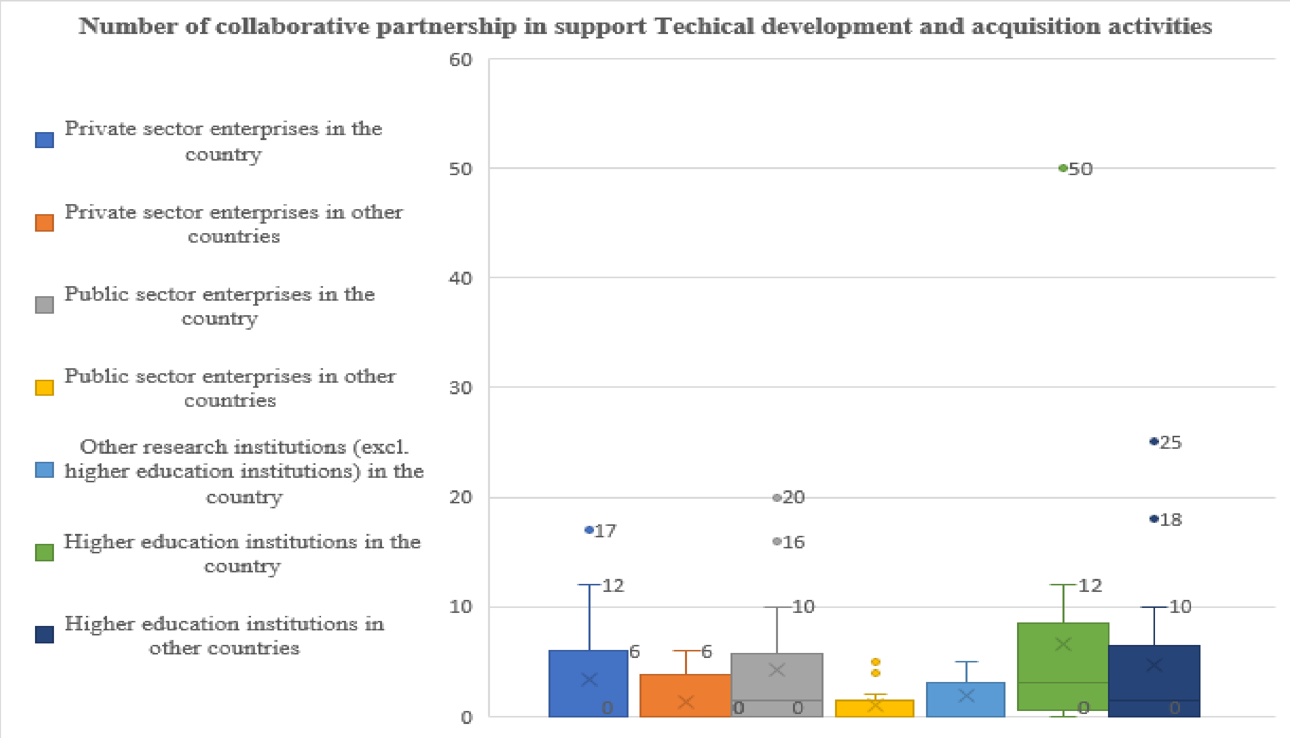


Figure 4.6: Number of partnerships supporting Technology Development and Acquisition activities among Universities and RTOs.

In regard to future budgets, 55 percent of the universities and RTOs forecasted to increase the budgetary allocation to support TT partnerships over the 2021-2023 period. About 10 % forecasted to decrease, 15% had no plans to make changes in the future while 20% felt that budgetary changes to support TT partnership will not apply in their situation. None of the firms reported having a budget allocated to developing technology partnerships in 2020 or any collaborative partnership in support of technology development and acquisition activities.

4.6. Spin-offs from TT development and acquisition activities

In 2020, about 35% (n=20), of institutions had spin-offs from TT development and acquisition activities. The highest number of spin-offs per institution was 86, and the least was 2. Majority of institutions had less than 12 spin-offs.

4.7. Technology Transfer Licensing

In 2020, two institutions (10%) paid for Technology Licensing In as part of technology acquisition and use. The first institution had paid USD 150 and projected to pay USD 1,500 in the next 3 years. The second institution had paid USD 1,234,838 in year 2020 and projected to pay USD 4,997,032 in the next 3 years. Majority of universities and RTOs have active technology licenses (**Figure 4.7**).

A single institution (1/20, 5%) granted a Technology License to other entities (Licensing OUT) which include four private sector enterprises in the country, one public sector enterprise, one research institutions (excl. higher education institutions) and one higher education institutions.

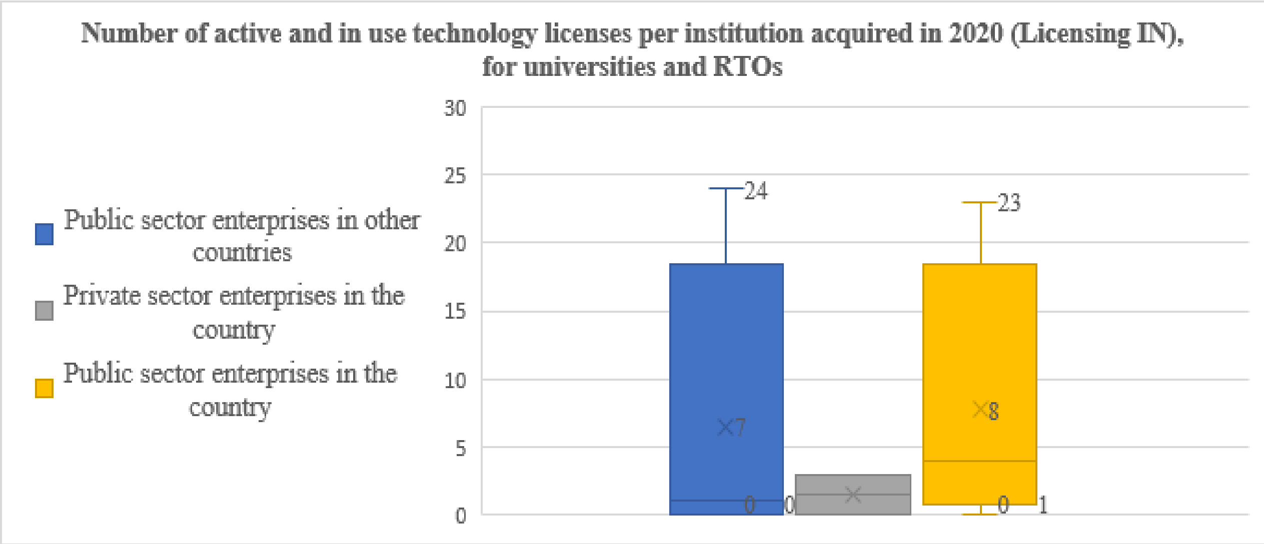


Figure 4.7: Active and in use Technology Licenses acquired by universities and RTOs (Licensing IN) in 2020.

Two firms (50%, 2/4) had active and in use technology licenses in 2020. The first firm had 2,500 licenses from external firms in Kenya, having made a Total Payment for Technology Licenses in 2020 (USD 196,000) and projecting to make Total Payment (USD 600,000) for Technology Licenses in next three years. The other firm had 8 and 5 licenses from external firms and outside the country, having made a Total Payment for Technology Licenses in 2020 (USD 400,000) and projecting to make Total Payment (USD 450,000) for Technology Licenses in next three years.

4.8. Intellectual Properties Rights

Two institutions (10%; 2/10) received USD 2,500 and USD 5,913 respectively as income from technology licensing in 2020 (**Figure 4.8**). Three institutions (15%), 3/20 forecasted income of USD, 1,000, 4,500 and 30,000 respectively. The majority of institutions had less than 15 patents. One institution had applied for 50 new patents in the year 2020.

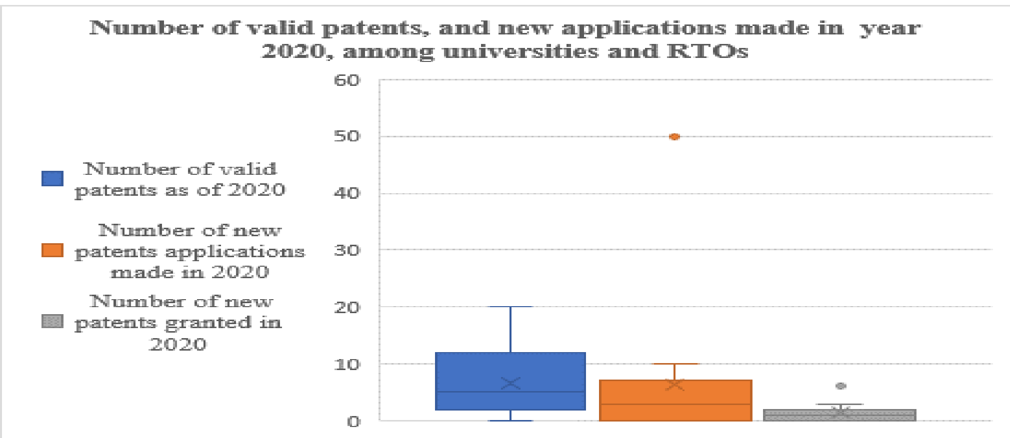


Figure 4.8: Valid patents and new patent application by universities and RTOs in 2020.

One firm (1/4) indicated the development of 2 new products in 2020 which it attributed to the licenses acquired, and 2 new production/ operation processes introduced in 2020 attributed to the licenses acquired. One firm (1/4) reported having 3 valid patents as of 2020, planned for four (4) in the next 3 years (2021-2023, and was granted 2 new patents in 2020. The firm reported having registered 23 trademarks as of 2020 and granted 13 new trademarks in 2020.

4.9. Technology Transfer Support Services

The TT support services captured included Business, Professional and Technical (BPT) Services (e.g. legal, engineering, architectural, training, research).

Out-sourcing of BPT Services

About 20% (4/20) of the universities and RTOs made payments to providers of BPT Services. The total payments made to providers of BPT services in year 2020 ranged from USD 7,000 to USD 300,000. The private sector enterprises in the country reportedly received the payment ranging from 8% to 80%. On the other hand, the proportion of payment made to public sector enterprises that provide BPT services ranged from 20% to 40% of the total payments.

Also, Universities and RTOs received payments for provision of BPT services from other institutions including public sector enterprises in other countries (maximum of 5% of total payments), research institutions (excl. higher education institutions) in the country (maximum of 25% of total payments), other research institutions (excl. higher education institutions) in other countries(maximum of 5% of total payments), higher education institutions in the country (maximum of 50% of total payments), and intra-institutional licensing - parent/ affiliate in Africa (maximum of 15% of total payments).

Two firms (50%, 2/4) made Payment on BPTS services in 2020, amounting to USD 1,107,000 and USD 20,000,000. The firms mostly sought services from external firms in the country (20% and 70% payment of the total BPTS services), external firms in other countries (15% payment of the total BPTS services) and Public sector enterprises in the country (80% payment of the total BPTS services).

In-sourcing of BPT services

One quarter, 25% (5/20) of the Universities and RTOs were paid for providing BPT services to other institutions. The total income made by providing of BPT services in year 2020 ranged from USD 4,000 to USD 360,000 per institution.

Universities and RTOs received more payment from the private sector enterprises in the country ranging from 10% to 100% of the total income from BPT services alone in 2020. Institutions also received income from public sector enterprises within a range of 20% to 80% of the total income made from provision of BPT services. The institutions received income for providing BPT services to other entities including public sector enterprises in other countries (maximum of 5% of total income), other research institutions (excl. higher education institutions) in the country (maximum of 25% of total income), other research institutions (excl. higher education institutions) in other countries(maximum of 5% of total income), higher education institutions in the country (maximum of 5% of total income), and higher education institutions in other countries (maximum of 17% of total income).

Two firms (50%, 2/4) made income of USD 5,000,000 and 50,000 incomes for providing BPT services in 2020. The payments mostly came from either external firm in the country (2% and 30% of the total income) or external firm in other countries (70% and 98% of the total income).

4.10. Procurement of Capital Goods for Application of Technology

One quarter, 25% (5/20) of the Universities and RTOs spend between USD 1,500 and USD 4,500,000 and purchase capital goods. Twenty percent (20%; 4/20) of the institutions spend between USD 200, and USD 3,000,000 to purchase foreign capital goods. Forty-five percent of universities and RTOs forecasted to have an increase in the year 2021 to 2023 budget for the purchase of capital goods and services. Only 5% of the institutions projected to have decreased budgets, 15 % did not anticipate any change in the future budget while 35% thought that changes in the future budget will not apply. Thirty-five (35%) percent of the universities and RTOs projected an increase in sales of capital goods in the next 3 years, while 5% project a decline in the sale of capital goods.

Two firms, 50% (2/4) of firms spend USD 2,351 and USD 2,700,000 to procure local capital goods. None of the firms reported sales on capital goods nor increased sales in the next 3 years (2021-2023). One firm projected an increase in budgetary allocation for the purchase of capital goods in the next 3 years (2021-2023).

4.11. Use of Open-Source Technologies

Universities and RTOs indicated a 70% frequency of use of open-source technologies as follows: 25% (low usage), 20% (used often) 5% (used all the time) and 20% (sometimes used). Key sources of open-source technologies are presented in **Table 4.2**. One firm reported a low use of open-source technologies by the firm (Laptops, desktops, phones).

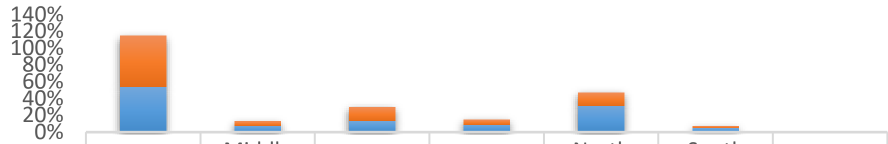
Table 4.2: Key sources of open-source technologies used by universities and RTOs

Frequency of use	Key sources/ platforms used to access these technologies
All the time	Python, PHP, C#, C++
Often	Internet such as Mozilla, use of zoom for online meetings, University website, patent information databases, ORACLE
Sometimes	HINARI, ICT, ODEL, Via collaborators (software research reagents, equipment, online search engines for specific data, Web
Low	Personalized research networks, internet and websites, adverts and marketing links with institutions collaborating with Egerton, Google application, LinkedIn, MOODLE, Internet search engines.

4.12. Technology Transfer Partners

Technology Transfer partners are geographically spread based on proportion of inward (acquisition by institution) TT activity partners by the home continent and the proportion of outward (provision from the institution) TT activity partners by their home continent. In the past 3 years, 54% of Universities and RTOs inward activity partners in Africa and 61% had outward TT activity partners in Africa (**Figure 4.9**).

Only one firm reported Inward (acquisition by the firm) TT activity partners by their home continent in the past 3-year: In Asia and Europe.



	Africa	Middle East	Europe	Asia	North America	South America	Oceana
Outward TT activity partners by their home continent	61%	5%	17%	6%	16%	2%	0%
Inward TT activity partners by their home continent in the past 3 years	54%	8%	13%	9%	31%	5%	0%

Figure 4.9: Proportion of inward acquisition and outward provision of TT activity partners among universities and RTOs **(n=20).**

4.13. Total Technology Acquisition Activities

Comparison of TT activities among universities and RTOs between three-year period (2015-2017) and 2021-2023 has been shown in **Figure 3.11 A and B**.

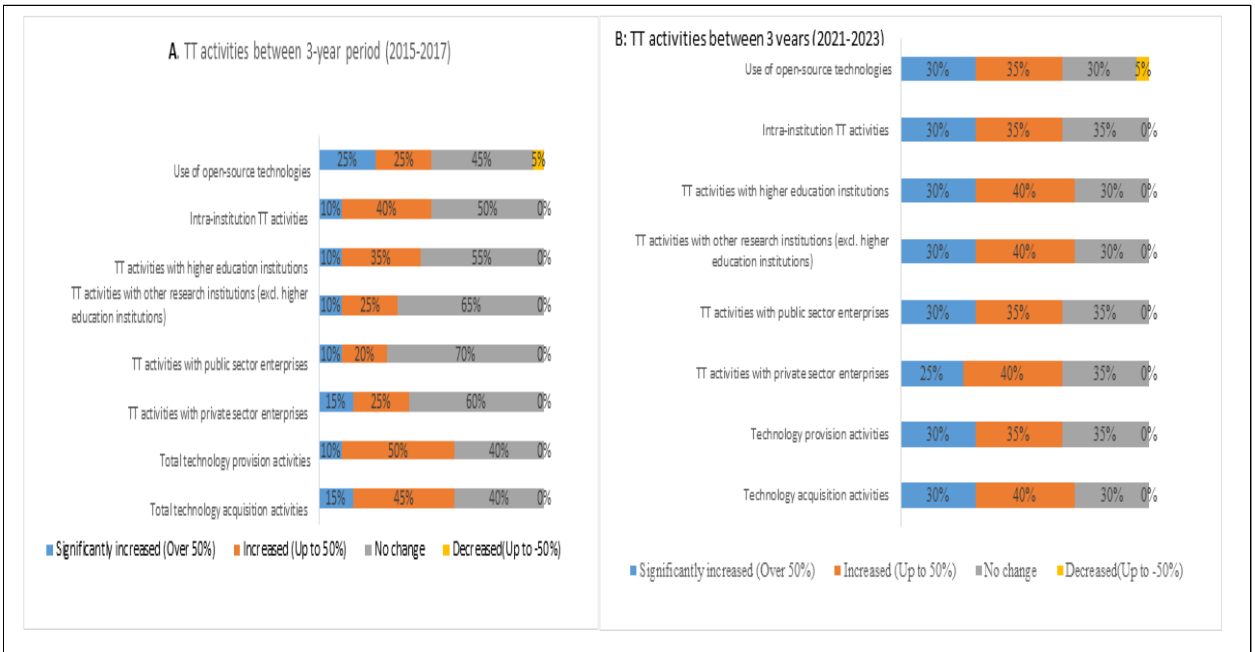


Figure 4.10: A comparison of current TT activities between 2015-2017 and 2021-2023 among universities and RTOs in Kenya.

4.14. Level of Technology acquisition and Deployment

Universities, and RTOs acquire and deploy different technologies including online sales and digital services, and renewable energy technologies. Between 2018- 2020 universities and RTOs acquired and deployed online sales and digital services reported as follows: 15% (significant), 30% (some), 10% (limited services), and 20% (large). During the same period, institutions acquired and deployed renewable energy technologies including 45% (limited) 25% (some), and 5% (significant). Digital services and renewable energy forecast in the next 3 years (2021-2023) by institutions (**Figure 4.11).**

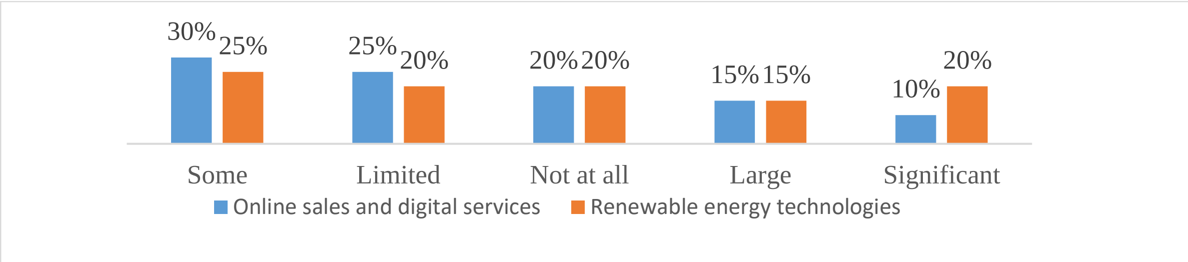


Figure 4.11. Digital services and renewable energy technology forecast for the next 3 years (20212-2023 by universities and RTOs**.**

4.15. Access to Government Incentives for TT activities

About 58% of institutions were not aware of any government incentives for TT among universities and RTOs. Of the 37% that are aware of government incentives (1/7, 14%) indicated that government gives incentives such as exemption of import duties of USD (5,000), (3/7, 43%), had applied for reduction or exemption of import duties; (2/7, 29%) applied for cost-sharing schemes; (3/7, 43%) applied for subsidies, (2/7,29%) applied for cash grants, (3/7, 43%) got cash grants USD (6,000, 1,000,000, and 25,000,000 respectively).

About 50% (2/4) of the firms were not aware of government incentives for TT activities in the country. One firm applied Tax reduction/ rebate for the acquired technology licenses; R&D expatriates employed and got (USD 2,008,000) and Cash grants (USD 19,900,000).

4.16. Key Motivations for Technology Transfer

High priority motivations for a majority of universities and RTOs to undertake transfer technology in include safeguarding intellectual properties, advancing human and institutional capabilities, becoming global technology leaders, and earning revenue from the technologies and cultivating strategic partnerships. However, issues like responding to stakeholder requests, making societal development impact, taking advantage of government incentives, establishing industry standards and exploring new applications were considered as minor (**Figure 4.12**).

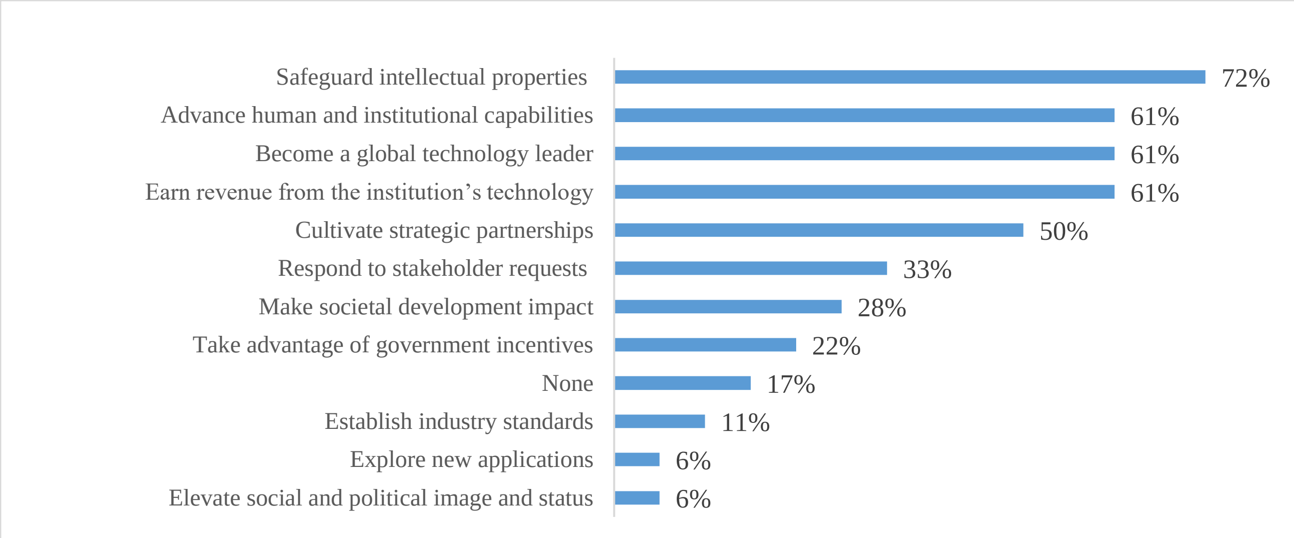


Figure 4.12: Factors motivating TT among universities and RTOs.

For firms, high priority motivations included: safeguarding intellectual properties (1), advancing human and institutional capabilities (1), earning revenue (2), becoming a global technology leader (2), cultivating strategic partnerships (2) and taking advantage of government incentives (2).

4.17. Challenges

Several factors challenge the process of technology transfer among universities and RTOs. Common technology or market related factors include difficulties in identifying and accessing TT partners and lack of readily or enough developed technology to be transferred (**Figure 4.13**).

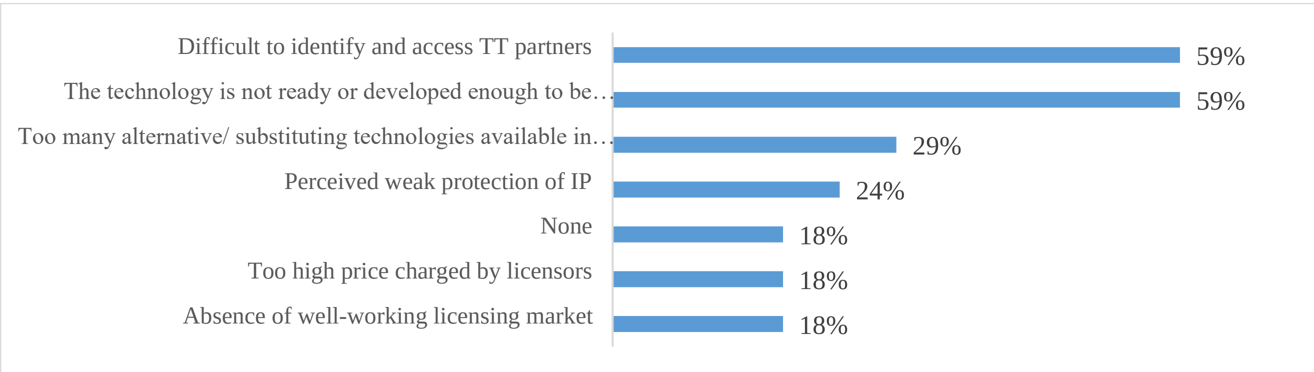


Figure 4.13: Technology or market-related challenges to TT in academia and RTOs

Commonly cited challenge among firms included: lack of readily or enough developed technology to be transferred and absence of well-working licensing market.

Common institutional challenges affecting TT activities among universities and RTOs include lack of information on technology needs and availability in the institution and lack of clear strategies and guidelines to direct and govern TT activities (**Figure 4.14**). Firms indicated that their key challenges include: lack of prioritizing TT activities and the fear of losing technological edge if technology is transferred out.

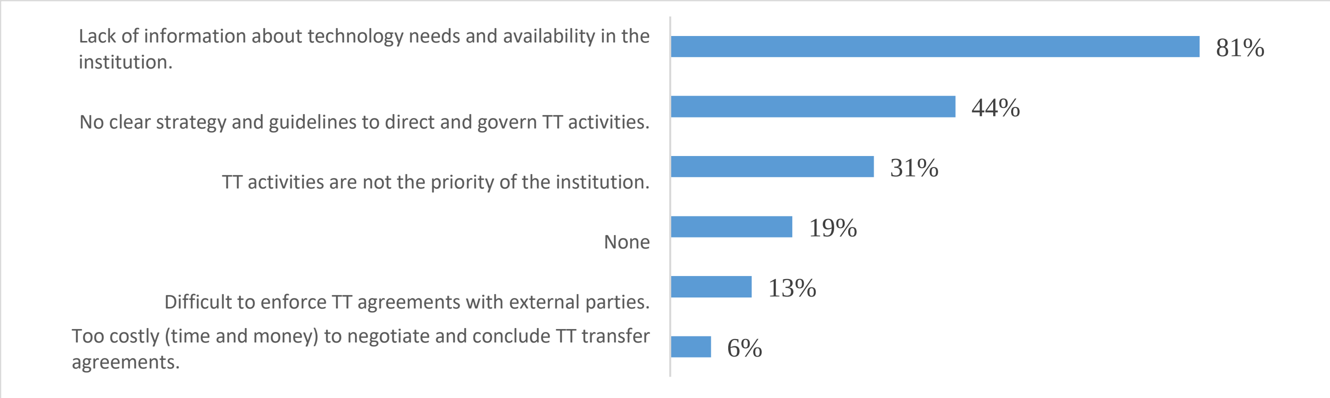


Figure 4.14: Institutional-related challenges in academia and RTOs.

4.18. Other information on technology transfer activities

- Universities develop many technologies which are never patented due to lack of funding. However, with renewed support for TT activities many products are being commercialized.
- Universities hosts startup centers, hubs, incubators, innovation centres and science parks that support the commercialization of technologies.
- To engage actively in technology, transfer activities, a high level of innovativeness is required.
- Higher institutions face major challenges in identifying innovations and patenting them.
- There is weak or cold university - industry linkages
- Universities are proactive in TT transfer adaptation
- Small budgets do not favour TT in most universities
- The government should set aside funds specifically for the establishment of TTO.
- The concept of TT is not yet institutionalized by many institutions especially in the universities where the focus is more on academic rather than business.
- There is a need to sensitize institutions on their ability to generate revenue from IP through TT.
- There is lack of technology exhibitions and demonstration sites.
- There is lack of funding for TT activities,
- There is lack of sufficient skills on TT activities.

CHAPTER FIVE

5.0. DISCUSSIONS

In Kenya Technological Transfer is changing how firms, universities, research and technology organizations (RTOs) conduct their businesses. Both public and private institutions understand the importance of TT in building resilience and sustainability. Public institutions including universities and research institutes need to acquire and develop appropriate technologies to sustain development in agriculture, food security, and health. Firms need technologies that can sustain their businesses and economic growth. The ECA supported survey on advancing Technology Transfer for sustainable development has generated useful evidence for the national government, county governments, universities, RTOs and firms. The survey covered 10% of the private and 90% of public institutions which included public universities and TROs that were sampled on the basis of having some semblance of TT activities. A few business firms 1.6% (n=4/252) participated in the study. The low response could be attributed to lack of policy on sharing information and the fear that firms might lose trade secrets to their competitors.

Agriculture and health were the main area for research and Technology activities for universities and RTOs, while firms described their main areas of focus as electricity, health and telecommunication. These main areas of research and technology activity are likely to be influenced by increased disease burden, food insecurity and energy. Since agriculture is the backbone of Kenya's economy most institutions and firms are involved in agricultural and food security activities. Technology Transfer in agriculture-based research therefore plays a strategic role in the process of economic development of Kenya. According to the Kenya National Bureau of Statistics (KNBS, 2022), the sector remained dominant, accounting for 22.4% of the gross domestic product (GDP) in 2021, despite a contraction of 0.1% from 2020. Just like in China and Japan TT in agriculture can significantly contribute to the transformation of different sectors of the economy (Mgendi et al., 2019). Agriculture remains the backbone of Kenya's economy and central to Kenya's development strategy.

5.1. Full Time Employees

According to the survey, the number of R&D researchers, technicians and managers increased by 4%, 1% and 5% respectively between 2018 to 2020. This increase can be attributed to the rapid expansion of universities in the country (Mukhwana. et al., 2017). More employees in universities and RTOs are engaged in research to comply with the Commission for University (CUE) requirement that career progression in higher education should be pegged on research outputs and academic qualification. There are more researchers compared to technicians in both RTOs and universities even though researchers in the universities are more than those in the RTOs. There is a tendency for universities to rely on lecturers (researchers) than technicians hence most universities hire fewer technicians and technologies as non-teaching staff. Although the impact of COVID-19 was a serious threat to both education and manufacturing sectors, TT activities continued in the education sector due to the rapid adaption of digital technologies to support blended learning(Young et al., 2021).

Most universities and research institutions in the public sector invested in infrastructures that support both virtual learning and safe face to face learning thereby creating job security for lecturers. To support online classes, the government lowered taxes on ICT equipment. Consequently, university students were able to purchase subsidized laptops and smart phones. Also, Kenya's National Research and Education Network (KENET), which is licensed by the Communications Authority of Kenya as a not-for-profit operator serving education and research institutions, offered subsidized internet bundles and laptops to online students.

Among the R&D managers, technicians and researchers, female employees (31%) were fewer than male employees (69%). The figures contrast with the government of Kenya policy a third gender rule. The constitution of Kenya requires that universities and RTOs to take measures to implement the principle that not more than two-thirds of the members of employees shall be of the same gender (Makau, 2019). However, ensuring that that at least a third of full-time employees in universities and RTOs are female, is difficult to achieve. This situation is influenced by socio-economic constraints and pressure to confirm to traditional gender roles, religion and households. As a result, retention rates for females in the entire education system end up being reflected in fewer females reaching the job market. Through the National Commission for Science, Technology and Innovation (NACOSTI), the National Research Fund (NRF) and the Kenya National Innovation Agency (KeNIA), the government has over the years prioritized and scaled up grants targeted at women researchers and innovators through multidisciplinary and multi-institutional funding schemes. In universities, 49% of the employees have PhD qualification whereas 18% of employees in RTOs possess PhD qualification. The higher numbers of PhD holders at university level is in response to the increasing demand for university education and also influenced by the Commission for University Education policy on obtaining a doctorate degree for lecturers' career progression.

5.2. R&D Budget and funding

In Kenya, universities and RTOs are funded by donors (43%) and the government (38%). In general, R&D funding among universities and RTOs is donor driven. That explains why institutions that have active TT activities collaborate with donor partners. In contrast, the private sector accounted only for 1% of funding for both universities and RTO's. This further highlights the inherent weak linkages between industry and academia and that there seem to be an indication that universities and RTO's that are supposed to play a critical role in the technology transfer process are not well positioned to offer industry friendly solutions. For universities to invent and innovate, they need an effective R&D processes leading to functioning market system (Schot & Steinmueller, 2018). With such weak academia-industry linkage, Kenya is experiencing market failure where on one hand the industries have failed to conduct basic scientific research while on the other hand the role and missions of the universities are focused on teaching a lone.

Incentives and funding by government should encourage the private sector to invest more in TT activities. However, in Kenya funds allocated for R&D are very minimal. Inadequate financing starts at budget preparation stage. This study reveals an increase in the minimum budget allocation per institution by 47% between 2018 and 2020 and decrease in actual funding per institution by 38% in the same period. This fluctuation could be due to the fact that during budget preparation, a common practice by most institution, is to present a wish list, which during actual funding is rationalized by the government or donors best of the availability of funds or economic performance. During the same period funding may also have decreased due to COVID-19 pandemic. When COVID-19 containment measures started biting in the mid-2020, both donors and the government reduced their funding.

5.3. Technology Transfer among Universities and RTOs

Most universities and RTOs (70%) have formalized their TT mechanisms by developing plans, policies and guidelines. For 71% of the universities, having TT policy and strategy is a means for using technologies to implement the government development agenda, Vision 2030 (Government of Kenya, 2007). Some universities and RTOs implemented their TT policies by setting up TT offices. In the survey, common TT strategies captured among the institutions include implementation of manufacturing contracts, establishing IRP offices, establishing Centers of Excellence (CoE), and science parks. Universities with established TT offices have stepped up to develop innovation and incubation hubs. This is evidenced by Manu Chandaria Business Centres spread across several universities. The Kenya Industrial Property Institute (KIPI) which is a body cooperative responsible for intellectual property has encouraged the establishment of intellectual property offices to encourage universities and RTOs to commercialize their innovations after fully protecting them as enshrined in the Kenya Constitution 2010. However, KIPI statistics show that universities and RTOs commercialize and apply for patents extremely poorly. KIPI's data seems to confirm the survey findings as very few institutions indicated that they had acquired a patent. Unlike in the US, where rights to intellectual property arising from federally sponsored research motivated universities and their faculty members to commercialize innovations, Kenyan institutions are less encouraged by similar arrangement (Woodell & Smith, 2017). This situation could be due to lack of a well-coordinated national framework to guide rights to intellectual property.

In the last decade, Kenya has been a cradle of technological innovation. Consequently, most of the innovation spaces, incubation centres, accelerators and labs are concentrated are either independent or operate under the framework of academic and research institutions. Generally, technologies being transferred or acquired by universities and RTOs are influenced by the 4th industrial revolution which is centred around evolution with digital technology and capability pillars. The pillars cover Artificial Intelligence (AI), Cybersecurity, 5G and Advanced networks, Digital Twins, Additive Manufacturing and Block chain.

To accelerate the TT process, universities and RTOs foster partnerships with local and international partners. TT strategies likely to achieve this include manufacturing contracts, international trade fairs and exhibitions that involve universities, industry and society. Internally, institutions assess their TT activities through surveys, performance appraisal and M&E system. All the assessment mechanisms apply to public institutions that are obligated to report their performance to the government. About 70% of the universities have dedicated teams that handle TT activities including licensing, contracts and knowledge exchange. However, lack of funding dedicated to these activities could be the main barrier for the technology team. Private sector firms had the highest number of partnership (50), indicating that the main motivation could be commercial.

Partnerships are required between universities and industrial players. But without adequate funds universities and RTOs fail to prioritize key activities to support partnership with the industry, hence the existence of many barriers to partnerships (Mwangi et al., 2018). For instance, allocations ranging from USD 1,000 to USD 3,000,000 recorded in the survey could meaning not priorities monitoring and evaluation activities for some institutions and firms (Mwangi et al., 2018). The survey further reveals, more outward activity partners between the Kenyan institutions and other African countries including Uganda, Tanzania, Egypt and South Africa. These countries are among Kenya's largest business partners in the region (Statista, 2022). Similarly, there exists inward acquisition of TT amongst Kenyan university partners through student exchange programmes, visiting lecturers, fellowships, scholarships and mentorship programmes.

According to the survey, a single institution generated a maximum of 86 spin-offs. The possibility of having spin-offs leads to institutions paying for licenses to generate revenues. A single institution paid USD 150 and projected to pay USD 1,500 in the next 3 years while another one has already paid USD 1,234,838 and projects to pay additional USD 4,977,032 in the next 3 years. Universities pay for licenses to support the establishment of incubators, science parks, centers of excellence, hubs and consultancy firm. Universities rely on such infrastructures to support start-ups commercialize their innovations and improve relations with industry and society under the public-private partnership framework (National Council for Law Reporting, 2015). In accordance with the Startups Bill, 2020, the Ministry of Information Communications and Technology shall establish tax incentives for startups in Kenya. In addition, the report of the Building Bridges Initiative (BBI) task force recommends tax policies that encourage investment, innovation, and value creation over value creation.

5.4. Support Services for Technology Transfer

Business, Professional and Technical (BPT) services form a source of revenue and expenditure for universities, RTOs and firms. In 2020 the universities and RTOs paid out to BPT service providers a minimum of USD 7,000 and a maximum of USD 300,000. About half of the payment (50%) was paid out to higher education institutions in Kenya. That means, the demand for BPT services by universities and RTOs is largely being met by higher education institutions. Such BPT service providers could be linked to older universities including the University of Nairobi (www.unes.co.ke), Kenyatta University, Moi and Egerton universities, with highly trained staff and well-established business centres and consultancy firms.

Compared to the public sector, that is service oriented, private firms which are business oriented received the highest payment, totaling up to 80%. Public sector enterprises affiliated to younger universities and RTOs are still focused on service delivery and the establishment of infrastructure for their future businesses. In their current state, they only outsource for BPT services and have little competitive advantage to provide BTP services in the market. That explains why the total income made to such providers of BPT service ranged from a minimum of USD 4,000 to USD 360,000 per institution in the year 2020. The universities received payments from the private sectors through research and training. Universities also host international centers for innovation i.e. incubation centers, live parks and science parks that make them receive income through BPT services. Therefore, large universities with well-established programmes, are likely to have firms that are BTP service providers compared to smaller or newer universities.

About 25% of the institution spends a minimum of USD 1,500 and a maximum of USD 4,500,000 on local purchases of capital goods to support TT activities. Considering that R&D funding is donor-driven, most capital goods are imported. The limited procurement of local capital goods could be driven by the government's "buy Kenyan Build Kenya strategy" which encourages publicly funded institutions to procure Kenyan made products and services (Government of Kenya, 2017). That means, with increased government funding, more universities and RTOs would buy more capital goods from the local market to support TT activities.

Universities and RTOs often use open source technologies such as zoom for virtual meetings, classes and graduations. Universities utilize additional open source technologies including Mozilla, patent information databases, ORACLE and HINARI. As universities implement post-COVID-19 containment measures, the demand for open source technology has increased. All universities and publicly funded RTOs in Kenya are required by the regulator streamline online services as part of the post-COVID-19 resilience measure.

Universities and RTOs acquire and deploy technologies such as on-line sales and digital services as well as renewable energy technologies such as photovoltaic cells. They are currently investing in robust solar systems such the Kenyatta university Urbasolar power system. Similar renewable energy technologies are utilized through the development of biogas systems such as the one at Kisii University. Firms such as Kenya Electricity Generating Company (KenGen) are also experimenting with solar assembly technology, Geothermal wellhead technology and solar grid tie technology.

5.5. Incentives for Technology Transfer

It is only through economic rewards that inventions, innovation, and knowledge disclosure will be supported and enabled. A variety of tea and coffee varieties have been commercialized in East Africa and elsewhere as a result of incentives in agriculture. As a result of the need to recover the costs associated with investing in innovation to bring it to market, a technology transfer incentive regime has been developed in Kenya. The exclusive rights of investors promote creativity, productivity, and information dissemination. Inventors must disclose their inventions to the public in order to be granted a patent. As a result, scientific and technological progress is advanced through knowledge transfer. The patent system in Kenya encourages innovation in all key economic sectors.

Therefore, IPR protection is critical to fostering innovation in Kenya. Successful inventors and institutions are given temporary and limited monopoly power over their innovations under IPRs. A successful investment in research and development (R&D) must produce profits large enough to compensate for the unsuccessful investment. Therefore, IPRs are an appropriate incentive for R&D that leads to innovation. In Kenya, businesses can create and register patents and utility models, which in turn can be licensed, granted rights to use, transferred or sold to another business, or integrated into products and services. Additionally, that business likely incurred significant capital costs, such as R&D, to develop the patent/utility model and commercialize it. An IPR protection system provides an exclusive monopoly over a business's ability to commercialize its IPR. The goal is to recoup the investment and generate profits.

In order to encourage universities and RTOs to conduct R&D, obtain legal protection, commercialize IPR, and recoup their investment, Kenya has established a tax incentive framework. The government provides a variety of incentives to support technology transfer, but most universities and RTOs (58%) are unaware of them. A few of the most prominent incentives include Export Processing Zones (EPZs), one-time capital investment deductions, withholding tax exemptions, and zero-rated VAT on goods and services procured by public universities and institutions, especially "state-of-the-art" equipment. Fiscal incentives are governed by the Income Tax Act, the Value Added Tax Act, and Customs legislation.

EPZs were established to attract Foreign Direct Investment (FDI) and turn Kenya into an export-oriented economy. Additionally, the zones were designed to create jobs, facilitate technology transfer, and link domestic producers and exporters. Foreign companies account for 61 percent of EPZ investors, while Kenyan and foreign joint ventures account for a quarter of investors and 14% of enterprises are dominated by Kenyans. Numerous tax incentives are provided at EPZs, including:

- a 10-year corporate income tax holiday, followed by a 25% rate (compared to the standard 30%) for the next 10 years.
- a 10-year exemption from all withholding taxes.
- Exception from import duties on machinery, raw materials, and inputs.
- Exceptions from stamp duty and VAT on raw materials, machinery and other inputs.

According to the current survey, a few institutions indicated that they have benefited from such government incentives. This low level of utilization of government incentives could be attributed to weak coordination mechanisms at the national level leading to lack of awareness by stakeholders. The Kenya Revenue Authority should collaborate with the Ministry of Health to build awareness and ensure that institutions benefit from government incentives.

According to the current survey, two key motivation for universities and RTOs to engage in transfer technology includes safeguarding intellectual properties and advancing human and institutional capabilities. Most institutions feel motivated when their intellectual properties are protected. Kenyan university intellectual property ownership is governed by the individual university research or commercialization policy. For that reason, universities develop TT policies to protect their IPR of their staff emanating from publications and innovations. However, apart from having policy frameworks and improved publication rates, the level of technology transfer in Kenyan universities and RTOs is still very low. As observed in the current and previous study, Kenyan universities perform poor in acquiring patents (Ayisi et al., 2016). To the contrary, studies have shown that in the US, the transfer of intellectual property (IP) ownership from the publicly funded granting agencies to universities through the Bayh-Dole Act of 1980, led to a massive increase in funding to universities by venture capitalists, hence a rapid rise in technology transfer (Woodell & Smith, 2017). To a small degree, the increased expectation that research in universities should contribute to the overall revenue coupled with reducing government capitation, has forced them to start research-related income generation interventions. Earlier studies pointed out that started this approach by developing strategic plans to shape and direct their research priorities (Ayisi et al., 2016). However, as the study findings have revealed, the industry has not been motivated to invest in public research.

It is evident that there is a gap exist between having policy frameworks and undertaking actual measures to boost commercialization. For instance, if terms of sharing income TT between universities and industry are not clear like in the case of Kenya, then the commercialization process is slowed down. In addition, clear royalty sharing formula, which determines the fraction of revenue that is allocated to a university faculty member who develops the technology act has a motivation in TT activities (Ayisi et al., 2016).

Currently, Kenya has adopted an input-based approach with respect to tax incentives for IPRs, as it allows a business to deduct expenditure incurred on scientific research — defined as activities in the fields of natural or applied science for the extension of human knowledge. This is a limited definition that carves out many of today's technological innovations. Unlike the current input-based approach, an innovation box targets successful R&D activity that result in commercially viable products as the special tax rate would only apply to the income generated by the IPR. It essentially conditions the tax incentive on the success of the innovative activity.

5.6. Challenges

Universities and RTOs stated their main challenges to TT as, lack of access to partners, inadequately developed technologies, lack of information on technology needs and clear strategy. These challenges are caused by insufficient time and financial resources for complete development and commercialization of new technologies. Sophisticated technologies require enough resources to support strong partnerships between stakeholders and the technology developers. In addition, institutions require extra resources to enforce TT agreements with external parties to manage the high stigma and fear associated with competition and loss of new ideas.

Universities and RTOs are unable to access partners and adequately develop their technologies because of staff limitation. Only a limited number of staff members are engaged in Research and Development. With limited researchers, the focus of most of the university staff is on teaching at the expense of R&D. According to Ayisi and others ((Ayisi et al., 2016) universities should move from "publish or perish" approach to "innovate or perish" approach to enable them have transformative human resource policies. The new approach would mean that the staff promotion polices should avoiding demanding for research outputs such as publications and dissemination to outcomes such as technologies transferred.

CHAPTER SIX

6.0. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

Successful transfer of technology requires more than just the moving of high-tech equipment from the developed to developing countries, or from one institution to another within the developing countries. This calls for building strong capabilities in knowledge management, technical and business leadership. These sets of skills have been reflected in the Kenyan context, as most universities and RTOs have heightened TT activities by integrating human skills, organization development and information networks in their core functional areas. Thus, TT is a broad and complex process entailing investigation disclosure, evaluation, patent application, assessment and marketing licensing of patents and commercialization (Jackson State University, 2021). At the end of TT, the recipient must have the ability to use, replicate, improve and if possible, re-sell the technology. There is no single strategy for successful technology transfer that is appropriate to all situations. Selecting the correct strategy for the situation is the most important aspect of TT. If the transfer of technology is inadequate, unsustainable, or unsafe, technology recipients should be able to identify and select technologies that are appropriate to their actual needs, circumstances and capacities.

According to the findings from the survey, the acquiring, venting and modifying capability at universities and RTOs are in high level. However, there is always room for these capabilities to improve to advanced levels. Also, for effective technology transfer to take place, development of converting/transforming and generating/innovating capabilities will be critical. Results indicate that the required technological capabilities of universities and RTOs are available within the institution. For this reason, it is very important for universities and RTOs to build, develop, strengthen, enhance and improve existing scientific and technological skills and capabilities to a world class status.

6.2. Recommendations

Recommendations given here are based on the research findings in TT process at universities, RTOs and firms. They give an idea to overcome barriers for success in TT, ways and, means to improve technological capacities and the technological components of the universities, RTOs and firms. Finally, the recommendations show insights on actions that should be taken by the universities, RTOs and firms for effective and successful technology transfer.

To address barriers to successful TT, the following recommendations to should be implemented:

Develop and fully implement policies that promote R&D and technology transfer in Kenya

- Although universities, RTOs and firms are at various levels of policy implementation, it is worth noting that policies that technology transfer are either not fully implemented or lacking. Such slow progress is attributed to inadequate funding for TT activities and lack of prioritization. Therefore, Institutions and firms without TT policies should be supported by management to develop such policies. Those with such policies should be supported by management to get enough budgetary allocation and staff to fully implement TT activities.

- In addition, other supportive policies and programmes including human resource policies, appraisal system and M&E system should contain outcome-based research indicators such as technology transfer, patents, startups etc.
- Institutions should hire dedicated Industrial Relations Officers to promote relations with the industry and societal stakeholders.

Build a robust well-coordinated national incentives and reward system

- To avoid challenges associated with system failure including poor coordination of multisectoral policies and lack of reflexivity, the government should support the establishment of a well-coordinated professional incentive and reward system. Such a system should have a framework on how research personnel should benefit from tax incentives, how intellectual property rights ownership should be shared among partners and establishment of new rewards for female researchers.
- The incentives and reward system should cover both research inputs, outputs and outcomes but with more focus on transformative outcomes in technology transfer and innovation.

Establish sustainable financing for Research and Innovation

- The government and international development partners should support universities, RTOs and firms to establish sustainable financing for Research and Innovation through national granting agencies including the National Research Fund (NRF) and the Kenya National Innovation Agency (KeNIA). Both traditional funding schemes (for maintenance) and innovative funding schemes (e.g. Research Fairness schemes) should be expanded.
- Universities and RTOs should get out of their “silos” through bilaterally funded joint multidisciplinary and trans-disciplinary projects involving the industry and the society.

Expand and Operationalize Technology Transfer Offices (TTOs)

- Although some universities and RTOs host TTOs, these offices should fully be operational and expanded to cover additional institutions. TTOs form a bridge between industry and academia and institutions require fully fledged TTOs to have effective TT. In addition, operational TTOs should provide assistance in sensitizing the institutions on relevant available incentives for TT.

Co-create Capacity Building Programmes in Relevant Skills and Policy Development

- Poor entrepreneurial culture, as evidenced in the study by low patent application, and fewer spin-off firms is a consequence of lack of understanding that transformative ideas can be realized through the co-creation process. Therefore, universities, RTOs and firms should build their capacity on knowledge co-creation, co-production and co-implementation of ideas. By embracing co-creation approach institutions can avoid being of purely academic orientation and take commercialization seriously.

- In addition, the institutions should focus on training of students, early career researchers and administrators in innovation, commercialization and entrepreneurship.

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Annex I: Work Plan

Activity	Deliverable	TIMELINES IN WEEKS										
		Quarter 4: 2021		Quarter 1: 2022			Quarter 2: 2022			Quarter 3: 2022		
		2	3	1	2	3	1	2	3	1	2	3
1. Acquisition of research permit	Permit											
2. Review of survey questionnaires	Final survey questionnaires											
3. Preparation of survey sample	Survey sample											
4. Data Collection	Completed questionnaires											
5. Data processing and analysis	Data analysis report											
6. Draft report & case study writing	Draft report											
7. Final draft report submission	Final draft report											

Annex II: 10 Pager Report

An Assessment of Technology Transfer Trends and Impacts in Kenya

Authors: Frank Ndakala and Richard Mavisi

Technology Transfer (TT) is an important means by which countries and organizations acquire new technologies across boundaries (international) or from one sector or one firm to another (domestic)(Pandey Shreya, 2020). It entails the movement of knowledge, skills, know-how, technology, intellectual property or capabilities from one entity to another including industry, academia, state and local government to meet societal needs. Common TT activities can include intellectual property rights (IPR), technology assessments, innovation surveys, marketing of technologies, startup creation and development and securing funds for research and start-up (www.twi-global.com).

In many African countries, innovation policies and international financial flows influence TT. A historical analysis of Kenyan policies reveals TT trends and impacts have been influenced by 3 policy approaches including, Research and Development (R&D) and Regulation, the National System of Innovation and Entrepreneurship and the emerging Transformative Innovation policies (Ayisi *et al*., 2019; Schot & Steinmueller, 2018).

R&D and Regulation

Kenya's R&D and Regulation this approach entailed providing incentives for the market to produce socially and economically desired technologies(Ayisi et al., 2019). The Government offered subsidies and measures including Intellectual Property Rights (IPR) that enhance innovation. Regulations were put into place to protect the citizens from unforeseen negative impact (Schot & Steinmueller, 2018). Through this approach Kenya prioritized the discovery process (invention) as the most important element of technological innovation. As a result, Kenya has spent decades building R&D and regulatory institutions. To date, the country has 74 universities (Mukhwana. *et al*., 2017), 11 research institutes and over 10 international research institutions (https://www.kenet.or.ke).

In the late 1990s, Kenya's R&D system began intensive sector-based specialization which unfortunately resulted in "silos" and weak linkage between academia and industry *(Koria et al.*, 2014). To the strengthen the IPR regime and overhaul the entire linear model of innovation (R&D system) the government reviewed the Science and Technology Act of 1977.

National Systems of Innovation & Entrepreneurship

Kenya's policy framework has three pillars. The first is Vision 2030 and the related Science, Technology and Innovation Sector (STI) Plans (GoK, 2008b). The second pillar is the STI Act of 2013, which establishes the national research institutions tasked with implementing Vision 2030 and the STI Sector plans (GoK, 2013). The third pillar is the Universities Act of 2012, which established the

Commission for University Education (CUE), the Universities Funding Board and the Kenya Universities and Colleges Central Placement Services Board, regulatory agencies responsible for the accreditation and governance(GoK, 2012). The Universities Act also regulates the production and dissemination of scholarly research and the promotion of innovation. Through the Vision 2030 Kenya intends to create a competitive country with a high quality of life through innovation by maximizing knowledge production, supporting commercialization and bridging the gap between discovery and application(GoK, 2013; GoK, 2010; GoK, 2008). This approach aims at strengthening linkages between various actors, improving absorptive capacity and capability formation of firms, and entrepreneurship (Schot & Steinmueller, 2018). Also, the approach focuses on technology transfer, building technology platforms and technology clusters to stimulate interaction and human capital formation.

According to Sihanya, common forms of TT in Kenya include contractual licensing, franchising, joint ventures, and foreign direct investment (FDI), assignment, securitization, venture capital, strategic alliance (SA), Special Purpose Vehicle (SPV), business incubation, franchising, and commercialization by business corporations, universities and research and development (R&D) institutions (Sihanya, 2018). Most universities and research institutes are in the process or have already developed business incubators to support the commercialization of innovations.

Transformative Innovation Policy

Although TT and Entrepreneurship feature prominently in Kenya's National Innovation System (NIS), elements of R&D and Regulation and Transformative Innovation remain part and parcel of the current institutional, legal and policy framework. The government has been mobilizing the power of innovation to address societal challenges including inequality, unemployment and climate change. The goal is to direct socio-technical systems into socially desirable directions and embed the processes of change in each and every sector. Transformative innovation Policy (TIP) explores changes in the socio-technical system to transform governance, the market, civil society, science, and to promote responsible research and innovation (Schot & Steinmueller, 2018). Finally, the model has a more constructive role for foresight to shape innovation process from the outset and on a continuous basis. Elements of transformative change found in Kenya include experimentation with the Universal Health coverage, competency based curriculum (CBC) and pro-poor housing and food security programmes of the Big 4 Agenda (GoK c, 2017)

Policy mix and Technology Transfer in Kenya

In Kenya, TT takes place in an environment that has mix of practices drawn from approaches of R&D, NIS, and TIP. Kenya's 50 years of post-independence investment in R&D with a focus on building institutions have indeed resulted in a linear model of innovation. Universities and research institutes have a focus on basic research and scientific discovery. The general assumption is, that such scientific discoveries will automatically be commercialized. All along the government has been playing a delicate art of balancing between local and imported innovations. The balancing act has resulted in the retardation of R&D in key areas especially in engineering and manufacturing.

Kenya's NIS constitutes of "Centres of Excellence", "science parks", "business incubators". All institutions supporting NIS have an entrepreneurship focus in terms of "clusters" of innovation activities including technology transfer and research activities (J. Ayisi et al., 2019a). Hence before 2013, the county had large institutional fragmentation, weak coordination of sectoral policies, donor driven financing and poor linkages between academia and the industry. Vison 2030 addressed these critical issues by proposing a raft of strategies to enhance technology transfer and the linkage between academia and industry through incubators and entrepreneurship (GoK, 2007). Since 2008, the implementation of the Vision has been phased out in five-year Medium-Term Plans (MTPs). MTP I and II (GoK, 2008a) (GoK, 2013) have already been implemented and the country is currently implementing MTP III (GoK, 2013b).

The Kenya Vision 2030 set out Science, Technology and Innovation (STI) as a key foundation for anchoring the social, political and economic pillars of national development. The first major achievement of the Vision 2030 was the promulgation of the 2010 Constitution of Kenya which recognizes the role of science and indigenous technologies in the development of the nation; and promotes the intellectual property rights of Kenyans (GoK, 2010). In line with the 2010 constitution, the STI sector in MTP II (2013-2017) had an overarching theme on STI (GoK, 2013). The policy framework supported establishing regional systems of innovation with support from the East African Science and Technology Council (EASTECO). It further intensified the coordination of STI through flagship programmes. Therefore, Vision 2030 and the 2010 Kenyan constitution significantly addressed systematic challenges in the innovation policy system in Kenya.

Analysis of Technology Transfer

Kenya is a favored business hub on many fronts including agriculture, tourism, oil and gas exploration, manufacturing exports, and consumer goods and services. The improved investment climate resulted from the abolition of restrictions on foreign shareholding in listed companies, and permitting full foreign control (UNCTAD, 2016). For decades the country has maintained TT through indigenous R&D, foreign direct investment, purchasing or leasing "off-the-shelf" overseas training and accessing patent documents in public domain kept in patent office's such as Kenya Industrial Property Institute (KIPI).

Through FDI, foreign firms have played a key role enhancing TT especially in the agriculture sector, floriculture and horticulture. Such FDI have concentrated on the consumer goods,and telecommunication (Gachino & Rasiah, 2003). Even with the improved business climate local Medium and Small Enterprises (MSEs) still face restrictions in TT, lack of information on existing technologies and their potential for increased trade (Ngwiri, 2016). Consequently, MSEs have low productivity, poor quality and limited range of products, and their products compete poorly in the market. Despite the challenges, jobs, firms and industries in all sectors are being transformed by automation, innovation and new technologies—robotics, big data, the internet of things, cloud computing, three-dimensional (3D) printing, block chain, gene editing, nanotechnology and solar photovoltaic. In the long term, the implementation of these new technologies is expected to reduce the demand MSEs-skilled workers in traditional sectors, while innovation is expected to raise the demand for high-skilled workers in new sectors of economic activity.

To improve productivity and food security, the country has been experimenting with different technical cooperation with international partners. For instance, the Smallholder Horticulture Empowerment Project (SHEP) which encouraged smallholder farmers to grow profitable horticultural crops according to market demand (JICA, 2014). This innovative approach was an initiative between the Ministry of Agriculture, Livestock and Fisheries (MOALF), and the Horticulture Crops Development Authority (HCDA) in Kenya with technical support from Japan International Cooperation Agency (JICA). Phase I of the SHEP had 2,500 farmers and phase II HAD 13,000 farmers who were capacitated in market-oriented horticultural farming and production techniques in order to produce as per market requirements. The programme increased income for the farmers and many scaled up their agricultural activities by expanding their horticultural fields and invested more in agricultural inputs.

Similar to many African countries, Kenya has sector-specific levies on consumers of digital services, such as mobile payments which have influenced the trend of TT. In January 2021, Kenya enacted a 1.5 percent tax on all digital services which covered both local players and global players such as Uber and Netflix (World Bank Group, 2021). The influence of taxes on digital technologies became evident when the government reduced taxes to promote virtual work and cashless payment during COVID-19 lockdown.

According to the World Health Organization (WHO), the COVID pandemic led to the development of more than 120 health technology innovations in Africa. To control the spread of the pandemic, Kenya rapidly developed and/ or adopted technology-based solutions such as digital technologies in a trend never witnessed before. Many existing manufacturing firms were repurposed to meet the large demand for personal protective equipment (World Bank Group, 2021). The innovations targeted surveillance, contact tracing, community engagement, treatment, laboratory systems, prevention and control of the pandemic. For instance, companies utilized 3D printing technology to manufacture PPE and a wide array of parts of medical devices to meet the needs in overstretched hospitals. Ultra-red technologies were used to design a 3D-printed prototype for a ventilator adaptor that enables enabled medical staff treat two to four patients simultaneously (World Bank Group, 2021).

COVID containment measures contributed to many losses in the manufacturing sector. However, a handful garment manufacturing companies repurposed their production lines for manufacturing PPE. These companies were issued with licenses to produce masks and sanitizers. For instance, Bedi Investments, a garment and textile manufacturer that exported to the U.S. and U.K. markets before the pandemic, repurposed production lines to manufacture face masks and surgical gowns, using locally-sourced materials. The company is currently selling 80 percent of its products in the local market. Another Kenyan company, Hela industries acquired machinery for production of N95 respirator masks (World Bank Group, 2021).

Recent Technology Transfer Trends in frontier technologies

The COVID-19 pandemic has spurred rapid development and adoption in frontier technologies. Examples of frontier technologies that have impacted the Kenyan society include digital technologies such as Artificial Intelligence (AI), Internet of Things (IoT), big data, block chain, fourth and fifth generation (4, and 5G) technology, 3D printing, robotics, and drones as well as gene editing, nanotechnology and solar photovoltaics (PV) (UNCTAD, 2021). The Kenya Institute for Public Policy Research and Analysis (KIPRA) discussion paper no. 225 of 2019 revealed that 75% of informal firms mainly use computers as follows: printing (16%), scanning (0.4%), data storage (19%), data processing (2%) and internet (60%) (Nyaware, 2019). From this assessment, it is evident that more people and firms are relying on technologies such as digital financial services, voice and video-based e-extension services and Uber-like platforms which are well-suited for the poor and marginalized populations who are unbacked, in informal farms and firms and less educated people with limited numeracy skills. Many of the frontier technologies are digital technologies that are accessible through the internet.

1. Digital Technologies

Artificial Intelligence (AI): During the period 1996-2018, there were 116,00 AI patents filed a cross the globe with the United States leading (28,963), followed by China 23,298) and Germany (12,056). In 2021, the top three AI patent owners included BASF (1,961/ Germany), Bayer (1,416/Germany) and Siemens (1,320/ Germany)(UNCTAD, 2021). In addition, common AI service providers including Alphabet, Google and DeepMind, Amazon, Apple, IBM and Microsoft (Ball, 2017) support various Kenyan service users in banking, discrete manufacturing and retail (IDC, 2019).

Internet of Things (IoT): The three leading owners of IoT patents in the world, Samsung Group of the Republic of Korea with 2,508 patents, Qualcomm of the United States with 1,213 patents and Intel of the United States with 667 patents are engaged in TT in Kenya(UNCTAD, 2021). More Kenyan firms, institutions and citizens are relying on IoT service providers including Amazon, Cisco, IBM, Microsoft, Oracle, PTC, Salesforce and SAP (Germany)(DA-14, 2018). The leading user sectors include consumer, insurance, banking, education and healthcare providers.

Big Data: The top three owners of big data patents in world including State Grid Corporation with 424 patents, Huawei with 158 patents and IBM of US with 145 patents are already operating in Kenya (UNCTAD, 2021). The main big data service providers in Kenya are largely US companies that include Amazon, Dell Technologies, HP Enterprise, IBM, Microsoft, Oracle, Splunk and Teradata (Software testing Help, 2022). The leading user sectors of big data are banking, manufacturing, professional services and hospitals. Similar to what is happening in other countries, the growth of big data services is mainly driven by increasing use of the internet and adoption of cloud services and solutions, and increases in the amount of data and the number of mobile devices and apps being developed in different hubs in Kenya (UNCTAD, 2021). The Kenyan big data market is driven by the demand risk management in financial services, customer services and real-time analytics in the education and health sectors.

Block chain: During the period 1996-2018, there were 2,975 block chain patents filed by the top three countries, the United States (1,277), Antigua and Barbuda (300) and China (270). In 2021, the top block chain patent owners including nChain (333/United Kingdom), Mastercard (181/United States) and IBM (134/United States) had their presence in Kenya. The top block chain service providers being used in Kenya include Alibaba (China), Amazon (USA), IBM (USA), Microsoft (USA), Oracle (USA) and SAP (Germany) (Akilo, 2018). The service providers operate in the finance, manufacturing and retail sectors (IDC, 2019B).

5 G technology: A majority of 61.4 million Kenyan mobile phone users recorded in 2020 were already using 3G and 4G internet. As at the end of 2021, at least 94% of the Kenyan population was covered by 4G network (CMA, 2021). During the period 1996-2018, there were 4, 161 patents of 5 G technology filed across the globe with Republic of Korea (3,201) leading followed by China (396) and the United States (317). The top 5 G patent owners in 2021 were Samsung Group (3,338/Republic of Korea), Intel (117/United States) and Huawei (108/China) (UNCTAD, 2021). In Kenya, Safaricom and airtel that support the 3G and 4G networks are expected to be the key providers of two important 5G components, network equipment and chips. Common 5G network equipment suppliers that are already operating in Kenya include Ericson (Sweden), Huawei (China), Nokia (Finland) and ZTE (China) while common chip makers already operating in Kenya include Huawei (China), Intel (United States), MediaTek (Taiwan), Qualcomm (United States) and Samsung Electronics (Republic of Korea). As more Kenyans demand for faster internet, plans are underway to extend the newly introduced 5G technology to cover 150 locations across nine Counties besides Nairobi, Kisii and Kakamega (STAR, 2022).

Robotics: During the period 1996-2018, there were 59, 535 robotic patents filed by top companies in the United States (31,642), the Republic of Korea (3,751) and Germany (3,228). In 2021, the top three robotic patent owners included Intuitive Surgical (2,615/ United States), Johnson & Johnson (1,063)/United States) and Boeing (890/United Sates). The top common manufacturers of industrial robots include ABB (Switzerland), FANUC (Japan), KUKA (China). Mitsubishi Electric (Japan) and Yaskawa (Japan) (UNCTAD, 2021). Top common manufacturers of humanoids include Hanson Robotics (Hong Kong, China), Pal Robotics (Spain), Robotis (Republic of Korea) and Softbank Robotics (Japan). Top common manufacturers of autonomous vehicle are Alphabet /Maymo (United States), Aptiv (Ireland), GM (United States) and Tesla (United States). Companies affiliated to the top robotic manufacturers are in operation in Kenya (UNCTAD, 2021).

The introduction of the robotic contest in 2007 accelerated the application of the technology in many sectors in Kenya. Such annual contests show how local problems can be solved using robots. Recently, the University of Nairobi in collaboration with the University of Komblez-Landau Germany demonstrated how to use robotic to enhance teaching and learning processes. The university intents to supplement robots with virtual learning (www.uonbi.ac.ke/news/robotics-teaching-next-big-thing). To reduce exposure of frontline health workers to COVID-19 infection, the Ministry of Health installed smart anti-epidemic robots at the Kenyatta National Hospital and Jomo Kenyatta International Airport in Nairobi. The robots assist in temperature screening, disinfection, communication of health messages and data capture (Kitinya Schola, 2021).

Drones: During the period 1996-2018 there are were 10,897 drone patents filed by organizations from top countries including the United States (2,995), the Republic of Korea (2,068) and France (1,481). In 2021, the top three drone patent owners were Parrot (325/France), Qualcomm (280/United States) and SZ DJI Technology (242/China). The common commercial drone manufacturers include 3D Robotics (United States), DJI Innovations (China), Parrot (France) and Yuneec (China)(UNCTAD, 2021). Common military drone manufacturers include Boeing (United States), Lockheed Martin (United States) and Northrop Grumman Corporation (United States) (UNCTAD, 2021). The United States Government has donated several military drones to Kenya to support the war on terror in Somalia (Times Aerospace, 2019). Also, the drone technology is already being used in journalism, conservation, medical supply, agriculture, land surveys and prevention of animal poaching.

2. Gene Editing Technology

Gene editing also called genome editing is a group of technologies that scientists use to make permanent and heritable changes at specific sites in the genome of an organism. Gene editing can be used to add, remove or alter DNA in the genome. It is cheaper, simpler and more accurate than other plant breeding techniques.

During the period 1996-2018, there were 2,899 gene editing patents filed with the top organizations from the United States (1,908), Switzerland (214) and China (212). The top three gene editing patent owners since 2021 include Sangamo Therapeutics (179/United States), Broad Institute (140/United States) and Harvard College (135/United States). Common top gene editing service providers include CRISPR Therapeutics, (Switzerland), Editas Medicine (United States), Horizon Discovery Group (United Kingdom), Intellia Therapeutics (United States) Precision Biosciences (United States) and Sangamo Therapeutics (United States)(UNCTAD, 2021; Acharya, 2019). The users of gene editing include pharm-biotech companies, academic institutes, and research centres, agrigenomic companies and contract research organizations (Acharya, 2019).

Universities in Kenya that use gene editing services offered by top service providers include Kenyatta University, Jomo Kenyatta University of Science and Technology, and Egerton university. Research Institutes applying gene editing include Kenya Agricultural and Livestock Research Organization (KALRO), Kenya Medical Research Institute and Kenya Veterinary Vaccines Production Institute (KEVAPI). Nairobi-based International research organizations including the International Livestock Research Organization (ILRI) and International Centre for Insect Physiology and Ecology (ICIPE) are also using gene editing technologies in their projects.

Kenyan scientists and organizations are acquiring gene editing technologies through several international partners including the International Maize and Wheat Improvement Centre (CIMMYT), Consultative Group for International Agricultural Research (CGIAR) and the International Institute of Tropical Agriculture (IIATA). By collaborating with international partners, Kenya is engaged in a number of agricultural gene editing projects involving sorghum, maize, bananas, pigs, and cattle. They include building resistance in the sorghum plant against the parasitic striga weed, controlling maize lethal necrosis disease, disease-resistant varieties of banana, drought-tolerance in maize and developing vaccines against two dangerous diseases affecting pigs and cattle in the region; African Swine Fever Virus (ASFV) and East Coast Fever (ECF) (Conrow, 2022).

3. Nanotechnology

Nanotechnology refers to the control of matter at the molecular level in scales smaller than 1 micrometre, normally 1 to 100 nanometres, and the fabrication of devices within the size range. The technology is already being applied in a variety of sectors including medicine, transport, agriculture, electronics, engineering, manufacturing energy and water purification.

During the period 1996-2018, there were 4, 293 nanotechnology patents filed across the globe, with the top by organizations from the United states (1,075), China (731) and the Russian Federation (696). In 2021 the top three nanotechnology patent owners included Aleksandr Aleksandrovich Krolevets (117/Russian Federation/individual), PPG Industries (76/United States) and Harvard College (66/United States). Top common nanotechnology companies include BASF (Germany), Apeel Sciences (United States), Agilent (United States), Samsung Electronics (Republic of Korea) and Intel Corporation (United States) (UNCTAD, 2021). The common user sectors of nanotechnology include medicine, manufacturing and energy.

In 2021, Kenya with support from China started a nanotechnology and semiconductor manufacturing factor at Dedan Kimathi University of Technology (DeKUT) The plant produces integrated circuits, sensors and related nanotechnology products for the world market (Xinhua, 2021). Most electronics and cosmetics consumer outlets stock nanotech products assembled in Kenya. Healthcare facilities too are already using nanotech equipment to conduct non-invasive surgeries and dispense optical corrective lenses (Kiplagat, 2022). Also, Kenyan affiliates of large multinationals manufacture nanotech pharma products such as precision surgical needles.

4. Solar photovoltaic

Photovoltaic (PV) is the conversion of light into electricity using semiconducting material. During the period 1996-2018, there were 20,074 solar PV patents filed across the globe, with the leading organizations from China (14,515) the republic of Korea (1,923) and the United States (1,232). In 2021, the top three solar PV patent owners included Wuxi Tianyun New Energy Technology (171/China), LG (152/Republic of Korea) and State Grid Corporation of China (152/China). Kenyan residential, commercial and utilities electricity consumers use solar PV from common manufacturers including Jinko Solar (China), JA Solar (China), Trina Solar (China), Canadian Solar (Canada), and Hanwha Q cells (Republic of Korea) (UNCTAD, 2021). TT in solar photovoltaics received a boost with the establishment of Photovoltaic power plant of Kenyatta University's Centre of Excellence (Urbasolar, 2017). The plant is a true collaborative platform of innovative technologies between Kenyatta University and Urbasolar with financial support from the French Government. The partnership supports the transfer of know-how as well as the training of new generation of students in the issues of sustainable development (Urbasolar, 2017).

Conclusion

Following the assessment of Technology Transfer trends and impacts in Kenya through the lens of Transformative Innovation Policy (TIP), it is evident that the current policy activities transcend across the three policy frameworks of Science, Technology and Innovation (STI) namely, R&D approach, science and technology approach, and innovation approach.

R&D policy trends in Kenya cover R&D stimulation measures (e.g. government subsidies, tax incentives, "buy Kenya build Kenya" targeted procurement, and mission oriented programmes centred on Vision 2030), building intellectual Property Rights regime by KIPI, and promoting Science, Technology, Engineering and Mathematics (STEM) in the education system.

Science Policy trends evolving in the country include the strengthening of links between Universities and Industry (e.g. through Linking Industry and Academia (LIWA) initiative), organizing of technology transfer (e.g. establishment of technology transfer offices), stimulating entrepreneurship and incubators (e.g., construction of science parks and incubators such as Manu Chandaria Innovation Centres), and improving business conditions for SMEs and Startups (e.g., Export Processing Zones).

Innovation Policy trends in the country include experimentation with niche technologies, scale-up and acceleration of sociotechnical transitions (e.g. KenGen drilling rig technology), establishment of new institutions to provide innovative solutions for changing the directionality of innovation activities through policy mixes (e.g., establishment of NRF), and promoting social, inclusive, frugal and pro-poor innovation (e.g., The Big Four Agenda Projects).

However, the above stated trends in policies tend to lay more emphasis on Science and Technology Policy activities such as Technology Transfer. Therefore, more resources are allocated for activities that focus to optimize productivity from the existing institutions and laying emphasis on practices in the traditional sectors such as energy, healthcare, agriculture, and environment.

The assessment of trends and impact in frontier technologies revealed rapid TT in four frontier technologies, namely, (1) digital technology, (2) gene editing technology, (3) nanotechnology, and (4) solar photovoltaic technology. Many universities, RTOs and firms are already applying a combination of different frontier technologies. Therefore, when viewed through the six elements of transformative change including directionality, societal goal, system level impact, reflexivity and deep learning, conflict versus consensus, and inclusiveness, the institutions and firms engaged in more frontier technologies have the highest potential for transformative change. Such institutions are likely to have sustainable activities and hence contribute immensely to the attainment of the SDGs.

In conclusion, KenGen's "Good to Greatness" Innovation Department, which is implementing projects in digital technology, nanotechnology and photovoltaic technology has the highest potential to bring about sustainable transformative change in Kenya and beyond.

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Annex III
A case study on technology transfer at Kenya Electricity Generating Company PLC (KenGen)

Introduction

The case study provides details of specific technology transfer performance. It also provides historical accounts of technologies that have been developed, adapted and diffused, as well as challenges and opportunities. In addition, it offers practical information on how the key elements of transformative change are evolving within the context of technology development and transfer. The key elements analysed in the case study include directionality, societal goals, system level impact, learning and reflexivity, conflict versus consensus, and inclusiveness. The presence of these transformation elements in technology transfer activities makes them more sustainable and resilient.

The detailed description of the case study was authored and provided in full by a team selected by the head of Kenya Electricity Generating Company's (KenGen) Innovation Department. The case study was further developed using the Transformative Innovation Learning History methodology and through Focus Group Discussion (FGD) in meetings with experts from the department.

Brief Overview

Kenya Electricity Generating Company PLC (KenGen) is Kenya’s leading electricity generation company with an installed generation capacity market share of more than 60%. The company is domiciled in Kenya and has a branch in Ethiopia. KenGen was incorporated in 1954 under the Companies Act (Cap 486) as Kenya Power Company Limited (KPC) and renamed as Kenya Electricity Generating Company Limited (KenGen) in 1998 as part of the energy sector reforms.

Currently, KenGen generates about 1,904MW, of which over 86% is drawn from green sources including Hydro (825.7MW), Geothermal (799MW), Thermal (253.5MW), and Wind (25.5MW). Backed by cutting-edge technology, KenGen is Africa’s leading geothermal power producer and among the top ten power producers in the world.

The Company is propelled by the Good to Great (G2G) Transformation strategy that strives to create sustainable value from generation to generation. The role of the Innovation Department is in implementing the G2G strategy is to institutionalize the innovation culture in the organization, track new technology developments in areas of interest, maintain a technological edge within the industry, analyse and improve upon technology standards and maintain organizational awareness of new technologies.

Directionality, Societal Goal and System Level Impact

Innovation is cumulative (building upon the past) and can have a direction (directionality) (Schot & Steinmueller, 2018; Ayisi et al., 2019b). With a track record of over 66 years of expertise in running hydro power plants in Kenya, KenGen pioneered the first wind farm in Ngong in the 1990s. The current Good to Great (G2G) Innovation Strategy ensures KenGen embeds innovation and continuous improvement for economic growth and sustainability. The Strategy in a non-neutral way sets the direction of the company's business while allowing for consideration of a wide range of technical options while addressing the social and technical issues they would provoke. The G2G strategy has stimulated experimentation with niche technologies, scale-up and acceleration of socio-technical changes, enabling the company to diversify its energy sources from hydro to wind, geothermal and thermal.

As the head of KenGen Innovation Department passionately said ***"Innovation is an indispensable tool for KenGen. It enables KenGen to deal with emerging realities such as the rising cost of clean and reliable energy. It enables the Company to navigate the regulatory process and balance the needs of its diverse stakeholders"*** It is clear from the account that KenGen innovates to address societal goals in clean energy and the environment as encompassed in the United Nations Sustainable Development Goals (Schot et al., 2018).

Through specific strategies and policies, KenGen also invests in the development, acquisition, and transfer of technology in conjunction with its G2G Innovation corporate strategy. The strategies and policies include Innovation and Research and Development, Knowledge Harvesting and Transfer, Innovation and R&D policies, Open Innovation policies, Intellectual Property (IP) policies, Rewards and Recognition policies, Information and Records Management policies, Partnership policies, and Human Resources policies. According to a recent IP update, KenGen has made 150 IP applications since 2017 and 128 have already been granted (**Table 1**).

Table 1: Recent KenGen IP update

Type of IP	**IP applications since 2017**	**IPs Under KIPI/KECOBO Review**	**IP Certificate Granted**
Patents	10	4	3
Provisional Patents	2	2	
Trademarks	34	10	24
Copyrights	101	2	99
Utility models	3	1	2
Total	150	19	128

KenGen operations in a liberalized market and its aspirations to lead in the provision of reliable, quality, safe and competitively priced electricity for economic growth and environmental sustainability have addressed change at the level of socio-technical systems in energy, security, health, environment, agriculture and water (Kanger & Schot, 2019). The impacts extend beyond the border into Ethiopia and Djibouti.

Learning and Reflexivity, Conflict versus Consensus and Inclusiveness

Structural system failure, a situation where an increase in R&D spending does not automatically lead to high performance in innovation activities is caused by several factors including lack of reflexivity, institutional democracy, and inclusiveness. Additional factors contributing to such system failures include wrong articulation of demands and poor coordination of multisectoral policies.

By enabling the innovation and R&D culture KenGen enables employees to reflect on their own routines, habits, cultures, positions and worldviews of others and rationality- a process called reflexivity (Daniels et al., 2019). To institutionalize the innovation culture, KenGen leverages different platforms that have given its employees the opportunities to share their ideas on how to improve the overall organizational performance of the organization.

Through platforms such as G2G innovation seminars, Communities of Practice (COPI), Ignite Fridays, Ignite Portal, and innovation awards, employees have developed a culture where their ideas are valued. Deep dive sessions during the platforms enable staff to question routines and cultures. This has contributed to deep learning where they fundamentally rethink how problems are defined at KenGen, and what solutions are considered appropriate.

KenGen's stage gate approach to screen ideas and drive the innovation process through various activation channels (**Figure 1**) has promoted democratization (participation) and inclusion of all actors in decision making processes.

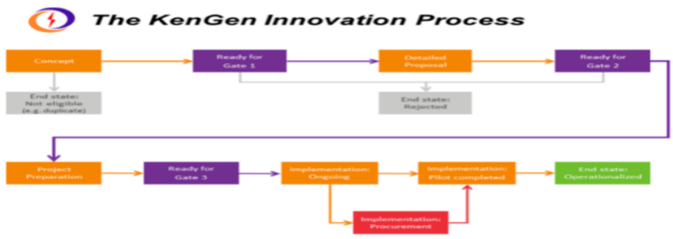


Figure 1: KenGen idea screening process.

Transformative Innovation Platforms

The Company leverages different platforms to give employees opportunities to share and advance innovative ideas that improve business processes. This is for the company's financial success and social and environmental benefits. The platforms include:

- **The G2G Global Innovation Seminar**

This is an annual gathering for sharing ideas and promoting creativity and innovation as envisaged in KenGen's G2G Strategy (**Figure 2**). The seminar promotes an innovative culture and continuous improvement philosophy through action-oriented translation of initiatives into commercial applications that generate growth for the company. Presented ideas are screened by the G2G Innovation Council and undergo further development.

Figure 2: Delegates during the 2019 G2G seminar.

- **Communities of Practice & Innovation (COPI)**
  Communities of Practice and Innovation (COPI) provide a forum for KenGen staff to share innovations, best practice and knowledge at a regional level (Swan et al., 2002). COPI forums began in March 2016 and cover all KenGen regions. The fora which are held biannually per region, stimulate ideas on how existing systems and business models can be improved to create value. Ideas presented during the COPI regional fora are screened and evaluated by the COPI committee which also assist in the implementation of all innovation ideas at an area level.

- **Ignite Fridays**
  KenGen hosts innovation sessions every last Friday of the month where staff from each section breakout for a two-hour discussion on innovation.
- **Ignite Portal**
  The company launched the Ignite portal in June 2018 to manage innovation ideas across the company. Staff can use the portal to submit ideas for future company developments and participate in their implementation online. Employees share ideas virtually and track their progress through screening. The portal facilitates speedy execution and tracking of selected ideas.

Figure 3: KenGen Digital Innovation Platform- IGNITE.

Successful G2G Technology Transfer Projects and Products

Since the start of G2G innovation seminars, twenty projects and several products have successfully been implemented. The projects and products which contributed to technology acquisition, development and transfer presented a variety of frontier technologies such as digital technologies, nanotechnology, and solar voltaic technology. In addition, the projects and products have been imbued with several elements of transformative change. These elements include directionality, system level impact, societal goals, learning and reflexivity, conflict versus consensus (democracy), and inclusiveness. The projects and products include:

- **KenGen Commercial Drilling-2012**

  In 2012, KenGen's geothermal drilling services enabled the company to extend its system level impact a cross the Kenyan boarder to Ethiopia and recently in Djibouti.

  The Company has successfully managed 2 projects ongoing (1) **Tulu Moye Contract** where the first phase entailed drilling a total of 8 geothermal wells and (2) **Aluto Drilling Contract.**

Figure 4: Tulu Moye drilling project-Ethiopia

Figure 5: Aluto Langano drilling project-Ethiopia

  The geoscientific services and geothermal drilling services acquired through over 50 years of experience and expertise in the KenGen owned Olkaria geothermal field. This has enabled KenGen to offer similar technical services to Independent power producers (IPP's) such as Ol Suswa, Akiira and Agil that are based in Kenya through competitive bidding tenders. The successful deployment of these services in Kenya has led to similar undertakings in Ethiopia, Djibouti, Rwanda, South Sudan and Zambia. In all these undertakings, KenGen has been able to transfer technical expertise pertaining to geothermal resources exploration and development.

  In 2012, KenGen's geothermal drilling services enabled the company to extend its system level impact a cross Kenyan boarder to Ethiopia and recently in Djibouti.

- **Geothermal Wellhead Technology**

  This technology was developed through piloting and rolled out by KenGen. This technology involves tapping of steam from wells that are undergoing testing or awaiting connection to permanent power plants in order to generate power that is directly connected to the grid. The advantages of the technology are early return on investment, optimal energy utilization and rapid deployment due to its modular nature. The Technology has been transferred to the Geothermal Development Company in Kenya and several Geothermal IPPs in Africa through benchmarking and exhibitions of the technology seminars and other technology forums. KenGen has signed an MoU with Toshiba Corporation to transfer the wellhead technology across Africa.

- **Exploiting the Social Media**

  KenGen communication strategy started venturing in social medial way back in 2012. To communicate effectively with stakeholders in the current fast-digitized world, KenGen has an active Facebook, Twitter and Instagram accounts and an interactive website. This facilitate instantaneous communication, promotes participation and inclusiveness among employees and stakeholders.

- **Benefits of Deep Drilling**

  Kenya's ambition of geothermal power commenced in 1956 with exploratory drilling in Olkaria of wells, X1 and X2. Between 1973 and 1984, 27 wells were drilled in Olkaria East field which currently hosts the 45MWe plant. By 1994, Olkaria's generating capacity had deteriorated to 31MWe. As a mitigation measure, the company drilled make-up wells and deepened well OW-05 from 900m to 2200m. The connection of the make-up wells, and deepening of well OW-5, increased the total steam availability from the existing wells. For KenGen deep drilling has tremendously increased wells productivity (with accurate well siting). Since 2012, the company has developed the capacity to drill operations to 3000m from the surface. Experts from the company therefore recommends that future well drilling should target at least 3500m from the surface.

- **KenGen Geothermal Spa**

  Since 2013, KenGen started diversification of its geothermal resource utilization. So far, the company has constructed the largest health facility, the geothermal spa, one of its kind in Africa. The geothermal spa ensures that operations of the company are sustainable and that they impact the health sector through medical tourism.

  Figure 6: The Geothermal Spa.

- **Real Time Relaying of Geothermal Field Data**
  To solve the problem of lack of data to inform decision-making, KenGen initiated a digital project in 2013. The project entailed online and web-based mapping using GSM, GPRS, WIFI and GIS technologies of mobile phones. In the project, user-friendly interfaces within the android operating systems and mobile mappers (GPS) are customized to transmit information directly from the field to computer server, mails, text messages and other relevant notifications. This system facilitates quick decision-making in the organization.

- **Web GIS in property Management**
  The creation of a system for managing all KenGen's properties using a Web Geographic Information System (GIS) interface started in 2013. GIS software can manage vast amounts of property with more accurate reflection of real-world circumstances and support better decision-making. The GIS was implemented using a UMN Map server architecture which has formed a system that is used for understanding and interpreting geographical patterns and relationships between features of the built environment.

- **Grid tie Solar projects**

  Due to the growing demand for solar related products in Kenya, the company started actualizing its solar power projects in the Eastern and Thermal region in 2015. The Piloting of the grid tie projects at Kipevu and Eastern Region are completed.

Figure 7: The 30 KW Grid-tie solar at Hydro Plaza- Easter Region.

  By contributing to green energy sources, the company's efforts have had system level impact on the environment and contributed to socio-technical change from the traditional sources of power such the use of diesel power generators.

Figure 8: The 40 KW Grid-tied solar at Kipevu- Thermal Region.

  This technology will be rolled out to the rest of the business areas once sufficient data has been collected.

- **Solar Cell Assembly**

  KenGen is planning to build a plant for assembling photovoltaic solar panels. The technology was acquired through internal prototyping by KenGen staff. The technical reviews generated are then shared through hosting benchmarking tours by various entities including Ethiopia Electric Power Company.

- **Gravity Base Station in Olkaria**

  In 2015, KenGen established an absolute gravity base station for Olkaria Geothermal field for microgravity, local and regional surveys. This is a home-grown solution implemented by experts in the field.

- **Steam Turbine Rotor Bow**

  Since 2015, the company has been investigating and mitigating steam turbine rotor bow and straightening: KWG 01 Unit 2 and KWG 03 wellhead plants with a view to institute suitable corrective actions to avoid recurrence. The project too is a homme-grown solution that has impacted on plant availability been implemented.

- **Digital Newspapers**

  By adopting and implementing digital newspapers across the Company since 2015 has reduced the print newspaper costs but at the same time increase access to news by the staff.

Figure 9: KenGen's digital newspapers.

- **Implementation of the Digital Signature**

  KenGen's journey to digitization of workflow processes started in 2015. A complete workflow automation of the signature which eliminated manual processes significantly reduced on the time taken in waiting to sign physical documents hence improved on efficiency.

- **Improving Drilling performance using PDC Bits**

  The project seeks to highlight and analyses the performance of Polycrystalline Diamond Compact PDC bits while drilling. The implementation of this project has accrued the benefits for the Company including; maximizing drilling performance and reduced drilling time.

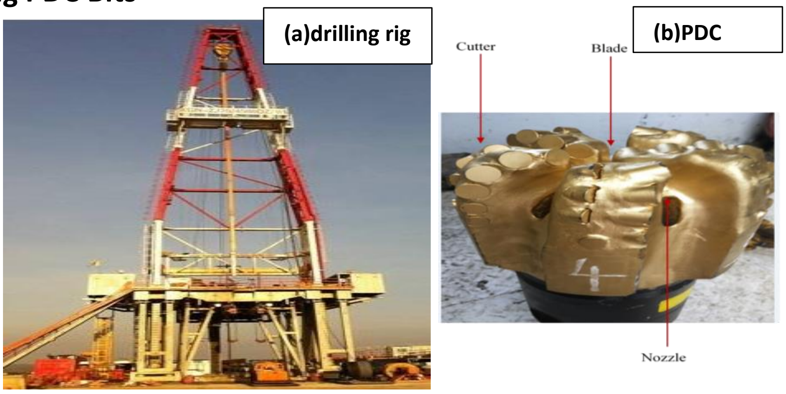


Figure 10: Improved drilling equipment (a) Drilling rig (b) PDC Bits.

- **KenGen Calibration Center**

  To offer calibration services within the region, KenGen constructed a modern "state of the art" calibration centre in 2016. The centre host three (3) Laboratories well-equipped laboratories namely: Electrical lab, Pressure lab and Temperature lab.

Figure 11: A modern equipment in KenGen's calibration Centre.

- **Re- Design of HT Cooling Water System at Kipevu 1**

  In 2016, to reduce breakdowns as a result of cylinder linear 'O' rings failures, KenGen re-designed its high temperature (HT) cooling water system at Kipevu I.

- **Gitaru Water Bottling Plant**

  The company started its water bottling project in 2017, hence impacting on the water and environment sectors. The project taps crystal clear seepage water coming from pervious rocks in the powerhouse at Gitaru Hydro Power Station, purifies it before bottling for consumption. The project has saved costs of procuring drinking water for staff.

- **Implementation of smart metering**

  Bulk energy meters are essential and resourceful devices that measure the amount of electricity KenGen generates. The data generated by these devices helps in billing and payment of power. In 2017, KenGen started automatic meter reading, using smart metering technology that automatically collects data from energy meters and transfer it to a centralized database for the purpose of analysis and billing.

The acquisition of accurate and real-time data has ensured timely billing, efficiency in data acquisition, energy management and revenue protection. In addition, automation of data acquisition has also helped to eliminate human error and improve business processes.

- **Installation of Electric Charging Infrastructure**

  KenGen is keen on mitigating the effects of climate change by encouraging the use of Electric vehicles (EV). As the country transitions to safer energy sources, there is increasing demand for electric power. In 2018, KenGen started an experiment by installing two (2) EV Chargers. The ultimate goal is to ensure that the Company is leader in provision of EV infrastructure across the Country.

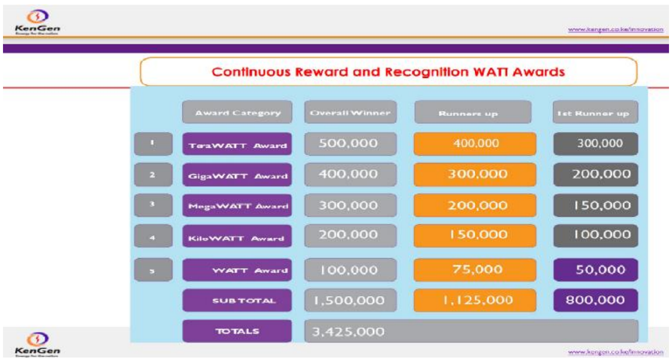
Figure 12: Geothermal Plaza EV Charger.

- **Installation of Optical Ground wire (OPGW)**

  KenGen Geothermal Power Plants Olkaria IAU, Olkaria IV and Olkaria V are automated and run on a distributed control system (DCS) and the plant and corporate data in the plants is transmitted through the Optical ground wire (OPGW). In 2020, the company completed the installation works for the Optical Ground Wire (OPGW) for the Geothermal Division in Olkaria.

- **Continuous Reward and Recognition WATT Awards**

KenGen has established a reward and recognition system to build the culture of innovation among the staff. Notable awards include: (1) Terawatt Award – targets individuals or teams who implement innovation initiatives that result in new revenue generation, (2) Gigawatt Award – targets individuals or teams who implement innovation initiatives that result in cost savings, (3) Megawatt Award – targets individuals or teams who implement process improvement ideas that result in turn around efficiency, (4) Kilowatt Award – targets exemplary leaders who go beyond the call of duty to support the implementation of innovation initiatives and (5). Watt Award – recognizes individual or team effort and courage to pilot, prototype or test an innovation initiative that did not result in success but lessons.



	Award Category	Overall Winner	Runners up	1st Runner up
1	TeraWATT Award	500,000	400,000	300,000
2	GigaWATT Award	400,000	300,000	200,000
3	MegaWATT Award	300,000	200,000	150,000
4	KiloWATT Award	200,000	150,000	100,000
5	WATT Award	100,000	75,000	50,000
	SUBTOTAL	1,500,000	1,125,000	800,000
	TOTALS	3,425,000		

Figure 13: KenGen's continuous reward and recognition WATT awards

Insights

Since 2019, KenGen's clean development mechanism has been reducing over 1.5 million tCO_2e from the atmosphere annually through implementation of green, low carbon developments and in return received technological and investment transfers.