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Research Article

Technology Adoption in Socializing Applied Sciences for Exploitation of Renewable Natural Resources Sustainably

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Abstract: **Kenya Vision 2030 aims to transform Kenya into a newly industrializing, middle class income country providing high quality life to all her citizens in a safe and secure environment by the year 2030. To achieve this, generation and management of a knowledge based economy and the contribution of indigenous inventions and technologies has been recognized as vital. A lot of efforts have been put in place on the application of Science, Technology and innovations as an engine and driver of knowledge based economy which is subject of re-evaluation during the innovation week. This paper looks at the socialization of applied sciences, adoption, adaption, transfer and diffusion of technologies with a view to measuring productivity, optimizing utilization of natural resources and bringing on board the "critical mass" of the small holder and small and micro enterprises (SMEs) to play their role in bringing about the desired change. The paper proposes a Technology Adoption Facilitation model (TAFaM) where the institutions of higher learning will play a pivotal role not only in creating and disseminating technologies but also in anchoring and overseeing technology adoption, transfer and diffusion by SMEs and Small scale Agribusiness in LDCs. This will not only engage youths, create self employment, generate income, contribute to economic development but also fight poverty, reduce hunger increase food security and improve quality of life. Two case studies are used to inform the discourse.**

Key words: **Technology Adoption, Technology Adaption, Technology Transfer, and Technology Diffusion: Poverty, Unemployment, Food Security, and Economic Development**

I. INTRODUCTION

The economic growth of a region depends upon the proper utilization of its natural resources which include land, water, minerals, forests, fisheries, livestock and intangible natural resources such as talent, wind and sun among others, which are a natural gift that can be transformed into tangible wealth on exploitation to produce agricultural, industrial and energy outputs. This requires creation, development, adoption, transfer and diffusion of technology, a task that National Council for Science and Technology (NCST) is expected to guide in Kenya. The NCST was formed to serve as advisory institution to the government on matters of science and technology with legal powers and capacity to develop, collect and make available information on scientific and technological advancement to users. The Universities, Research institutions and other institutions of higher learning are expected to encourage research, innovation and contribute to community service among other objectives, [1]. While NCST Universities and Research institutions has continued to improve and upscale their performance and the economic development is on the rise in Kenya, three main disadvantages still afflict the majority of its citizens namely poverty, unemployment and food insecurity.

II. THE PROBLEM

Globally, 1.3 billion people live in extreme poverty (World Bank, 2013). In Kenya 45.9% of the total population live on less that USD 1.25 a day (KDHS 2009, World Bank 2013). Globally, poverty levels have been noted to be in the decrease [2]. It has been noted that the poor people are increasingly found in middle income countries and fragile states [3]. Overall, economic activity in 2012 showed improvement despite a myriad of challenges that include a turbulent global economy, delayed long rains and a weakened Kenya shilling in the beginning of the year. This performance was supported by: stable macroeconomic environment, increased domestic demand, modest growth in credit and notable growths in Agriculture, wholesale and Retail Trade, and Transport and Communication, [4].

The importance of poverty reduction as a part of the Millennium Development Agenda has motivated greater interest in the geographic dimensions of poverty, natural resources availability and food security [5]. In Africa poverty has been on the increase both in the incidence and absolute number of people living in income poverty [6].The situation in Kenya indicates a slight reduction in poverty across the country and across rural areas over the last decade but still high, 46%

of the Kenyan total population is absolutely poor, living below the poverty line while 49% of the rural population is absolutely poor [7].

In general global unemployment rose to 197.3 million in 2012, an increase of 4.2 million over the previous year and 28.4 million above the level in 2007, the year preceding the crisis. Moreover, given the slowdown in activity, the ILO's baseline projection is a further deterioration in 2013, with the global unemployment rate ticking up to 6 per cent and a further increase in the number of unemployed around the world of 5.1 million. On the basis of current macroeconomic forecasts, the global unemployment rate is projected to remain at around 6 per cent until at least 2017 [8].

On youth, unemployment statistics indicate that it is likely to remain at over 6 percent globally until 2016 [8]. But in 2012, the ILO estimates that the number of unemployed youth is on the rise again since 2011, after declining somewhat from the peak it reached at the height of the global financial crisis. It was expected to reach 73.4 million young people by 2013 [9]. The global youth unemployment rate has also been rising since 2011; it is currently estimated at 12.6 percent and is projected to increase to 12.8 percent by 2018. In contrast, the global adult unemployment rate, while also rising slightly, is much lower at 4.6 percent in 2013 [9].

On youth and employment, Sub-Saharan Africa is perhaps the region of the world that will face the greatest challenges with the youth bulge going forward. Because fertility has not declined as sharply as in other regions, sub-Saharan Africa will not benefit from a demographic dividend in the coming decades. Youth are expected to be about 20 percent of the population there for the next couple of decades, and they will make up over 30 percent of the working age population through about 2045. Despite these pervasive and enduring demographic pressures, the ILO projects that youth unemployment in Africa will remain stable at 11.7 percent through 2018, a rate that is well below the world average [9].

On development, the world will not have eradicated extreme poverty in 2015, but the Millennium Development Goal target of halving world poverty will have been met. The proportion of people living on less than $1.25 a day fell from 43.1 percent in 1990 to 22.7 percent in 2008, reaching new lows in all six developing country regions. While the food, fuel, and financial crises over the past five years worsened the situation of vulnerable populations and slowed poverty reduction in some countries, global poverty rates continued to fall in most regions. Preliminary estimates for 2010 confirm that the extreme poverty rate fell further, to 20.6 percent, reaching the global target five years early. Except in South Asia and Sub-Saharan Africa the target has also been met at the regional level [9].

In Africa, although many policies, programmes and projects have been directed at the problem, unemployment continues to be a major obstacle to full utilization of human resources. In Kenya, unemployment rate of youths aged 15-24 years was 24% in 2005/2006 compared to the overall unemployment rate of 12.7% with urban unemployment rate (19.9%) higher than rural unemployment rate (9.8%) [9].

On food security, the number of people lacking access to the minimum diet rose from 284million in the baseline year 1990 to 1,020 million in 2009 [10] on a global perspective. In Africa, one third of Africa countries, the average daily caloric intake availability is below the recommended level of 2100 Kcal [10]. In Kenya, despite the effort made by the government to achieve national, household and individual food security throughout the country, 51% of the Kenya population still lack access to adequate food [11].

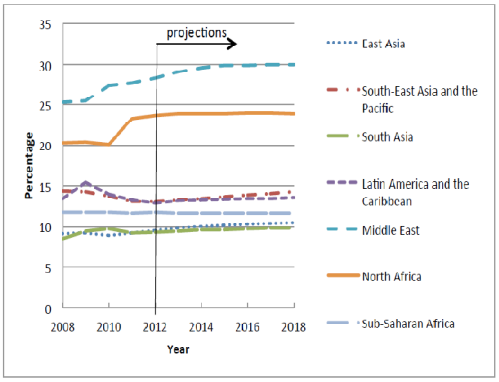

Figure 1: Youth Unemployment Rates by Region, Ages 15-24

Source: ILO [12].

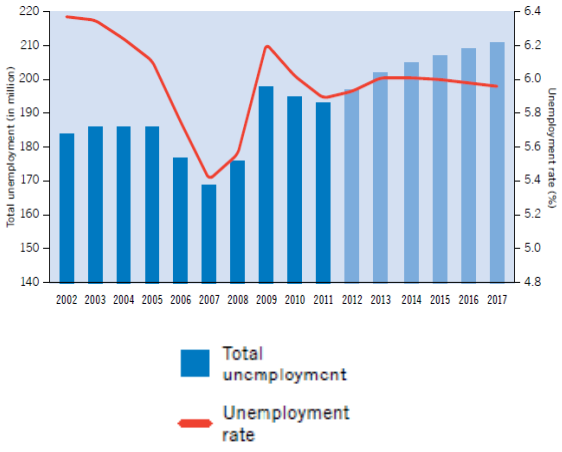

Figure 2: Global unemployment trends and projections, 2002–17

Source: ILO, Trends Econometric Models [9].

This statistics on the trend of poverty, unemployment and food insecurities in Kenya is poor despite the efforts being made to improve economic development and realize the objectives of vision 2030. Research institutions, Universities and other institutions of higher learning continue to conduct research, create and disseminate new and innovative technologies, whose impact does not seem to subdue this growing statistics. The technology developed, innovations created and documented do not seem to percolate, reach the "critical masses" that need to adopt it and change their lot. Kenya [13] observed that, to build a competitive advantage, SMEs and the small holder producers need the challenge of technology. Universities as higher institutions of learning need to take the challenge of technology adoption to the "critical mass" and oversee technology adoption, transfer and diffusion of technology who seem lethargic to it thereby socializing applied sciences, creating employment, reducing poverty, contributing to food security, improving living standards and helping Kenya achieve its vision 2030 [14].

Science, Technology and Innovation application in Exploitation of Natural Resources

Science and technology are intimately connected with development because: (i) they have a historical record of bringing advances that have led to healthier, longer, wealthier and more productive lives and (ii) they are key ingredients to solutions to the most serious poverty alleviation and economic development challenges that we currently face and are likely to face in the future. There are many ways in which science and technology impact poverty alleviation across various sectors and economic growth merit attention.

In relation to Energy, despite its importance to economic growth and poverty alleviation, energy continues to be exploited in a short-sighted and unsustainable way. Unfortunately many countries are promoting fossil fuel energy policies and practices that are causing environmental degradation at the local (particulates and smog), regional (acid deposition) and global (climate change) scales, leading to significant loss of human life and ecological damage. Currently, two billion people in the world are without electricity.

Science, Technology and Innovation (ST & I) has enabled Kenya to exploit other sources of renewable energy such as solar energy, wind power, Biomass energy, electricity from crop residue ,biogas among others and at the same time providing low power consumption appliances such as energy saving bulbs, energy "jikos' among others.

In the domain of food security, advances in S&T provided the foundation for the Green Revolution, and have allowed food prices to remain at historical lows for the past several decades. Improved knowledge of plant biology and breeding techniques led to better seeds and cultivation practices that drastically increased yields . Not surprisingly, Africa, the region of the world with the lowest indicators for S&T capacity, has had the greatest difficulty in capitalizing on and benefiting from the Green Revolution. Throughout the rest of the developing world, yields rose much faster than the population increased, mitigating pressures to extend cultivation to scarce additional land. It is estimated that, without the scientific advances of the past 50 years, an additional land area the size of Europe would be required to produce the world's current agricultural output.

Technology has transformed the agricultural sector by replacing the traditional farming methods with contemporary practices. For example, the floriculture industry in Kenya is an African example of what is possible with access to technologies, investment funds and enabling policies. Another example is in banana farming which has also improved with the introduction of Tissue Culture (TC) techniques. The basis of the technology is the ability of many plant species to regenerate a whole plant from a shoot tip. In economic terms this improves the productivity of every citizen which overall leads to growth in GDP.

Advances in science and technology are, in many ways, the ultimate Global Public Good: once discovered, their benefits can be extended to additional users at little or no marginal costs. In the most basic and critical areas of human need, science and technology have made possible significant progress to date, and they hold the best prospects for continued progress, particularly with respect to agriculture, health, energy, water, and environmental concerns.

III. THE PURPOSE

The purpose of this paper is to propose a Technology Adoption Facilitation Model (TAFaM) whose main objective will be to enhance technology adoption, socialize applied sciences, improve utilization of Natural resources, create employment, reduce poverty and hunger, enhance food security and eventually contribute to

sustainable industrial development and achieving of vision 2030.

Technology Adoption Facilitation Model (TAFaM)

Technology aims at facilitating innovations in product design, diversification and quality improvement thus enriching market opportunities [15]. According to Republic of Kenya [16] technology adoption is a process that progresses through a series of steps that include creating awareness where potential users learn enough about the technology and its benefits and decide whether to investigate further. The second step is assessment where potential users evaluate the usefulness and usability of the technology and the ease or difficult of adopting it. This is followed by acceptance at which point the potential users decide to acquire and use the technology or not to adopt it. After acquiring, the users develop skills and knowledge required to use the technology effectively. The final step is usage when users take up, apply and demonstrate appropriate and effective use of the technology that benefits the individual, the enterprise, the house hold, the society and the Nation.

Where market is available for the goods, the user attracts attention and others are likely to get interested and start the process leading to further adoption, adaption, transfer and diffusion. In Kenya, there seems to be apathy in technology adoption even when it has been proven to work and improve productivity especially among the majority in the small and micro enterprises, small holder farmers and the rural poor. These are the groups that form the critical mass that need to be empowered in technology adoption for sustainable economic and national development. The Silicon Valley is an example of how the universities and other institutions of research and higher learning can influence society, foster technological innovations, create employment and contribute to sustainable economic and national development. Harnessing natural resources to boost income at the household level and employing/adopting technology wood ensure food security, alleviate poverty and reduce conflicts. Land, water, wind, sun, and the human capital are some of the natural resources that could be harnessed by use of traditional, appropriate or/and modern technology to increase farm productivity and sustainability in agribusiness and environmental conservation. Some of the green energy techniques in use and available in the libraries in the universities and higher institutions of learning and research institutes are in the areas of irrigation, rain water harvesting, surface water harvesting, shallow well technology, wind energy, solar energy, and biomass or bio-energy. What is lacking is their widespread use especially among the underprivileged rural poor members of society and in particular those living in arid and semi arid areas. This is the gap this model proposes to fill by roping in the universities and thereby socializing applied sciences.

IV. THE CASES

The case study approach has been applied to present three different situations in this paper. First, to explain the causal links in real – life interventions that are too complex for other research strategies. Second, to describe real life context in which an intervention has occurred or for illustrative purpose. Third, to explore those situations where a single set of outcomes is not clear [17].

Case One: Harnessing Natural Resources for Agribusiness in Kitengela, Kanjiando County-Kenya

Kajiando District is semi arid and most of the residents pastoralists. Virtually no farming takes place in the district except for the large flower farms that use irrigation. During excessive drought, which is frequent in the district, farmers lose their livestock and face starvation as a result. Since the district is windy, fairly flat and has scarce rainfall, a multifaceted approach is recommended for small scale farming for the common man. In this case, I set up a project with a view to introduce the concept of Green technology adoption in Agribusiness. The following steps have been adopted and are recommended.

(i) Isolate a portion of land 2 – 5 acres to be devoted to Agribusiness.

(ii) Fence off the parcel to keep off livestock.

(iii) Plant life fence with a view to keeping off wild animals. There are drought resistant trees and shrubs that make very good live fence. In this case, Euphorbia, Cactus ad Bougainvillea has been used. Cactus is especially good since no wild animals will want to come near it even when it is still a low hedge.

(iv) Identify the crop that is suitable for the region. (The Ministry of Agriculture has staff in all areas and provide technical advice). These steps are illustrated in plate 1.

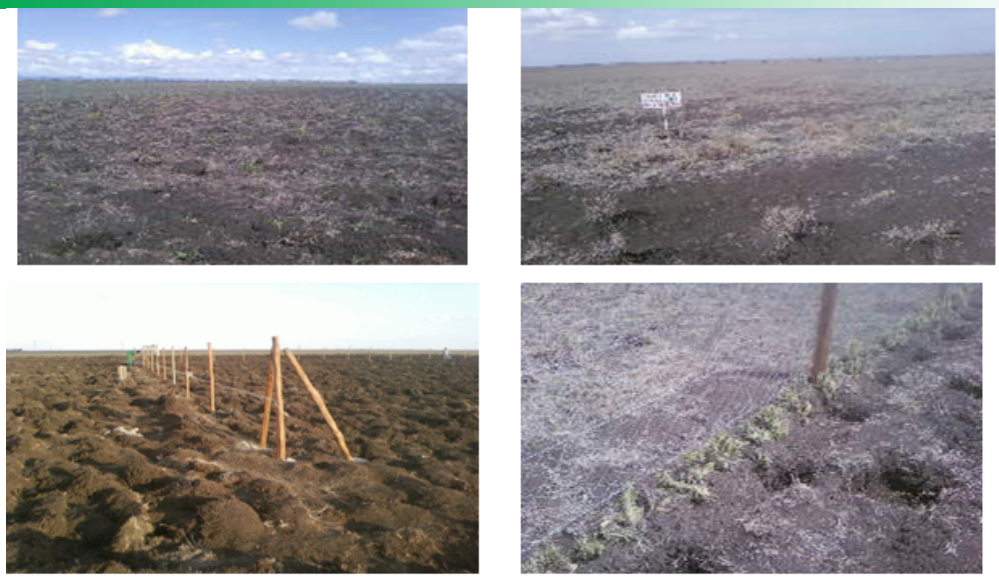

Plate 1: The parcel of land set aside for Agribusiness fenced in November 2010

V. OBSERVATIONS

It has been observed that:

(i) In this particular region, though fertile, during the short rains (October – December), the amount of rainfall is not sufficient to make the crop complete the cycle. Plate two shows a variety of drought resistant crop for the region as recommended by the extension agricultural office in the region.

Plate 2: The first crop dependent on natural rainfall

(ii) During long rains (March – June), season, the yields are betters but less than optimal. Plate 3 shows a variety of crops still on session planted in May 2012.

Plate 3: Maize, Soya Beans and Njahi (Doricos Lablab) Planted in May 2012 and still enjoying better water supply

In this case, I have been involved in a Buadalangi Poverty eradication project since 2009 working with Baba Foundation. Baba Foundation is a local Community Based Organization (CBO) registered under the ministry of culture and social services in 2002. The organization's mission is "To empower fisher communities of Bunyala to alleviate suffering through initiation of activities that address ignorance, poverty, diseases and injustice in collaboration with other stakeholders".

The first challenge the CBO experienced was mobilization of resources and change of attitude by residents so that they could abandon the fisher community mentality and embrace farming as a way of life.

Case two: Budalangi Poverty Alleviation, Agribusiness and Value addition Project

Plate 4: Fish selling point and land not used for agricultural activities around homesteads

Intervention Recommended

There is need to invest in available green technology, initially to harvest the rain water and store it temporary so as to use it to irrigate and enable the crops in the small parcels of land complete the cycle. Tanks could be used for roof water harvesting and a dam or underground water tank for surface runoff water. Mechanisation could/will follow to improve the irrigation. In the long run, shallow well could/will be dug and wind and/or solar water pumps installed to provide irrigation water all year round. This will be the next phase of this case. By this time, other Agribusiness activities could/will be introduced in the parcel of land including zero grazing, Apiary, poultry, greenhouse and drip irrigation farming before venturing into value addition.

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Plate 5: Agribusiness activities embraced in Port Victoria, Budalangi – Cassava, sweet potatoes, Maize, sorghum and dairy goat farming

Upon an appreciable success in embracing agribusiness, it quickly emerged that there was no sustainable market for the farm produce. Baba foundation was again able to get a financier and a value adding plant was installed and it began operation in November, 2011 as shown in plate 6.

Plate 6: Baba Foundation farm produce value addition plant (Installed in November 2011)

The organization produces 5 varieties of flour with both ugali and uji mixes as well as a drinking powder mix that can be taken as tea. All flours are Grade 1 flour that can be either sifted or unsifted. The Blends are as follows:

Extra Meal

This flour is uji flour that is comprised of Millet, Soya, Ground Nut, Amarantha, Ginger, Bullrush, and Maize. This blend is good for healthy body functioning and energy.

Maize Meal

This flour is a Grade 1 sifted ugali flour comprised of Maize.

Nguvu Meal

This flour is a Grade 1 ugali flour comprised of Cassava and Sorghum.

Drinking Powder

The drinking powder is comprised of Soya, Ginger and Maringa leaves. This product is to be taken as a healthier alternative to tea/ chai.

Plate 7: Some of the composite flour products and their packaging

Nene Meal

This flour is uji flour comprised of Millet, Soya and Ground Nut. This blend is good for weaning babies.

Afya Meal

This flour is uji flour comprised of Millet, Soya, Ground Nut and Citric Acid. The blend is good for adults.

VI. CHALLENGES FACING KENYA UTILIZATION OF SCIENCE AND TECHNOLOGY

Kenya faces the following challenges in the utilization of ST&I for Exploitation of Natural Resources:

Lack of emphasis in sciences in the Education System: In Kenya most of the technical institutions were upgraded to universities in the last two decades resulting to a serious shortage of the critical mass on ST &I at the tactical level.

Inadequate funding towards Science, Technology and Innovation (ST&I): Kenya spends less than 0.3% of its Gross Domestic Product (GDP) in R&D in comparison with the BRICS (Brazil, Russia, India, China and Singapore) countries where 10% of GDP is devoted to R&D.

Weak application of the R&D: Kenya has insufficient focus towards R & D that would enable sustainable industrial development. Kenya's R&D findings are not tried in the industrial sector and have low impact on development.

Policy Level Commitment: In Kenya, ST&I has been divorced from the mainstream of national economic activities due to huge gap between policy formulation, implementation and consequently lack of good will and its support at the policy level. The link between ST&I policy and macro-economic policies has not been fully integrated and stakeholders at national level should be involved in the formulation and implementation of ST&I policies and ineffective enforcement mechanism on monitoring and evaluation on implementation of ST & I policies and initiatives.

VII. CONCLUSION AND RECOMMENDATIONS

The lessons from these two cases are the same. Institution of higher learning have a role to play in facilitating and anchoring technology adoption, technology transfer and technology diffusion in solving real life problems in our communities. The green technology for use in small scale Agribusiness is readily available in our research institutions and institutions of higher learning. The small scale holder hardly invests in technology either for lack of capital for resistance to adoption. This situation needs to be addressed and the technology gap between institution of research and higher education bridged. This will also gradually lead to sustainable rural based employment and self-employment, create a sustainable stream of income, and reduce idleness, poverty and conflict over the traditionally exploited meager natural resources.

It is recommended that the green technology adoption model and the university community outreach model could be adopted and adapted to form a basis for engaging the community in engineering solutions to their problems and thereby creating employment, reducing conflict over resources and contributing to the countries development agenda. The TAFaM and the community outreach models proposed and illustrated below are recommended to enhance

socialization and adoption of applied Sciences, innovations and technology for exploitation of renewable natural resources sustainably.

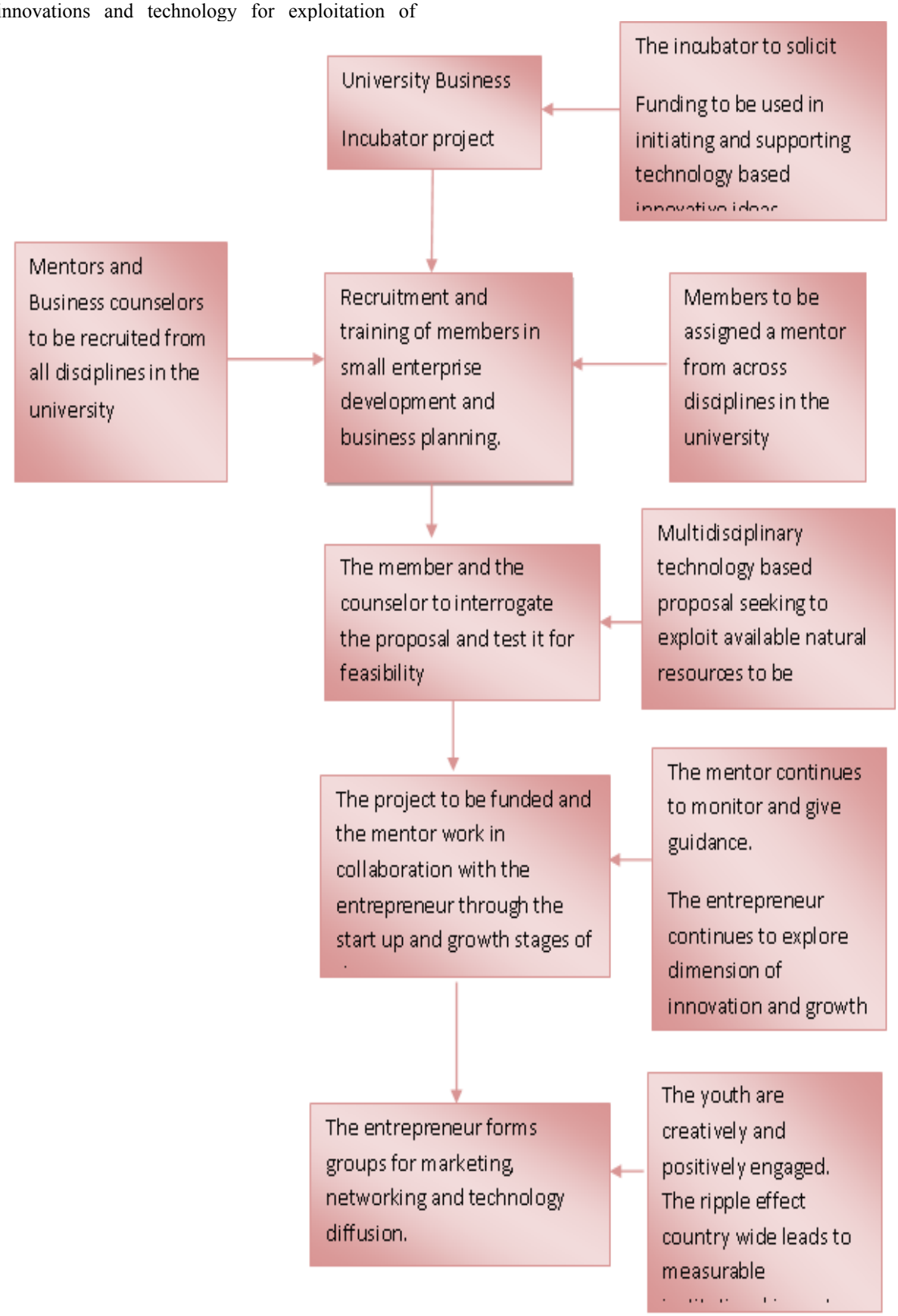

Figure 3: Technology Adoption Facilitation Model (TAFAM)

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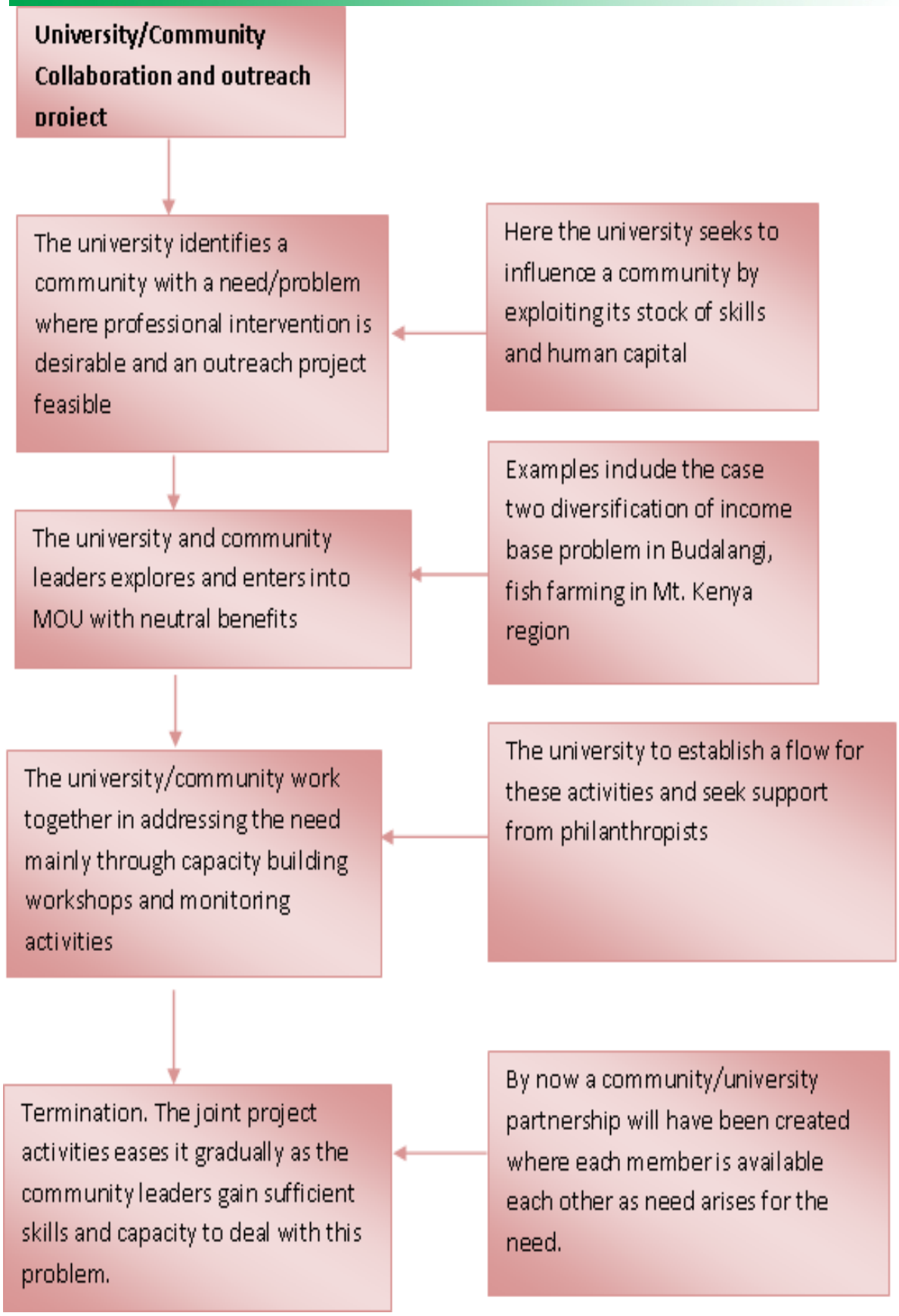

Figure 4: University Community Outreach and TAFaM

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IX. APPENDICES

Appendix I: Kenya Growth of GDP by Industry

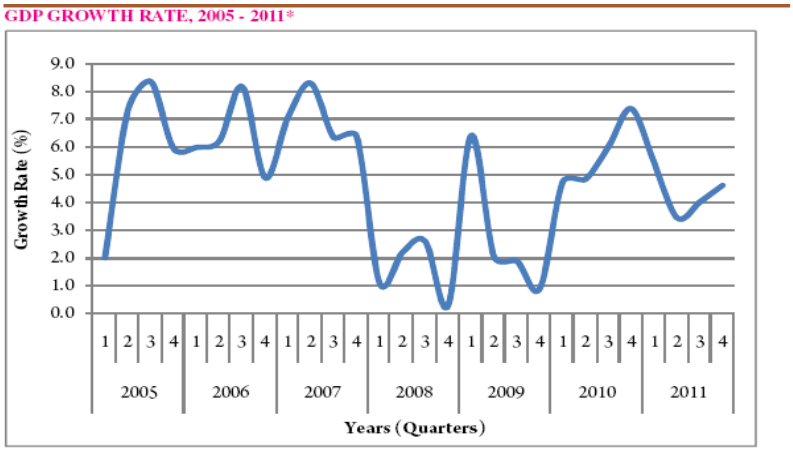
GROWTH RATES OF GDP BY INDUSTRY

Percentage

Industry	2008	2009	2010	2011*
Agriculture and forestry	-4.1	-2.6	6.4	1.5
Fishing	-13.2	3.8	2.7	3.1
Mining and quarrying	2.9	-4.5	9.7	7.1
Manufacturing	3.5	1.3	4.5	3.3
Electricity and water supply	5.3	-3.0	9.7	-2.6
Construction	8.2	12.7	4.5	4.3
Wholesale and retail trade, repairs	4.8	3.9	8.0	7.3
Hotels and restaurants	-36.1	42.8	4.2	5.0
Transport and communication	3.0	6.4	5.9	4.5
Financial intermediation	2.7	7.2	9.0	7.8
Real estate, renting and business services	3.7	3.0	3.2	3.6
Public administration and defence	0.6	1.6	2.3	2.5
Education	5.9	2.7	4.5	4.9
Health and social work	3.6	4.4	1.4	3.5
Other community, social and personal services	2.9	2.6	2.7	4.5
Private households with employed persons	2.0	2.0	2.0	2.0
Less: Financial services indirectly measured	-13.9	13.9	-5.7	5.2
All industries at basic prices	1.1	2.6	5.7	3.8
Taxes less subsidies on products	4.4	3.8	6.0	7.9
GDP at market prices	**1.5**	**2.7**	**5.8**	**4.4**

Source: Kenya Facts and Figures (2012)

Appendix II: Kenya GDP Growth Rate 2005-2011



Source: Kenya Facts and Figures (2012)

Appendix III: Percentage Contributions to GDP by Activity in Kenya

PERCENTAGE CONTRIBUTIONS TO GDP BY ACTIVITY (CURRENT PRICES)

Percentage

Industry	2008	2009	2010	2011*
Agriculture and forestry	22.3	23.5	21.4	24.0
Fishing	0.4	0.4	0.6	0.5
Mining and quarrying	0.7	0.5	0.7	0.7
Manufacturing	10.8	9.9	9.9	9.4
Electricity and water supply	2.1	1.9	1.4	0.9
Construction	3.8	4.1	4.3	4.1
Wholesale and retail trade, repairs	10.2	9.8	10.2	10.6
Hotels and restaurants	1.1	1.7	1.7	1.7
Transport and communication	10.3	9.9	10.0	9.7
Financial intermediation	4.6	5.4	5.6	6.4
Real estate, renting and business services	5.1	4.9	4.8	4.5
Public administration and defence	5.0	5.0	5.6	5.0
Education	6.3	6.0	6.2	5.8
Health and social work	2.4	2.5	2.6	2.5
Other community, social and personal services	3.4	3.4	3.3	3.2
Private households with employed persons	0.4	0.4	0.4	0.4
Less: Financial services indirectly measured	-0.9	-1.1	-0.8	-1.1
Taxes less subsidies on products	11.8	11.7	12.2	11.7
GDP at market prices	**100.0**	**100.0**	**100.0**	**100.0**

Source: Kenya Facts and Figures (2012)

